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Environmental Assessment of the Old Harry Prospect Exploration Drilling Program

Report Prepared for:

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EXECUTIVE SUMMARY

This environmental assessment presents information on the proposed exploration drilling program, as proposed by Corridor Resources Inc. The proposed program would be conducted offshore western Newfoundland within the Laurentian Channel on the Old Harry Prospect, within Exploration Licence (EL) 1105. The Old Harry Prospect is located in the northeastern part of the Gulf of St. Lawrence (Gulf). Part of the prospect lies within waters under the jurisdiction of the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), and the other part where a joint agreement between Quebec and Canada has recently been established. The proposed exploration well is located in lands administered by the C-NLOPB.

A description of the proposed program and the existing physical, biological and socio-economic environments is included. Valued Environmental Components (VECs) were identified to focus the environmental effects analysis. The VECs selected for this assessment were:

- Species at Risk;
- Marine Ecosystem;
- Marine Fish, Shellfish, and Habitat;
- Marine Birds;
- Marine Mammals and Sea Turtles;
- Sensitive Areas; and
- Commercial Fisheries and Other Users.

This environmental assessment includes consideration of the environmental effects of the proposed exploration well on each of the VECs, including the potential environmental effects of planned activities and potential unplanned (e.g., accidental) events. It also considers potential cumulative environmental effects. Mitigation measures that are technically and economically feasible have been incorporated into the program design and planning. Monitoring programs are considered where appropriate. Provisions of relevant legislation and guidelines (e.g., *Offshore Waste Treatment Guidelines* (National Energy Board et al. 2010)) have been identified and incorporated into the proposed exploration drilling program.

The environmental assessment indicates that no significant residual adverse environmental effects, including cumulative environmental effects, will occur as a result of the Project.

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Acronyms and Units of Measurement

Acronym	**Definition**
2-D	Two-dimension
3-D	Three-dimension
AZMP	Atlantic Zone Monitoring Program
BOP	Blow-out preventer
BSF	Below seafloor
CAPP	Canadian Association of Petroleum Producers
CEAA	Canadian Environmental Assessment Act
CEA Agency	Canadian Environmental Assessment Agency
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
Corridor	Corridor Resources Inc., the Operator
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
DP	Dynamically-positioned
EBSA	Ecologically and Biologically Significant Area
ECSAS	Eastern Canadian Seabirds at Sea
EL	Exploration Licence
FEZ	Fisheries Exclusion Zone
FFAW	Fish, Food and Allied Workers
FNI	Federation of Newfoundland Indians
GOM	US Gulf of Mexico
HC	Hydrocarbon
HI	Hydrogen Index
HSE	Health, Safety and Environment
IBA	Important Bird Area
LOMA	Large Ocean Management Area
MAKMA	Mi'kmaq Alsumk Mowimsikik Koqoey Association
MODU	Mobile offshore drilling unit
NAFO	Northwest Atlantic Fisheries Organization
NEB	National Energy Board
NMFS	United States National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OBIS	Ocean Biogeographic Information System
OCS	US Outer Continental Shelf
OWTG	Offshore Waste Treatment Guidelines
PIROP	Programme Integre de Recherches sur les Oiseaux Pelagiques
RV	Research vessel
SARA	*Species at Risk Act*
SBM	Synthetic-based mud
SEA	Strategic Environmental Assessment
SFA	Salmon Fishing Area
SLGO	St. Lawrence Global Observatory
TAC	Total allowable catch
TOC	Total organic carbon
The Gulf	The Gulf of St. Lawrence
VEC	Valued environmental component

VSP	Vertical seismic profile
WBM	Water-based mud

Symbol	**Unit of Measurement**
10^2	hundred
10^6	million
°C	degree Celsius
bopd	Barrels of oil per day
cm	centimetre
dB	decibel
g/kg	gram per kilogram
ha	hectare
Hz	Hertz
in^3	cubic inch
kg	kilogram
kHz	kilohertz
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
L	litre
m	metre
m^2	square metre
m^3	cubic metre
m BSF	metres below seafloor
mg/kg	milligram per kilogram
mm	millimetre
MT	metric tonne
psi	pounds per square inch
t	metric tonne

1.0 INTRODUCTION

Corridor Resources Inc. (Corridor) is proposing to conduct one exploration well on the Old Harry prospect in the Gulf of St. Lawrence (Gulf) (Figure 1.1). The exploration well will be located within Exploration Licence (EL) 1105.

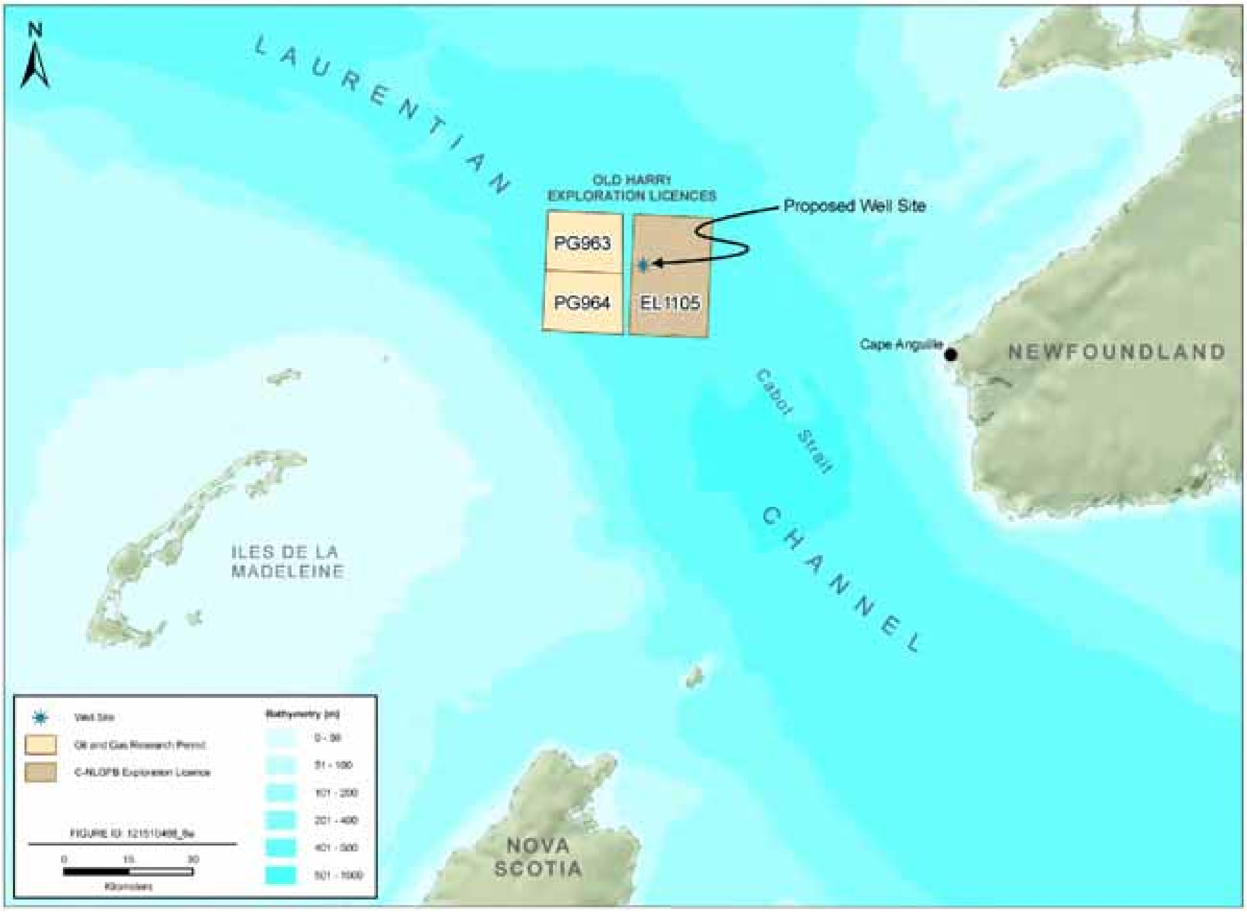

Figure 1.1 Location of Exploration Licence 1105 and Quebec Licences PG963 and PG964 Covering the Old Harry Prospect

The purpose of the exploration well is to obtain information that will assist Corridor in the ongoing evaluation of the hydrocarbon potential of the Old Harry prospect.

1.1 Project Overview

The official name of the Project is the Drilling of an Exploration Well on the Old Harry Prospect – EL 1105. EL 1105 is located in the Laurentian Channel portion of the Gulf, approximately 80 km west-northwest of Cape Anguille, Newfoundland and Labrador.

Corridor anticipates drilling one exploration well in EL 1105 on the western side of the licence, as illustrated in Figure 1.1. Depending on exploration drilling results, a decision will be made with respect to well testing. The drilling and testing program will be conducted in accordance with all Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) regulations and guidelines.

The information obtained from this well will assist Corridor in the ongoing evaluation of the hydrocarbon potential of the Old Harry prospect. This is an undrilled prospect and a well is required to confirm the hydrocarbon potential. If this exploration well provides encouraging results, a follow-up program may be developed and could include additional seismic or subsequent wells within EL 1105 or Corridor's other Old Harry Oil and Gas Research Permits. These activities, if conducted, would be covered under a separate regulatory process. This environmental assessment addresses the drilling of one well on EL 1105. The well is anticipated to take between 20 to 50 days to drill. A testing program could take up to several additional weeks on location depending on the geological and operational requirements.

The mobile offshore drilling unit (MODU) to be used for the exploration well is under consideration and could be a semi-submersible drilling rig or a drill ship. The MODU will be supported by a number of supply vessels and offshore helicopters. Vertical seismic profiling (VSP) activities may also be conducted in conjunction with the drilling activities.

1.2 The Proponent

Corridor, an Eastern Canadian company, is engaged in the exploration for and development and production of petroleum and natural gas resources onshore in New Brunswick, Prince Edward Island and Quebec, and offshore in the Gulf. The company is headquartered in Halifax, Nova Scotia, with a production office for its McCully Field operations in Penobsquis, New Brunswick. Corridor has been producing natural gas from the McCully Field since 2003. In June 2007, following construction of a field gathering system, a gas plant and a pipeline lateral, the McCully Field was connected to markets through the Maritimes and Northeast Pipeline. Corridor safely and successfully conducted seismic programs at Old Harry in 1998 and 2002, a seismic program offshore west coast Cape Breton in 2003 and a geohazard survey at the Old Harry site in the fall of 2010.

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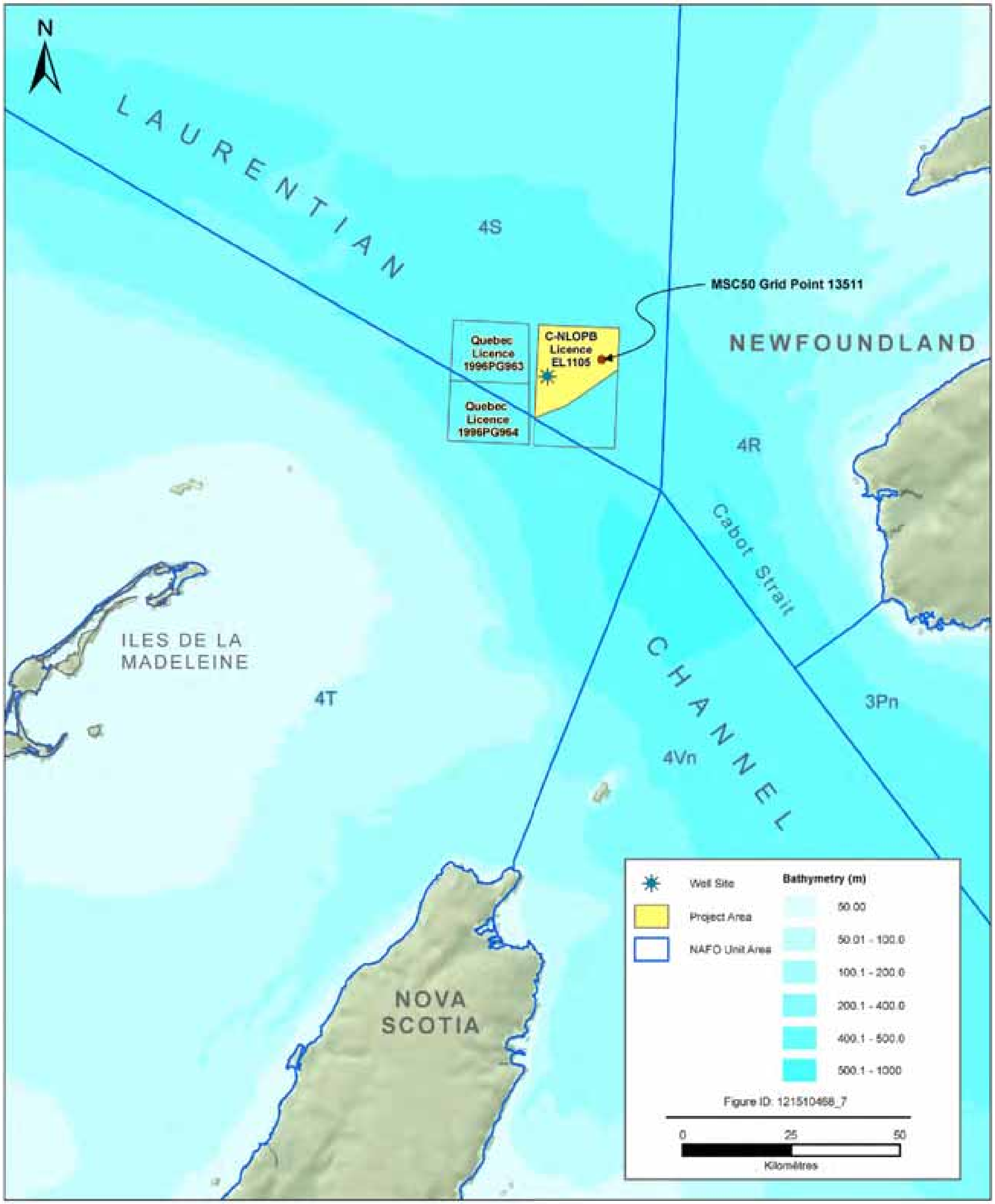


Figure 1.2 Old Harry Prospect Project Area

1.3 Regulatory Context

This exploration well occurs within EL 1105. Therefore, the activities associated with the exploration well will occur within the jurisdiction of the C-NLOPB.

The Project will require authorizations pursuant to Section 138(1)(b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 134(1)(a) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*, collectively known as the Accord Acts. Pursuant to Section 5(1)(d) of the *Canadian Environmental Assessment Act* (CEAA), the C-NLOPB is a Responsible Authority and Federal Environmental Assessment Coordinator and must undertake an environmental assessment of the Project. The environmental assessment will be reviewed by other Responsible Authorities (such as Environment Canada and Fisheries and Oceans Canada (DFO)) and Federal Authorities (such as Department of National Defence (DND)), who have broad knowledge of the Gulf and will provide comment and direction on both the Scoping Document (C-NLOPB 2011a) and the environmental assessment.

The C-NLOPB has appointed an Independent Review that will focus on the potential environmental effects of the proposed drilling of a single exploration well on EL 1105. Public consultations will be held in the five jurisdictions bounded by the Gulf and the Independent Reviewer will present a report to the C-NLOPB at the conclusion of the independent review, which will also be made public by the C-NLOPB.

The C-NLOPB commissioned a Strategic Environmental Assessment (SEA) of the Western Newfoundland Offshore Area (LGL 2005a) and an amendment area (including the Old Harry prospect) (LGL 2007a) prior to the issuance of EL 1105 to Corridor, which included consultation with federal agencies and other stakeholders. On August 15, 2011, the federal Minister of the Environment requested an update of the 2007 SEA for the Western Newfoundland Offshore Area. The C-NLOPB will establish a working group to oversee the process of updating the SEA for the Western Newfoundland Offshore Area, which begins with the development of a scoping document for the SEA. An integral part of the SEA process is public consultation and the C-NLOPB will ensure that this will be conducted as part of the review process. This process will address broader policy issues.

Legislation that is relevant to the environmental aspects of this Project includes:

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

There is no federal funding of this Project. EL 1105 is administered by the C-NLOPB.

A finalized Scoping Document was issued by the C-NLOPB (with input from other regulatory agencies and the public) on August 17, 2011 (Appendix A). This screening-level environmental assessment has been submitted to fulfill the requirements of CEAA and the Scoping Document.

1.4 Rationale for the Project

The long-term goals of the Operator are to:

- conduct a safe and environmentally responsible exploration drilling program on the Old Harry prospect while meeting or exceeding all due diligence requirements;
- undertake the drilling of the Old Harry exploration well through the implementation of industry best practices and adherence to all applicable regulatory requirements and authorization conditions;
- establish and maintain positive relationships with regulators, other stakeholders, suppliers and contractors;
- explore and discover new oil and gas fields in Eastern Canada;
- create long-term benefits and enhance the energy infrastructure for Newfoundland and Labrador and the whole Eastern Canadian region; and
- execute a cost-effective program by phasing capital investment and carefully planning all aspects of the Project.

1.5 Document Organization

The environmental assessment is organized as follows:

- Section 1 introduces the project, proponent, regulatory context and rationale for the Project;
- Section 2 provides a description of the components of the proposed Project;
- Section 3 details the consultation conducted as part of the proposed Project;
- Section 4 describes the existing physical (geology, meteorology / oceanography and sea ice and icebergs) environment setting;
- Section 5 describes the existing biological (species at risk, fish and fish habitat, marine birds, marine mammals and sea turtles, special areas and commercial fisheries and other users) environment setting;
- Section 6 details the methodology used to conduct the environmental effects assessment;
- Section 7 is the environmental effects assessment;
- Section 8 is the accidental events environmental effects assessment;
- Section 9 is the cumulative environmental effects assessment;
- Section 10 provides a summary of the residual adverse environmental effects;
- Section 11 addresses monitoring and follow-up;
- Section 12 describes the potential effects of the environment on the Project;
- Section 13 describes the environmental management for this Project;

- Section 14 provides an overall summary and conclusion; and
- Section 15 provides literature cited in the preparation of the environmental assessment.

2.0 DESCRIPTION OF THE PROJECT

2.1 Background of the Project

The Old Harry Prospect is a large, doubly plunging anticline in the northeastern part of the Gulf approximately 30 km long and 12 km wide.

The southern Gulf is underlain by a large sedimentary basin that is up to 12 km deep and contains all of the necessary components for a viable petroleum system. The basin contains abundant sandstone reservoir rocks, shale and coal for hydrocarbon source rock and numerous geological structures for potential trapping of hydrocarbons. A recent petroleum resource assessment by the Geological Survey of Canada (Lavoie et al. 2009) estimates 39 trillion cubic feet of in-place natural gas and 1.5 billion barrels of in-place oil for the Maritimes Basin, which covers the southern Gulf and adjacent areas. These petroleum resource estimates were made, in part, through the analysis of previously drilled offshore wells in the Gulf.

2.2 History of Hydrocarbon Exploration in the Gulf of St. Lawrence

There is a long history of hydrocarbon exploration in the Gulf, starting with the first offshore exploration well drilled by the Island Development Company in Hillsborough Bay, Prince Edward Island, in 1944. Since that first well was drilled, nine more offshore wells were drilled and thousands of kilometres of seismic data were acquired (Table 2.1). The locations of the previous wells drilled and seismic programs conducted are shown in Figure 2.1. This extensive database of existing seismic and well information highlights the exploration potential of this area.

Table 2.1 Offshore Wells Drilled in the Gulf of St. Lawrence

#	Well	Year Drilled	Total Depth (m)
1	Hillsborough No.1	1944	4,479
2	Northumberland Strait F-25	1970	3,001
3	Cable Head E-95	1983	3,235
4	Beaton Point F-70	1980	1,734
5	East Point E-49	1974	3,526
6	East Point E-47	1980	2,662
7	St. Paul P-91	1983	2,885
8	Cap Rouge F-52	1973	5,059
9	Bradelle L-49	1973	4,421
10	St. George's Bay A-36	1996	3,240
Refer to Figure 2.1.			

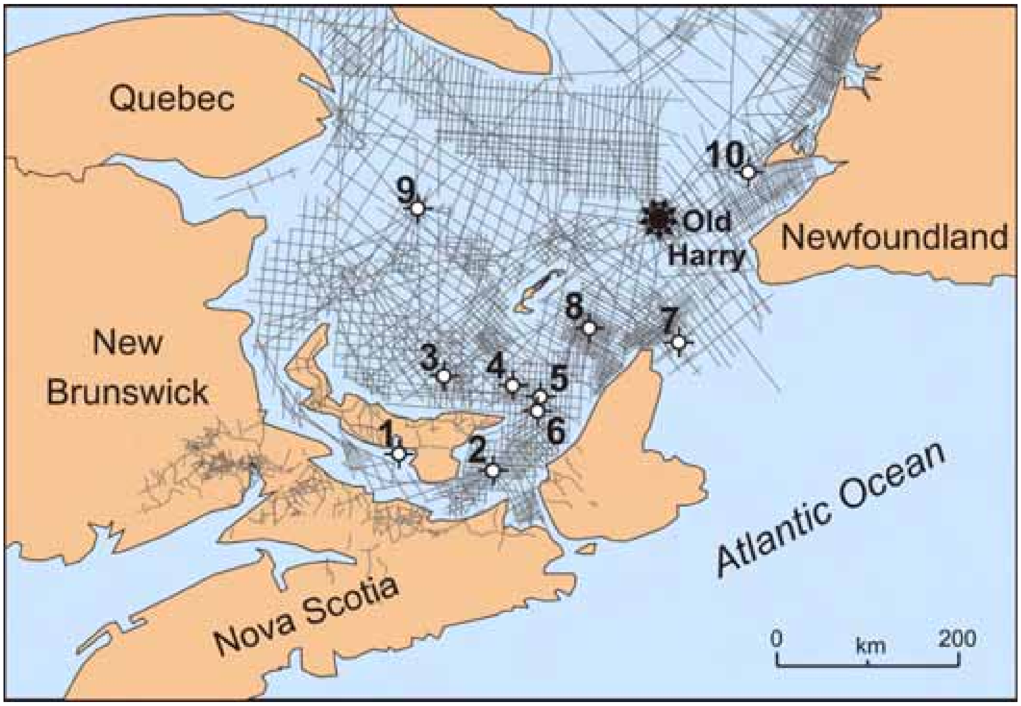


Figure 2.1 Location of Seismic Programs and Wells in the Gulf of St. Lawrence

Most of the offshore wells were drilled in the 1970s and early 1980s (see Table 2.1). At that time, the petroleum companies were seeking oil deposits, whereas the drilling results in the Gulf have yielded indications of natural gas. Of the offshore wells drilled, five yielded no hydrocarbon shows, four had minor natural gas shows, and one well (East Point E-49) was reported as a significant natural gas discovery. A subsequent delineation well at this site (East Point E-47) was unsuccessful and only yielded minor hydrocarbon shows. The most recent drilling in the Gulf occurred in 1996 at the Bay St. George A-36 well. This well was located about 10 km southwest of Cape George and about 120 km northeast of the Old Harry prospect. This well was unsuccessful and was subsequently abandoned.

The southern Gulf is an extremely large area, spanning approximately 600 km in an east-west direction and 300 to 400 km north to south. However, only 10 offshore wells have been drilled in this vast, under-explored area, where the Old Harry prospect is just one of many geological structures with hydrocarbon exploration potential. The results of the 10 offshore wells indicate the presence of a viable petroleum system on the Old Harry prospect. Corridor previously completed an extensive work program at Old Harry to identify a well location, including the collection of 2-D seismic data in 1998 and 2002, as well as a geohazard site survey in October, 2010. Old Harry has multiple drilling targets, the potential for large hydrocarbon resources, and, if results from the exploration well are promising and lead to further activity, the potential to generate substantial economic benefits in Newfoundland and Labrador and the entire Eastern Canadian region.

2.3 Type of Oil Likely to be Found at Old Harry

Ten offshore wells have been drilled to date in the Gulf, an area encompassing approximately 140,000 km^2. Half of those wells encountered non-commercial quantities of natural gas and, with respect to oil, none encountered anything more than oil staining. For reasonable and appropriate oil spill modelling, an oil sample is required to determine the necessary oil properties (e.g., density, viscosity, pour point). Since an oil sample is not available from the Old Harry structure to determine its properties, identification of a suitable surrogate oil is required.

The issue of identifying a suitable surrogate oil was remedied by applying a sequential scientific approach. First, Corridor undertook geochemical studies to identify the types and relative abundance of organic material that is preserved in the shale source rocks in the vicinity of Old Harry. This was followed by petroleum systems modelling to simulate the burial, maturation and generation of hydrocarbons from the organic material, followed by migration and trapping of hydrocarbons at Old Harry. Finally, the geological characteristics of the Old Harry area were compared to other areas with similar geological characteristics to identify a suitable surrogate for the hydrocarbons potentially trapped at Old Harry.

2.3.1 Geochemical Studies of Old Harry Source Rocks

Corridor hired an independent world-renowned organic geochemistry consultant (Dr. Prasanta Mukhopadhyay of Global Geoenergy Research) to complete geochemical studies of rock samples from the source rocks in the Brion Island No. 1 well, which is the closest well to the Old Harry prospect; located approximately 70 km to the west. The geochemical studies included measurements of total organic carbon (TOC), hydrogen index (HI) values (from Rock-Eval pyrolysis) and thermal maturity (vitrinite reflectance and thermal alteration index values). In addition, a scanning organic facies assessment (manual examination and classification of organic material using a high-powered microscope) was completed to determine the type of organic material in the source rocks. The results of geochemical analyses for 16 rock samples from the Brion Island well are provided in Table 2.2.

The first two columns in Table 2.2 indicate the depth of the rock sample studied in either feet (column 1) or metres (column 2). Column 3 shows the thermal maturation data with values that range between 0.6 to 1.0 percent Ro and show an advanced stage of thermal maturation. These sediments fall within the present day main phase of oil (oil window) to early condensate generation (gas window; see column 11). Columns 4 and 5 show the main geochemical results of the TOC, the HI and the production index. The interpretation of the present day TOC (ranges from 0.34 to 1.60; column 4) and HI values (ranges from 7 to 123 mg hydrocarbon (HC)/g TOC; column 4) would typically indicate a moderately organic-rich gas-prone Type III kerogen that is likely to generate only natural gas. However, a more in-depth investigation into the type of organic facies deposited in the rocks reveals a more oil-prone organic material.

Table 2.2 Reconstruction of Original Total Organic Carbon and Hydrogen Index Based on Organic Facies, Present Total Organic Carbon/Rock-Eval and Production Indices of the Brion Island #1 Well

Depth (ft)	Depth (m)	% Ro (Mean)	Present TOC/HI	Prod. Index	Scanning Organic Facies Assessment (approximate percentages; qualitative determination)	SR condition	Original TOC/HI	Kerogen Type	Maturity	HC Zones
4080	1252	0.58	0.34/18	0.5	mixtures of 50% spore, suberin, algae; 50% vitrinite + inertinite	depleted	1.0/225	II-III	mature	oil
4410	1353	0.64	0.36/33	0.33	mixtures of 30% spore, suberin, algae; 70% vitrinite + inertinite	depleted	0.8/150	II-III	mature	oil
4990	1531	0.71	1.09/91	0.12	mixtures of mainly 40% suberin, spore; 65% vitrinite + inertinite	depleted	2.0/200	II-III	mature	oil
5060	1552	0.75	1.6/123	0.06	mixtures of 50% cuticles and algae; 50% vitrinite + inertinite	depleted	2.5/250-300	II-III	mature	oil
5500	1687	0.8	1.51/64	0.11	mixtures of 60% AOM 2, spore, resin, algae; 40% vitrinite + inertinite	depleted	3.0/250-300	II-III	mature	oil
5690	1746	0.86	1.03/67	0.14	50% exinite; 10% algae; 10% AOM 2; 30% vitrinite + inertinite	depleted	2.5/250	II-III	mature	oil
5770	1770	0.86	0.73/45	0.15	20% exinite; 5% algae; 5% AOM 2; 70% vitrinite + inertinite	depleted	2.0/150-200	II-III or III	mature	oil
5930	1819	0.84	1.54/68	0.1	70% exinite; 5% algae; 5% AOM 2; and 20% vitrinite + inertinite	depleted	2.5/250-300	II-III	mature	oil
6760	2074	0.92	0.95/73	0.12	60% exinite; 5% algae; 5% AOM 2; and 30% vitrinite + inertinite	depleted	2.5/250	II-III	mature	oil
7030	2156	0.93	1.16/42	0.08	40% exinite; 5% algae; 5% AOM 2; 40% vitrinite + inertinite; 10% bitumen	depleted	2/150-200	II-III	mature	oil
7300	2240	0.9	0.58/19	0.21	30% exinite; 25% AOM 2; 20% vitrinite + inertinite; 10% bitumen	exhausted	2/200-250	II-III	mature	oil
7410	2273	0.94	0.96/53	0.12	50% exinite; 10% algae+AOM 2; 30% vitrinite + inertinite; 10% bitumen	exhausted	2/200	II-III	mature	oil
8370	2568	0.94	0.60/13	0.27	30% exinite; 15% AOM 2; 1-5% algae; 44-40% vitrinite + inertinite; 10% bitumen	exhausted	2/200-250	II-III	mature	oil
8570	2629	1.02	0.55/22	0.37	30% exinite; 25% AOM 2; 5% algae; 30% vitrinite + inertinite; 10% bitumen	exhausted	2.0/200-250	II-III	mature	condensate
8710	2672	1.05	0.59/19	0.31	20% exinite; 15% AOM 2; 45% vitrinite + inertinite; and 20% bitumen	exhausted	2.5/250	II-III	mature	condensate
8890	2727	1.08	0.34/7	0.43	30% AOM 2; 10% algae; 10% exinite; 30% vitrinite + inertinite; 20% bitumen	exhausted	3/250-300	II-III	mature	condensate

% Ro = mean random vitrinite reflectance for autochthonous vitrinite grains (main maturity)

TOC: total organic carbon content in wt %; **HI** = hydrogen index in mg HC/g TOC determined from Rock=Eval Pyrolysis

Prod. Index = production index (ratio of S1 and C2 curves) determined by Rock-Eval pyrolysis

exinite = exine rich organic components includes spore (sporinite), cutin (cutinite), and suberin (suberinite) - various lipid components derived from plants

AOM 2 = amorphous organic matter type 2 variety that are oil prone

Bitumen = solid bitumen - a secondary hydrocarbon transformation products derived from primary macerals (phytoclasts)

Original TOC/HI = the original TOC and HI was calculated based on present day TOC and HI, production indices, and organic facies reconstruction

Column 6 in Table 2.2 shows the results of the scanning organic facies assessment. The majority of the organics were derived from a terrestrial source (exinites and vitrinites). Vitrinite is basically the woody portion of plants and is generally by far the most abundant organic material in terrestrially-derived source rocks. Vitrinite is gas-prone Type III organic matter. However, in some deltaic deposits such those identified at Old Harry, much less vitrinite is deposited and the terrestrial lipid (oil- and gas-prone) organic components (exinites) can be dominant. These terrestrial lipid components are mainly Type II-III suberinite (plant suberin), resinite (plant resin) and cutinite (plant cuticles). These types of organic material usually generate liquid hydrocarbons within C17 to C27 normal alkanes during the early stages of thermal maturity (oil window) and, like all organics, will generate natural gas at higher stages of thermal maturity (gas window).

Other less abundant organic material found in the Brion Island source rocks is Type II amorphous liptinite (biodegraded algae). Together, all of the organic material in the Brion Island well form a Type II-III condensate-, oil- and gas-prone source rock. The C30+ hydrocarbons (mainly wax and asphaltene components) that are usually present within the botryococcus type lacustrine algae are absent in the various source rocks in the Brion Island well. These data suggest that asphaltene or wax-rich heavy oil is very unlikely at Old Harry because of the organic facies (nature of the terrestrial lipids) of the major source rocks and their thermal maturity.

Given that these rocks are greater than 250 million years old, it is reasonable to expect that at least some hydrocarbons would have been generated over geologic time. This is confirmed by the high production index. The various geochemical and organic facies data were assessed to determine the present-day condition of the source rocks, and column 7 lists the source rock condition. The fluorescence characteristics of the source rocks in the Brion Island well indicate that they have been depleted in liquid hydrocarbons. In general, the source rocks from the Brion Island well are depleted of their hydrocarbon generation potential above approximately 2,200 m depth and those below 2,200 m are exhausted. Since these source rocks are depleted or exhausted, the original source rocks prior to burial and thermal maturation would have had higher TOC and HI values. Therefore, the original TOC and HI values were recalculated on the basis of maturity, present day TOC, HI and production index values, and the scanning organic facies data. The recalculated values are presented in column 8 of Table 2.2.

2.3.2 Petroleum Systems Modelling

The organic facies and geochemical data were integrated with the interpreted 2-D seismic reflection data to develop a series of 2-D Petroleum System Models of the Old Harry structure. The Petroleum System Modelling was completed using the PetroMod 2D modelling software (version 11.04; Patch 3) of IES GmbH, Aachen, Germany (currently of Schlumberger Incorporated). A key part of petroleum systems modelling involves determining the development of the Old Harry structure through geologic time, including the stratigraphy, burial history, heat flow, hydrocarbon migration paths and other geological and geochemical information. The modelling incorporated the following information:

- lithology for each stratigraphic unit based on the Brion Island well and 2-D seismic interpretation;
- timing of erosion, palaeowater depths, and palaeotemperature (through time) from biostratigraphic analysis;
- heat flow in relation to basement structures;
- the hydrocarbon reservoirs and seals in relation to the structure;
- organic richness of various source rock intervals and hydrocarbon potential (HI values in mg HC/g TOC);
- trends of palaeoheat flow, palaeowater depths, and palaeotemperatures;
- multi-component kinetics of selected default source rocks; and
- oil and gas properties for each individual source rock, based on compositional analysis using pyrolysis-gas chromatography (Mukhopadhyay 2006) and the PetroMod 2D software database.

The stratigraphy, timing of sediment deposition, erosion, salt migration, folding and faulting were determined based on the interpretation of 2-D seismic reflection profiles. The seismic data were correlated to the Brion Island well to facilitate the identification of source rocks, reservoir and shale seal rocks. The stratigraphic ages of the individual formations were determined using the International Geological Time Scale of Ogg et al. (2008) and Giles and Utting (2003).

The palaeowater depth and palaeowater temperatures for each formation were incorporated in the models. The thermal maturity data (vitrinite reflectance and thermal alteration index values) indicates that the majority of the source rocks from the Brion Island #1 well are between 0.6 to 1.0 percent Ro (column 3 in Table 2.2). The calibration of the heat flow model used the measured vitrinite reflectance data points and their corresponding trend as seen in the Brion Island well. The heat flow calibration was later corroborated by one measured bottomhole temperature and Apatite Fission Track analysis by Grist et al. (1995).

As described above, the original TOC and HI values were recalculated on the basis of maturity, present day TOC, HI and production index values and the scanning organic facies data. Based on the early oil generation potential as seen from the scanning organic facies data, a range of source rock kinetics were selected for modelling. The kinetics of a source rock describes the generation of hydrocarbons from the source rock during thermal maturation (i.e., when hydrocarbons are generated, what volume and whether oil or gas is generated). Three different classes of modelling simulations were completed to test the range of hydrocarbons that could be generated at Old Harry:

a. IES Gmbh default kinetics of kerogen Type II-III Monterrey source rock and Taranaki Basin Type II-III source rock;
b. Mahakam Delta Type III kinetics and Taranaki Basin kerogen Type II-III kinetics; and
c. IES default kinetics of kerogen Type II-III Monterrey source rock and Taranaki Basin Type II-III; however, higher TOC and HI values were used for source rocks in the deep basin to the south of the Old Harry structure.

The results of this modelling indicate that, at the present stage of thermal maturation of the source rocks, the hydrocarbons within the Old Harry structure, if present, are likely to comprise a very light, 45 to 56° API gravity oil with low to moderate gas-oil ratio. In fact, none of the model simulations indicated that the gravity of the hydrocarbons would be less than 50° API; however, oils with an API gravity of 45 to 56° API were included as a conservative estimate of the range of predicted hydrocarbons at Old Harry.

Various input parameters for the models were modified for each simulation to assess the change in hydrocarbon composition and saturation in the Old Harry reservoirs. The API gravity of the modelled hydrocarbons for all model simulations consistently fell within a narrow range, indicating the robust model results irrespective of variations in TOC and HI. However, it should be noted that increases in Type III kerogen relative to Type II kerogen in the modelled source rocks tends to decrease the amount of liquid hydrocarbons (oil) and increase the amount of gas, while the API gravity of the hydrocarbon liquids remains within the modelled range.

Note that the modelling cannot confirm that a structure is trapping and therefore the structure may contain no hydrocarbons and only water. As well, if hydrocarbons migrate from deeper within the basin where the organics are in the gas window, the structure could potentially be filled with natural gas.

2.3.3 Identification of Surrogate Oil

Petroleum Systems Modelling identified the potential range of hydrocarbons that could be trapped at Old Harry and the next step was to identify an appropriate surrogate oil for use during oil spill modelling. Corridor considered geological parameters such as depositional environment, the type of organic material (kerogen) and types of hydrocarbons encountered in several areas. Although only natural gas has been encountered in offshore Gulf wells, high API gravity oils have been identified in Gaspé (47° API), Port-au-Port, Newfoundland (51° API) and the Scotian Shelf (47 to 52° API). Several characteristics of the geology in the Maritimes Basin (Old Harry area) compare favourably to the geological conditions encountered in the Scotian Basin. as shown in Table 2.3. The clastic reservoir rocks in the fields on the Scotian Shelf typically comprise fluvial and shallow marine, stacked, sandstone sequences that are analogous to the fluvial sandstone reservoir rocks at Old Harry. Of particular note is the known kerogen type in both basins is Types II-III and III. In addition, light oil was produced from the Cohasset / Panuke / Balmoral Fields on the Scotian Shelf (Kidston et al. 2005). Consequently, Corridor geoscientists have selected the Cohasset oil from the Scotian Basin as an appropriate surrogate for the oil that could be found at Old Harry.

Table 2.3 Comparison of Geologic Characteristics of the Maritimes and Scotian Basins

Characteristic	Maritimes Basin (Old Harry)	Scotian Basin
Tectonic Environment	Strike-Slip Rift	Extensional Rift
Depositional Environment	Fluvial-Deltaic	Fluvial-Deltaic to Shallow Marine
Kerogen Type	Types II-III and III	Types II, II-III and III
Hydrocarbon Types	Natural Gas and Light Oil	Natural Gas and Light Oil

2.4 Location and Water Depth

The proposed Project Area is located approximately 80 km west-northwest of Cape Anguille, Newfoundland and Labrador (see Figure 1.1). The Project Area is located within a physiographic feature called the Laurentian Channel. Water depths in the area are approximately 470 m.

2.5 Alternatives to and Within the Project

The alternative to this Project is to not drill on EL 1105. However, Corridor has been awarded rights to explore on EL 1105 through a regulated competitive bidding process and seeks to fulfill its commitments made as a part of the licencing process within the remaining time window.

Alternate means to be evaluated within the Project include the use of a semi-submersible drilling rig or a drill ship, both of which are considered MODUs. A harsh-environment jack-up rig is typically limited to water depths of approximately 120 m off the east coast of Canada and therefore will not be considered within this Project. Additional information regarding MODUs is provided in Section 2.7.

Other alternatives to be considered will be the drilling program, selection and use of drilling fluids, supply base location, helicopter support base location, waste management and program timing. Selection of the alternatives for the program will be guided by a consideration of safety, environmental, technical, community and economic factors.

2.6 Project Scheduling

This well is anticipated to take between 20 to 50 days to drill and will occur when there is no ice present in the Gulf. If testing is conducted, the rig will spend up to several additional weeks on location. The temporal scope of the environmental assessment is year-round to allow flexibility in the event of an ice-free year. If this well provides encouraging results, a follow-up exploration program, including a seismic program or another exploration well, may be developed for EL 1105 or Corridor's other Old Harry Oil and Gas Research Permits. Corridor intends to drill one exploration well between 2013 and 2014, with the specific timing dependent upon rig availability and regulatory approvals. Although the Project Description indicates a drilling start date as potentially mid-2012, this date is no longer achievable due to the implementation of the Independent Review process by the C-NLOPB for this screening-level environmental assessment.

All activities in EL 1105 will be conducted in accordance with stringent oil and gas regulatory requirements for working offshore Newfoundland and Labrador.

2.7 Project Personnel

The Project will be managed out of an office in Newfoundland and Labrador where the Project Team will be located and key decisions will be made. The drilling activities will be managed by a Drilling Manager located in this office. The Drilling Manager will have the authority to effectively manage the operational aspects of the Project. Day-to-day drilling operations will be directed by the Operator's drilling superintendents. Offshore, the management team consists of the Senior Drilling Supervisors (Operator's offshore representative), the designated Offshore Installation Managers and Supply Vessel Masters.

2.8 Mobil Offshore Drilling Units

For this environmental assessment, it is necessary to describe and consider two MODU types because rig and contractor selection is still in progress. While there are differences among the rig types, drilling, testing, well abandonment / suspension and discharges and emissions considerations are similar.

Drilling may be conducted from an anchored semi-submersible, a dynamically-positioned (DP) semi-submersible rig or a DP drill ship. Rig selection will be based on the characteristics of the well site, physical environment, well site water depth, expected drilling depth, logistical considerations, and the mobility required based on well site weather and ice conditions (Canadian Association of Petroleum Producers (CAPP) 2001a), as well as other safety and environmental performance criteria.

A semi-submersible is a MODU where the drilling platform sits atop steel pontoons that are ballasted with water so that the unit floats with the main deck above water and the remainder below the water surface. Semi-submersibles are towed to the drilling site and are either moored to the bottom (with a series of 8 to 16 anchors which may extend up to 1 to 2 km from the rig) or are kept on station using a DP system (computer-controlled thrusters) in deeper waters (300 to 3,000 m). The maximum water depth is a function of many rig design criteria, including the length of the rig's riser, the main pressure containing pipe that runs from the blow-out preventer (BOP) on the seafloor to the MODU and through which drilling fluids and other material are conducted.

A drill ship is a MODU where a maritime vessel has been fitted with a drilling platform and station-keeping equipment. The vessel transits to location on its own power and is usually kept on location through a DP system.

These MODUs (semi-submersible and drill ship (Figure 2.5)) are self-contained units, with derrick and drilling equipment, a moon pool, a helicopter pad, fire and rescue equipment and crew quarters. The operations and discharges are similar for both drilling units. While there are differences between rig types with respect to capabilities, treatment facilities and effluent discharge depths, the characteristic volumes and types of waste streams are similar among drill units.

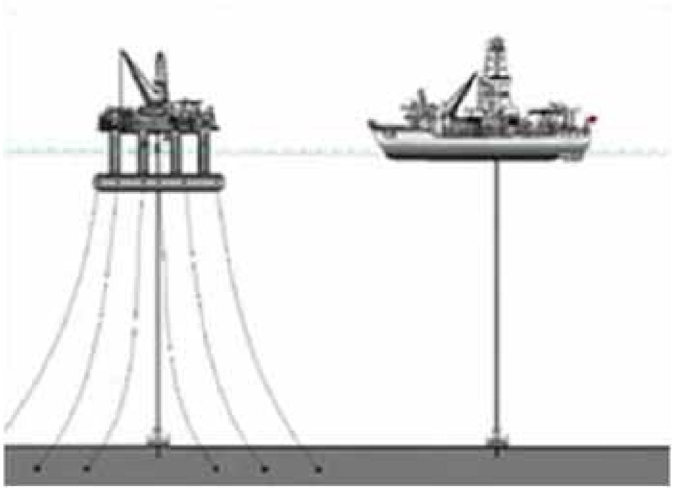


Figure 2.2 A Moored Semi-submersible and a Dynamically-positioned Drillship

2.9 Logistic Support

The Island of Newfoundland will be the base of operation and support centre for the Project. The Operator will engage a drill rig, supply vessels, helicopter and related goods and services on a direct hire or a contractual basis. To support these resources, the Operator will acquire marine support base, logistics and telecommunications services including, but not necessarily limited to, support vessels, meteorological and oceanographic services and emergency response services from third-party providers. All such goods and services will be acquired through a formal competitive process to the extent possible, which will be executed over a period of several months. The Operator will ensure that all selected contractors will meet the stringent competency requirements for working in the Newfoundland and Labrador offshore oil and gas sector.

2.9.1 Shorebase Facilities

The existing infrastructure and activity in Atlantic Canadian harbours enables the petroleum industry to optimize the use of supply vessels and other logistic assets. Existing facilities are capable of servicing multiple operations with the current infrastructure, including office space, crane support, bulk storage and consumable (fuel, water) storage and delivery capability. Additional harbours, which are not currently used by the industry but may be closer to the location of operations, will be investigated for suitability to supply the services necessary to support an offshore supply base. Warehouse facilities will be provided by third-party contractors as required and will consist primarily of storage for tubular goods and the equipment belonging to the drill rig, which can be stored onshore.

Operation and coordination service of all aeronautical and marine voice and data communication services will be provided from a central facility by a third-party contractor. The primary communications link between the drill rig and the Project Operations office will be via a dedicated satellite service. Independent backup communications systems will be provided by high quality high-frequency radio service, available through the coastal radio station.

2.9.2 Marine Support Vessels

Supply / standby vessels will be Canadian flagged and Canadian crewed and will be managed from the contractors' offices in Atlantic Canada. Letters of Compliance for each chartered supply / standby vessel will be in place prior to the onset of work. The vessels will be comparable to those presently operating on the Grand Banks in terms of power and capabilities. The supply boats (anchor-handling type) will have a range of 12,000 to 15,000 HP and be capable of storing and delivering drilling fluids, casing, deck cargo, water, cement, diesel fuel, and other bulk commodities. The vessels will be used for re-supply and safety standby. It is anticipated that two to three support vessel trips will be required per week. Any support vessels that may come from St. John's, NL, will use the recognized shipping lane through the Laurentian Channel.

2.9.3 Helicopter Support

Corridor is cognizant of the recent Offshore Helicopter Safety Inquiry report issued by Commissioner Robert Wells, Q.C., and the Transportation Safety Board of Canada's Aviation Investigation Report. Typical helicopter support for the Project may involve Sikorsky S-92, Sikorsky S-61 or Eurocopter AS332 aircraft. Auxiliary flight services, including First Response Equipment and technicians, alternate landing site facilities, weather station, aviation fuel, helicopter passenger transportation suits, aircraft maintenance, passenger loading terminal, and flight following services will be arranged. Contract helicopter support will be provided by offshore-rated helicopters. The helicopter contractor will also provide all auxiliary flight services for search and rescue, First Response equipment and technicians, alternate landing sites complete with weather station, aviation fuel, helicopter passenger transportation suits and an aircraft maintenance and passenger loading terminal located in Atlantic Canada. Several existing heliport locations will be investigated, as well as potential new locations in existing airports closer to the offshore operation. Helicopter support of approximately three trips per week will be required to transport personnel and light supplies and equipment.

2.10 Project Activities

A MODU will be contracted to drill one well within EL 1105. The MODU will be supplied and supported by vessels operating from a shorebase facility with the capability of storing and delivering drilling supplies, including drill fluids, casing, deck cargo, water, cement, diesel fuel and other bulk commodities including provisions.

Well design is currently in development, with some preliminary design information provided in Section 2.9.2. The actual hole sizes and casing setting depths will be finalized for the specific well requirements and design criteria.

Following completion of the exploration well, well abandonment / suspension will be conducted in accordance with recent *Drilling and Production Guidelines* (C-NLOPB and Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) 2011) and the *Newfoundland Offshore Petroleum Drilling and Production Regulations* (SOR/2009-316) under the *Canada-Newfoundland Atlantic Accord Implementation Act*.

2.10.1 Project Components

The Project will consist of the activities associated with a one well exploration program within EL 1105. These activities include the mobilization of a MODU and the drilling, evaluation and subsequent abandonment / suspension of the well. The evaluation of the well may occur over a few stages and could include wireline logging, VSP and well testing activities at a later date.

2.10.2 Exploration Drilling

The potential reservoir targets at the Old Harry structure are located between 850 and 2,000 m below the seafloor. The well would be started with a conductor hole either drilled or jetted to reach a depth typically 90 m below the seafloor (BSF). Following the cementing of this conductor pipe, a surface hole would likely be drilled without a marine riser to a depth between 300 to 600 m BSF and cemented back to the seafloor. The high-pressure wellhead housing would be run on this string of pipe, facilitating the installation of the subsea BOPs. These two strings of steel pipe provide the structural support for the remainder of the drilling, as well as the pressure integrity required to reach the desired targets. The drilling fluids used from this point forward will be maintained as a closed loop system, with all fluids returned to the drilling unit through the BOPs and marine riser that connects the rig to the BOPs.

The intermediate hole would then be drilled to reach just above the upper reservoir targets and casing would be installed at this point. The final hole section to be drilled to total depth of the well would be the main hole section. A suite of evaluation logs would be run to gather data to confirm the presence of significant hydrocarbons. If the reservoir targets are hydrocarbon-bearing, a final production casing string or liner may be installed to enable future testing or production from the wellbore. If the well is deemed to be unsuccessful, it may be abandoned without the installation of the final string of casing / liner and the open hole abandoned using appropriate cement plugs in accordance with the *Drilling and Production Guidelines* (C-NLOPB and CNSOPB 2011).

An example hole size and casing profile for the Old Harry well is provided in Table 2.3. This design will be finalized as the engineering of the Project progresses.

Table 2.4 Description of Example Drill Hole and Casing Sizes

Hole Section	Hole Size (mm)	Casing Size (mm)	Setting Depth (m BSF)	Drilling Fluid Type	Drilling Fluid Return
Conductor	914	762	90	Seawater	Seafloor
Surface	660	508	300 to 600	Seawater with sweeps	Seafloor
Intermediate	444 to 311	340 to 245	800 to 1,200	WBM (SBM)	Drilling Rig
Main / Production	311 to 216	245 to 178 (liner)	2,000 to 2,200	WBM (SBM)	Drilling Rig

2.10.3 Vertical Seismic Profiling

VSP using an air-source array from a support vessel may be conducted as part of the exploration activities. The air-source array is similar to that employed by 2-D or 3-D seismic surveys, but is usually smaller and deployed in a small area for a limited amount of time (several days). An application for VSP activities may be included with the application to drill a well. For all geophysical surveys, the Operator will adhere to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011b).

2.10.4 Well Testing

A Well Data Acquisition Program will be submitted to the C-NLOPB in support of the well approval at least 21 days prior to the anticipated spud date. There is no regulatory requirement to test the exploration well. The Operator will include in the Well Data Acquisition Program its intention with respect to testing; however, the final decision to test, suspend or abandon the well will only be made once the well has been drilled to total depth and the initial geological evaluation completed. The decision to test a well is dependent on the quality, quantity and content of the hydrocarbon-bearing formations encountered. If well testing is warranted, the Operator could suspend the well and return to the location at a later date with all the necessary equipment.

During typical well testing operations, downhole test tools complete with perforating guns are run into the cased wellbore. There are additional tools placed across the subsea BOPs to ensure well control is maintained at all times. Once the well has been perforated, reservoir fluids are allowed to flow up the test string in the wellbore (tubing or drill pipe) to the deck of the drilling unit. On the deck of the rig, a temporary flow testing facility will have been installed, pressure and function tested, and certified to handle the flow of the fluids from the wellbore in a controlled manner. These fluids may contain hydrocarbons (oil and gas) and/or formation water. The hydrocarbons are measured and separated from the produced water in the test package. Hydrocarbons and small amounts of produced water are flared using high-efficiency burners to combust the hydrocarbons and minimize emissions. If produced water occurs, it will either be flared or treated in accordance with the *Offshore Waste Treatment Guidelines* (OWTG) (National Energy Board (NEB) et al. 2010) prior to ocean discharge. Once the testing is complete, the test string is removed from the well and, depending upon the results of the test, the well is either suspended or abandoned in accordance with the *Newfoundland Offshore*

Petroleum Drilling and Production Regulations (SOR/2009-316). If a well is suspended, the well will be left in a safe state to prevent hydrocarbons from flowing out of the well until the well is re-entered in the future for additional testing or long term production.

2.10.5 Well Abandonment / Suspension

Depending on the preliminary information received during drilling, the exploration well may be suspended for future re-entry. The wellbore is plugged below the seafloor using mechanical and/or cement plugs in accordance with the *Drilling and Production Guidelines* (C-NLOPB and CNSOPB 2011). A suspension cap is installed to protect the wellhead connector for potential future re-use.

If the offshore well is abandoned, the wellhead may be removed or in some cases, approval may be granted for leaving the wellhead in place. When the wellhead is removed, the wellhead and associated equipment are removed to at least 1 m BSF. This is typically performed using mechanical cutters from the drilling unit. However, there are cases that require subsea cutting involving the use of shaped explosive charges. This option is employed only in instances where mechanical removal has failed. It is a requirement that operators have authorization from C-NLOPB before shaped charges are used. If approval is granted for leaving a wellhead in place, several factors are considered, including the occurrence and type of fishery in the area, as well as water depth at the location of the wellhead.

2.11 Waste Discharges, Air Emissions and Treatment

All discharges from the rig will be managed in compliance with the OWTG. Other requirements may be attached to individual authorizations from the C-NLOPB. Details are provided in the following sections on the discharges associated with exploratory drilling operations, which include drill muds and cuttings, produced water, grey and black water, ballast water, bilge water, deck drainage, discharges from machinery spaces, cement, BOP fluid (glycol / water) and air emissions.

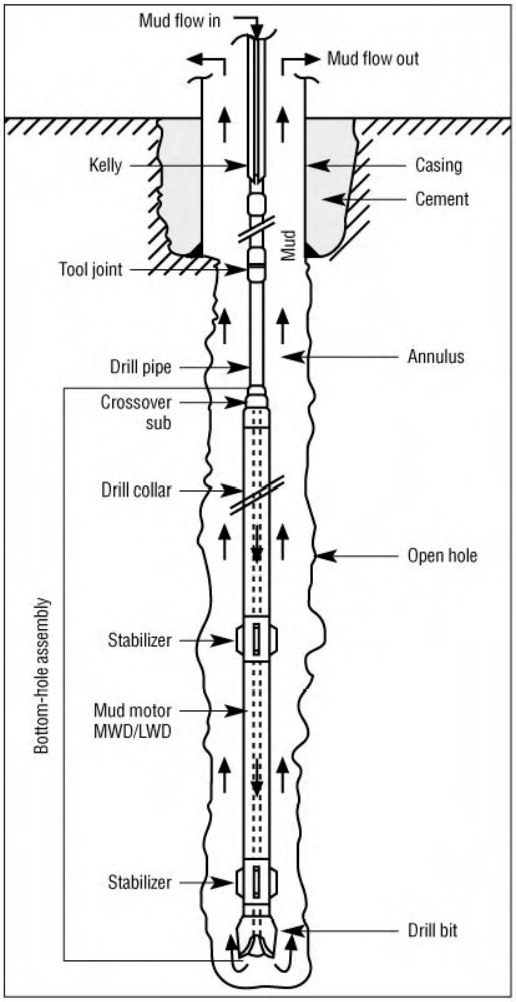
2.11.1 Drill Mud and Cuttings

The well at EL 1105 is planned to be drilled to depth using water-based mud (WBM). However, it is recognized that during the drilling, conditions may be encountered (e.g., wellbore instability and formation damage concerns) that necessitate the use of synthetic oil-based mud (SBM). Therefore, the environmental assessment for EL 1105 considers the use of both WBM and SBM.

The drill bit cuts the formation rock, producing drill cuttings, resulting in the creation of the well bore. Drill mud is circulated through the drill pipe and out through small jets or holes in the drill bit. The velocity and viscosity of the mud flushes drilled cuttings away from the bit, transporting them to the surface through the annulus, as illustrated in Figure 2.6 (CAPP 2001a).

At pre-determined intervals as described in Section 2.10.2, steel casing is cemented into the wellbore (see Figure 2.6), thereby providing a conduit that returns muds and cuttings to the drill unit for treatment. Drilling mud is removed from the cuttings in a series of successive separation phases that may use shakers, hydrocyclones and/or centrifuges. The cleaned cuttings are then discharged overboard via a cuttings chute. Drill mud is recovered and reconditioned for reuse as much as possible. However, some mud will remain on the drill cuttings and be discharged. Discharged drill cuttings are required to meet the limits outlined in the OWTG for the disposal of drill solids (no limit for WBM cuttings, 6.9 g of mud or less/100 g of cuttings for SBM cuttings overboard discharge).

The total volume of cuttings and drill mud discharged will be dependent upon the wellbore depth and drilling conditions encountered. Drilling of conductor and surface hole locations tend to be drilled with sea water and small amounts of WBM, with mud and cuttings discharged to the seafloor. For this well, the intermediate and production hole sections are planned to be drilled with WBM in a closed loop system, using a marine riser from the seafloor back to the drilling unit. SBM may be used, if it is required for wellbore integrity and safe drilling practices. The exploration well is planned to be drilled vertically. If drilling requires the use of SBM, the SBM will be recycled, reused and brought to shore for disposal when spent.



Source: CAPP 2001

Figure 2.3 Drill String Components Illustrating Drill Mud Circulation

The muds and the cuttings are dispersed in the water column and settle to the seabed, with heavier cuttings and particles settling near the well bore and the fines dispersed at increasing distances from the MODU. The dispersion pattern for muds and cuttings is irregular, largely dependent on water depth and current direction, as well as discharge intensity. Drill mud and cuttings and their potential environmental effects have been discussed in several studies (Husky 2000, 2001; CAPP 2001a; Hurley and Ellis 2004) and all confirm that exploratory drilling has no measureable environmental effect on the marine environment.

2.11.1.1 Water-based Muds

WBM employs freshwater or brines (salt water) as the continuous liquid phase and the solid phase is generally composed of barite, bentonite or other clays, silicates, lignite, caustic soda, sodium carbonate / bicarbonate, inorganic salts, surfactants, corrosion inhibitors, lubricants and other additives for unique drilling problems (Thomas et al. 1984; GESAMP 1993). The constituents of muds are screened via the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands* (NEB et al. 2009). Composition of an example of a typical WBM formulation is presented in Table 2.4. Spent and excess WBM may be discharged as per the OWTG.

Table 2.5 Example of Drilling Fluid Components and Drill Cuttings Discharge

	Unit	Conductor	Casing Strings		
			Surface	Intermediate	Main
Hole Section	mm	914	660	445	311
Drilling Fluid System		Seawater / Gel	Seawater / Gel	WBM	WBM
Depth (See Notes)	M BSF	±90	±320	±850	±2,100
Volume Usage	m^3	340	530	765	±600
Wash Out	%	50%	30%	20%	10%
Products					
Barite	MT	150	100	20	20
Bentonite	MT	50	100	-	-
Caustic	kg	250	350	450	350
Fluid Loss Agent	kg	-	-	3,200	1,700
Potassium Chloride	kg	-	-	87,500	67,500
Glycol Inhibitor	L	-	-	23,000	18,700
Soda Ash	kg	250	375	500	375
Viscosifier	kg	-	1,135	3,400	2,835
Biocide	L	-	-	800	800
Drilled Cuttings	kg	240,000	300,000	257,000	282,000
Volume of Cuttings	m^3	90	110	95	105

Notes:
1. The information provided is an example of a potential well design scenario. This will be finalized in the detailed design.
2. 914 mm (36-inch) and 660 mm (26-inch) hole sections will be drilled without a marine riser. It will have near seabed discharge of cuttings.
3. WBM is planned for the complete well.
4. The average water depth in the Project area is assumed to be 470 m.
5. All depths are measured bsf as the planned MODU has yet to be determined.

2.11.1.2 Synthetic-based Muds

SBM refers to a water-in-oil emulsion whose continuous phase is composed of one or more fluids produced by the reaction of a specific purified chemical feedstock, rather than the physical separation processes such as fractionation, distillation and minor chemical reactions. The synthetic-based fluids used in the preparation of SBMs are water insoluble and, as such, the SBM does not disperse in water in the same manner as a WBM (Hurley and Ellis 2004). The discharge of whole SBM is not permitted. SBM cuttings may be discharged provided they do not exceed 6.9 g/100 g time weighted average of oil on wet solids (see Section 2.4 of the OWTG).

The most commonly used SBM on the Grand Banks uses PureDrill IA-35 as the base fluid, together with weighting agents, wetting agents, emulsifiers and other additives. The SBM PureDrill IA-35 that is used on the Grand Banks is classified as a high purity synthetic alkane consisting of isoalkanes and cycloalkanes (Williams et al. 2002). PureDrill IA-35 has undergone an evaluation using the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands* (NEB et al. 2009). The fluid was screened from a facility, human health and environmental perspective (Williams et al. 2002). PureDrill IA-35 base oil is a component of a whole mud system called ParaDrill that received a Group E classification by the Offshore Chemical Notification System classification system used in the UK. The Group E classification is the best rating achievable under the Offshore Chemical Notification System and is assigned to chemicals that have relatively low toxicity and/or does not bioaccumulate or readily biodegrades. The formulation of ParaDrill-IA is presented in Table 2.5. If required for this program, a similar mud would be used for this Project.

Table 2.6 Composition of ParaDrill-IA

Component	Purpose
PureDrill IA-35	Base Fluid
NOVAMULL	Primary Emulsifier
NOVAMOD L	Rheology Modifier
NOVATHIN L	Thinner
MI-157	Wetting Agent
HRP	Rheology Modifier
TRUVIS	Viscosity
VERSATROL	Filtration Control
ECOTROL	Filtration Control (Alternative)
Lime	Alkalinity
Calcium Chloride	Salinity
Water	Internal Phase
Barite	Density
Source: Williams et al. 2002, in LGL Limited 2005a.	

2.11.2 Cement

The upper reaches of a well may be drilled into sediments with no casing by a process referred to as ‘spudding’. The drill string is removed and a pipe (casing) is inserted and cemented into place. In order to avoid damaging subsurface equipment, excess cement from the conductor casing is not brought back to the drilling unit but discharged to the sea floor. The actual amount can only be estimated by remotely operated vehicle survey after the discharge. Additional cement returns from surface, intermediate and production casings may be discharged according to the OWTG. Cement components will also meet the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands* (NEB et al. 2009).

2.11.3 Produced Water

If hydrocarbons are present and flow testing is conducted, then small amounts of produced water may be discharged by atomizing with hydrocarbons and flaring. If the flare capacity is exceeded, then small amounts of treated produced water will be brought onshore for disposal or discharged according to the OWTG.

2.11.4 Grey / Black Water

Typical drilling units will accommodate up to 150 personnel, depending upon the rig. Each rig will discharge up to approximately 50 m^3 of grey water per day. Black water or sewage will be macerated to 6 mm particle size or less and discharged as per the OWTG. Estimated amounts of black water are up to 25 m^3 per day per rig.

2.11.5 Machinery Space Discharges

Machinery space drainage will be through a closed system and treated to OWTG standards of 15 mg/L of oil or less.

2.11.6 Bilge Water

Bilge water will be treated to OWTG standards so that residual oil concentration in discharged bilge water does not exceed 15 mg/L.

2.11.7 Deck Drainage

Any deck drainage, such as the rotary table floor and machinery spaces, will undergo treatment in accordance with the OWTG so that residual oil concentration does not exceed 15 mg/L.

2.11.8 Ballast Water

Water used for stability purposes in both supply boats and drilling rigs is stored in dedicated tanks and thus does not normally contain any oil. If oil is suspected in the ballast water, it will be tested and if necessary treated to OWTG standards so that the residual oil concentration does not exceed 15 mg/L.

2.11.9 Cooling Water

Electrical generation on most modern rigs is provided by large diesel-fired engines and generators. These engines are cooled by pumping water through a set of heat exchangers. The water is then discharged overboard in accordance with the OWTG. Other equipment is cooled through a closed loop system, which may use chlorine as a disinfectant. Water from closed systems will be tested prior to discharge and will comply with the OWTG. Any proposals for alternate biological control will be submitted to C-NLOPB for consideration prior to use.

2.11.10 Solid Waste

All trash and garbage, including organic waste from galleys, will be containerized and transported to shore for disposal in approved landfills. Combustible waste such as oil rags and paint cans will be placed in hazardous materials containers for transport to shore. The rig will have a recycling program.

Any hazardous waste will be properly containerized, sealed, labelled and its disposal on shore at an approved facility will be the responsibility of a certified waste handler. All third-party waste management facilities will be assessed by the Operator to ensure they meet waste management standards.

2.11.11 Blow-out Preventer Fluid

With all subsea BOPs, the test fluid (glycol / water) is released at intervals. Chemicals potentially discharged offshore will be screened using the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands* (NEB et al. 2009). Excess chemicals or chemicals in damaged containers will not be discharged into the sea but returned to shore on a supply vessel. Any spent or excess acids will be neutralized as approved by C-NLOPB and discharged.

2.11.12 Miscellaneous

Substances not discussed above or covered in the OWTG will not be discharged without prior notification and approval of the C-NLOPB.

2.11.13 Air Emissions

Exploration installations are usually in an area for a short duration (e.g., 20 to 50 days for the Old Harry well). The main source of air emissions associated with routine activities of exploration drilling includes the burning of diesel fuel for power generation on the drill unit and flaring during any required well testing. Fugitive emissions will be a negligible source. Air emissions will be reported in accordance with OWTG and the National Pollution Release Inventory.

Typical emissions produced during a 20- to 50-day exploration drilling program would meet the stipulated air quality criteria in the short-term and in near-field and far-field locations. There will likely be no exceedances of the NAAQ Objectives.

Air emissions will be reported in accordance with the guidelines and the National Pollution Release Inventory. Sulphur dioxide, nitrogen oxides (NOx), hydrogen sulphide, particulate matter (PM), PM2.5, PM10 and volatile organic compounds are Criteria Air Contaminants, emissions of which must be reported to Environment Canada under the National Pollutant Release Inventory (NPRI) by June 1 annually. This reporting is required for production operations but drilling operations are exempt from NPRI reporting. Greenhouse gas emissions for development drilling are reported to the C-NLOPB annually on March 31.

The primary criteria air contaminants are carbon dioxide (CO_2), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides and particulate matter. It is estimated that a drilling rig consumes approximately 110 barrels of marine diesel per day (each barrel is assumed to hold approximately 42 US Gallons (159 L) of fuel). Additional assumptions made for the purposes of the estimate of emissions includes: the marine diesel used has a fuel sulphur content of 5,000 ppm (or 0.5 percent (typical for marine diesel)); and 1 gallon of diesel fuel produces approximately 139,000 Btu of energy.

The US EPA AP-42 Emission Factor Inventory was used, providing representative emissions factors for air contaminants released to the atmosphere by source type. In general, these emissions factors are understood to be representative of long-term averages for all facilities in the source category. For this estimate, AP-42, Fifth Edition, Volume 1, Chapter 3.4: Large Stationary Diesel and All Stationary Dual-fuel Engines was used, since the main domestic use of large stationary diesel engines (greater than 600 horsepower) is for the application of oil and gas exploration and production. As stated in the study, evaporative losses are nominal in diesel engines due to low volatility of diesel fuel; therefore, only air contaminant emissions emitted through exhaust were considered.

The emissions factors as prescribed by AP-42 for large stationary diesel internal combustion sources are shown in Table 2.7.

Table 2.7 Gaseous Emissions Factors for Large Stationary Diesel Internal Combustion Sources

Air Contaminant	Emission Factor (fuel input) (lb/MMBtu)
NO_x	3.2
CO	0.85
SO_x[A]	$1.01S_1$
CO_2	165
PM	0.1

[A] Assumes that all sulphur in the fuel is converted to SO_2. S_1 = % sulphur in fuel oil. Therefore, for this estimate, a sulphur fuel content of 0.5%, results in an emission factor of 0.505.

Daily air contaminant emissions for the case of consumption of 110 barrels of fuel per day were evaluated and are shown in Table 2.8. Whereas a formal analysis has not been conducted on air emissions from a semi-submersible, the resultant emissions would be slightly higher due to greater fuel consumption required for activities such as station-keeping. These emissions are comparable to emissions from a single large container ship of the type that commonly transits the area. There will be minimal effect on the health and safety of workers on the drill rig.

Table 2.8 Daily Criteria Air Contaminant Emissions for the Project Drilling Rig Consuming 100 Barrels of Fuel per Day

Air Contaminant	Diesel Fuel (# bbl/day)	# US Gallons/ day	Energy Produced Per Day (MMBtu)	Emission Factors (fuel input) (lb/MMBtu)	Air Contaminant Emissions (lbs/day)	Air Contaminant Emissions (tonnes/day)
NO_x	110	4,620	642	3.2	2,055	0.93
CO	110	4,620	642	0.85	546	0.25
SO_x*	110	4,620	642	0.505	324	0.15
CO_2	110	4,620	642	165	105,960	48
PM	110	4,620	642	0.1	64	0.03
MMBtu = 1,000,000 Btu.						

There is ample assimilative capacity for emissions resulting from these activities because of the strong average winds at the site. As the drill rig will be more than 50 km from the nearest coastal community, there will be no effect on the coastal communities from the Project. The drilling rig would correspond to less than 0.2 percent of the greenhouse gas emissions for Newfoundland and Labrador (based on 2003 greenhouse gas emissions data).

Within Canada, Transport Canada and Environment Canada have regulatory authority concerning marine vessels. Transport Canada instituted the air pollution regulations in the *Canada Shipping Act* that addresses fuel usage standards. However, this section of the *Canada Shipping Act* simply categorizes the smoke produced from marine vessels according to different levels of smoke density. Environment Canada has authority to regulate emissions from marine diesel engines of less than 37 kW and addresses the import, production and sale of fuel in *Canadian Environmental Protection Act* 1999, Part 7.

2.12 Project-specific Model Inputs and Results

Corridor has conducted project-specific modelling to determine the areal extent of:

- drill cuttings dispersion; and
- hydrocarbon fate and behaviour spill trajectory.

2.12.1 Drill Cuttings

To estimate possible drill cuttings depositions, primarily the thicknesses and distances from the well site, a numerical model was employed which considered the proposed sequence of well sections to be drilled for the Project and an associated time history of cuttings discharges. The subsequent path of the discharged cuttings (with advection as a result of the ambient ocean current) to their ultimate fate on the seabed was predicted with a 3D sedimentation computer model.

Modelling of the dispersion of cuttings predicts the initial deposition of the cuttings only, not the subsequent weathering, erosion and fate of the material accumulated on the seabed over an extended period of time.

2.12.1.1 Model Inputs

Two publicly available sources of currents were used to serve as an input base for the Benthic Boundary Layer Transport model: the WebTide (DFO 2011a) and WebDrogue (DFO 2011b) model based velocity fields.

Tidal Currents

WebTide is initially a user interface designed to get the tidal predictions (elevation and velocities) at a (user selected) particular location. The tool uses the solutions of modelling studies performed over the years by DFO scientists and staff. The finite element mesh used for this study was the Northwest Atlantic Mesh described in Dupond et al. (2002).

Tidal solutions (elevation and currents) from the core program of WebTide (‘tidecor’) were interpolated on a regular grid to provide a time-series of spatial tidal velocity fields.

To provide a representative cycle, a full lunar month (30 days) of simulation was extracted and saved hourly over a grid covering from about 46.05°N to 50.05°N and 62.39°W to 58.39°W (2 degrees around the proposed drilling location).

Tidal current speeds and directions for all the phases of the tidal cycle are summarized in Table 2.9. The currents flow toward the direction given relative to true North.

Table 2.9 Tidal Currents at Drilling Site from Webtide Model Run

	Neap-Flood	Neap-Ebb	Spring-Flood	Spring-Ebb	Slack Water
Tidal current	0.07 m/s 320° N (to)	0.08 m/s 140° N (to)	0.21 m/s 320° N (to)	0.17 m/s 140° N (to)	0 m/s
Notes: magnitudes rounded to nearest cm/s and directions rounded to nearest 10° sector					

Seasonal Mean Current Fields from Webdrogue

WebDrogue is another user interface developed by DFO providing access to the results of numerical modelling of the general circulation in the Eastern Canada region of the Northwest Atlantic Ocean. The domain used for this study, covering the Gulf, was the one developed for DFO’s operational model to forecast currents, temperature, salinity and ice field over the Eastern Coast of Canada (DFO 2011c).

The seasonal current fields at the surface and the bottom were extracted from the model domain mesh for winter, spring, summer and fall, and interpolated on the same grid as for tidal currents (Section 2.12.1.1). In WebDrogue, the bottom layer is defined as “the average over the bottom 10 m” (DFO 2011c), and therefore representative of the benthic boundary layer. Seasonal mean currents are summarized in Table 2.10.

Table 2.10 Residual Currents at Drilling Site from WebDrogue Model Run

	Winter	Spring	Summer	Fall
Surface	0.04 m/s 130° N (to)	0.04 m/s 110° N (to)	0.06 m/s 150° N (to)	0.08 m/s 160° N (to)
Bottom	0.025 m/s 310° N (to)	0.05 m/s 300° N (to)	0.05 m/s 310° N (to)	0.03 m/s 330° N (to)
Notes: magnitudes rounded to nearest .01 m/s and direction rounded to nearest 10o sector				

Stratification

Vertical stratification of the water column was derived from DFO monthly climatology of temperature and salinity for the region of the Gulf of St. Lawrence (DFO 2011d) around Old Harry. Density stratification resulting from temperature and salinity stratification is summarized for each season in Table 2.11.

Table 2.11 Disposal Site Water Column Physical Properties

Depth (m)	Density (kg/m^3)			
	Winter	Spring	Summer	Fall
0	1025.7	1025.5	1023.6	1024.3
200	1027.9	1028.0	1028.0	1027.8
400	1029.4	1029.4	1029.4	1029.4

Cuttings Particles Characterization

No cuttings particle size distributions that would quantify the composition of different mineral materials as a function of depth are available from the anticipated well to be drilled in EL 1105.

An overall estimation of the cuttings and sediment composition for the well is 38 percent sandstone, 49 percent shale, and 13 percent siltstone. Based on this limited knowledge, together with consideration of the cuttings sizes likely to be created from the drilling, it was assumed that most (perhaps 75 percent) of the cuttings will be large on the order of 1 to 3 cm, approximately 20 percent on the order of 0.5 to 1 cm, with the remainder less than 0.5 cm. For the two upper sections of the hole for which cuttings are discharged at the sea floor, this distribution was applied to the total in situ cuttings volume of 196 m^3. For discharge of the cuttings from the rig from the deeper two sections, a similar distribution with one refinement was applied to a total in situ cuttings volume of 211 m^3. To consider the presence of very fine particles that could be expected during drilling of the deeper well sections, a small amount, 5 percent, was moved from the larger particles to fines (Table 2.12).

Table 2.12 Cuttings Particle Size Composition

Well Type/Section	Measured Weight Percent Material			
	Large Cuttings	Pebbles	Coarse Sand	Fines
Scenario 1: conductor and surface	75	20	5	0
Scenario 2: main and intermediate	70	20	5	5

It is assumed that the cuttings will enter the sea in a disaggregated form. The model considered the large cuttings, pebble, and sand materials to remain disaggregated in their fall to the seabed. Any fines were assumed to aggregate into flocs of size on the order of approximately 0.1 mm and settle with a constant speed.

Particle fall velocities, w, were estimated from the particle diameter using the following relationships from Sleath (1984):

$$w = 4.2\sqrt{D}, D > 0.0001m \quad (4)$$

$$w = 12x10^4 D^2, D \leq 0.0001m \quad (5)$$

For the four particle types considered, this yields the values reported in Table 2.13.

Table 2.13 Cuttings Particle Size Characterization

	Cuttings Material			
	Large Cuttings	Pebbles	Coarse Sand	Fines
Particle Diameter (mm)	20	7	1	0.1
particle fall velocity (m/s)	0.594	0.351	0.133	0.0012

Ocean Currents

The seasonal bottom current fields from WebDrogue were combined with tidal current fields for use as Benthic Boundary Layer Transport current input. Thirty days of tidal currents were synthesized for each season. Subsequently, the corresponding residual current velocity was added to the tidal currents to yield separate composite current time-series representing each of winter, spring, summer, and fall conditions. For the near field models, currents are assumed to be uniform over the small model domain. For the mid and far field exercises with Benthic Boundary Layer Transport, currents vary in time and space to be representative of regional seasonal circulation patterns.

Water Based Mud Discharge Characteristics

The modelled scenarios include the release of 450 m^3 of material, consisting of 50 m^3 of brine at a density of 1,060 kg/m^3 and 400 m^3 of WBM. The composition of the WBM includes 35.25 m^3 of clay with a density of 2700 kg/m^3, 3.45 m^3 of barite at 4,200 kg/m^3, and 361.3 m^3 of seawater at 1,025 kg/m^3. Therefore, the input to the STFATE model consists of the solid fractions and 411.3 m^3 of seawater with an effective density of 1,029.3 kg/m^3 (Table 2.14). Both the barite and the clay fractions are considered. The initial fall velocities were based on nominal mid-range values (Niu et al. 2008), as cohesive sediments can form floccules of various sizes and their falling velocity is thus dependent on the concentration at any given time. The material is to be released from a chute with a width of approximately 0.5 m, over a period of five seconds.

Table 2.14 Water-based Mud Characteristics Input into STFATE

Description	% Total Sample (dry)	Specific Gravity	% WBM Volume	Fall Velocity (mm/s)	Character
Barite	9	4.2	0.77	5	Cohesive
Clay	91	2.7	7.83	0.6	Cohesive
Interstitial seawater density assumed: 1025 kg/m^3					

Long-term Dispersion Of Drilling Mud Discharge

Since barite (a weighting agent) and bentonite (a clay mineral) are the primary components of WBM and also are material of concern for the marine environment (Cranford and Gordon 1992; Cranford 1995; Cranford et al. 1999), only these two components were considered in this study. Barite and bentonite have significantly different densities and settling velocities.

The files describing the mud discharge were created using the following information and assumptions:

- The drilling program was assumed to occur without any interruption between drilling and cementing of the sections of the hole. This represents a worst case scenario in terms of release of material into the environment. The overall discharge program was compressed and modelled to span a period of 15 days; in reality, drilling operations would span 20 to 50 days.
- Mud discharge was assumed to be continuous with material being added to the system in hourly time steps.
- Mud released from the rig with the cuttings during drilling of the two deeper sections of the well was also considered to be a continuous discharge. The volume considered is that of the loss during the recycling process (565 m^3). Only barite is assumed to be discharged here as no bentonite is used for these sections of the hole. Overall, about 8.355 t and 11.14 t of barite are assumed to be discharged during the drilling of these two sections, respectively.
- The remaining amount of barite is assumed to be released instantly as a bulk discharge after completion of the last well section. The total amount of material assumed to reach the benthic boundary layer within the vicinity of the rig is estimated to be 20 percent based on the fraction method of Loder el al. (1999). Therefore, 3.1 t of barite are assumed to be discharged instantly at the drill site during this release.
- In order to bracket the range of possible settling velocities, two values were retained for the simulations: 0.1 cm/s and 1 cm/s.

2.12.1.2 Model Results

Seafloor Discharge of Cuttings

A uniform depth of 470 m was assumed. The discharge included a total volume of 196 m^3 of drill cuttings. The cuttings deposition predicted following completion of the conductor and surface sections for the winter season is illustrated in Figure 2.4. Thicknesses of 1 mm, 1 and 2 cm, 10 and 20 cm, and 1 and 2 m are shown. There is very little difference in the pattern for spring, summer, and fall due to the discharge location being approximately 10 m above the seabed.

Model results indicate cuttings will be deposited up to approximately 30 m from the well site. The thickness of the deposit will be greatest immediately adjacent the well site with maximum thickness of about 4.7 m. From the well center outward to approximately 20 m, average thickness of the deposit is predicted to be about 220 mm. From 20 m outward to 50 m from the well center, the average thickness is predicted to be less than 1 mm.

Surface Discharge of Cuttings

A uniform depth of 470 m was assumed. The discharge included a total volume of 211 m^3 of drill cuttings. Cuttings deposit thickness is greatest near the drill center, as large as 15 mm, due to the more rapid fall of the larger and heavier cuttings particles. Outward to approximately 100 m from the well center, predicted deposit thickness is as large as 6 mm but about 2 mm on average. Outward from 100 to 200 m, deposit thicknesses are as large as 6 mm but the average range is from about 0.5 to 1 mm. The cuttings deposition patterns on a 25 km x 25 km grid (with inset showing a finer resolution 500 m view to resolve the deposition of the larger, faster settling particles) is illustrated in Figure 2.5. A regional view of the deposit in the Gulf is provided in Figure 2.6. The oil concentration on the cuttings is approximately one to two times the oil thickness in microns (e.g., if the thickness is 1,000 microns (1 mm), the oil concentration is approximately 1,000 to 2,000 mg/kg). The oil concentration within 50 m from the point of discharge, calculated for the one model grid cell immediately surrounding the well site, is predicted to be approximately 25 percent of that on the cuttings originally released, or 17,000 mg/kg. Within the band between 50 m and 100 m of well centre, the oil concentration drops to approximately 2,400 mg/kg (i.e., a further reduction by a factor of seven). Outside the 200 m radius, the oil concentration on cuttings is 44 mg/kg or less. The predicted concentration is 3 mg/kg or less outside of 500 m.

Seafloor Discharge of Mud

The mud suspension will be diluted as it rises in a turbulent eject plume. A continuous drilling operation is considered to be comprised of a series of puffs of ejected material, the total of which will amount to 1,210 m^3. Each puff will experience dilution as its momentum mixes with the slower moving background currents and as a result of oceanic turbulence and shear dispersion as it is advected away from the well site by ambient currents.

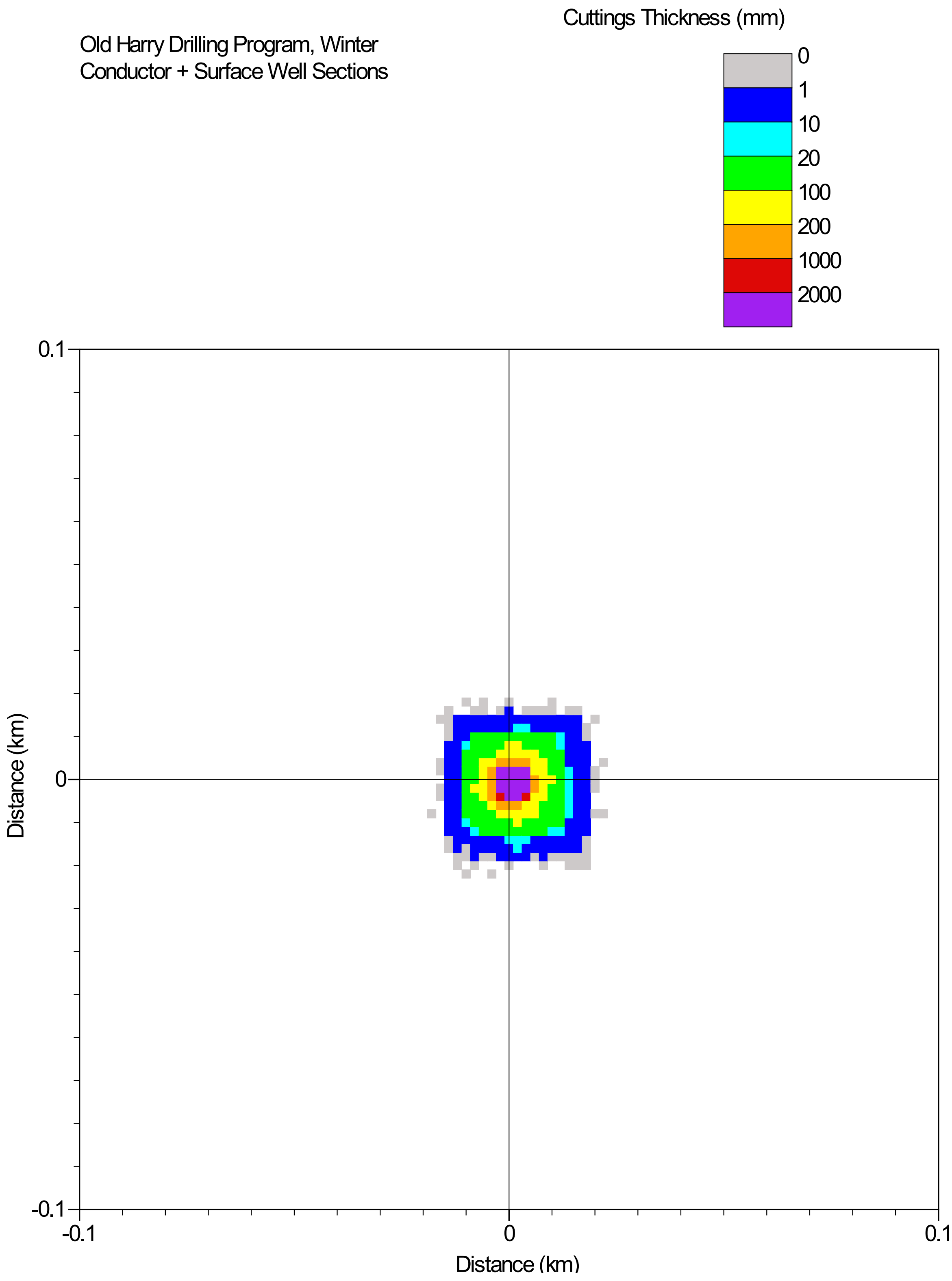
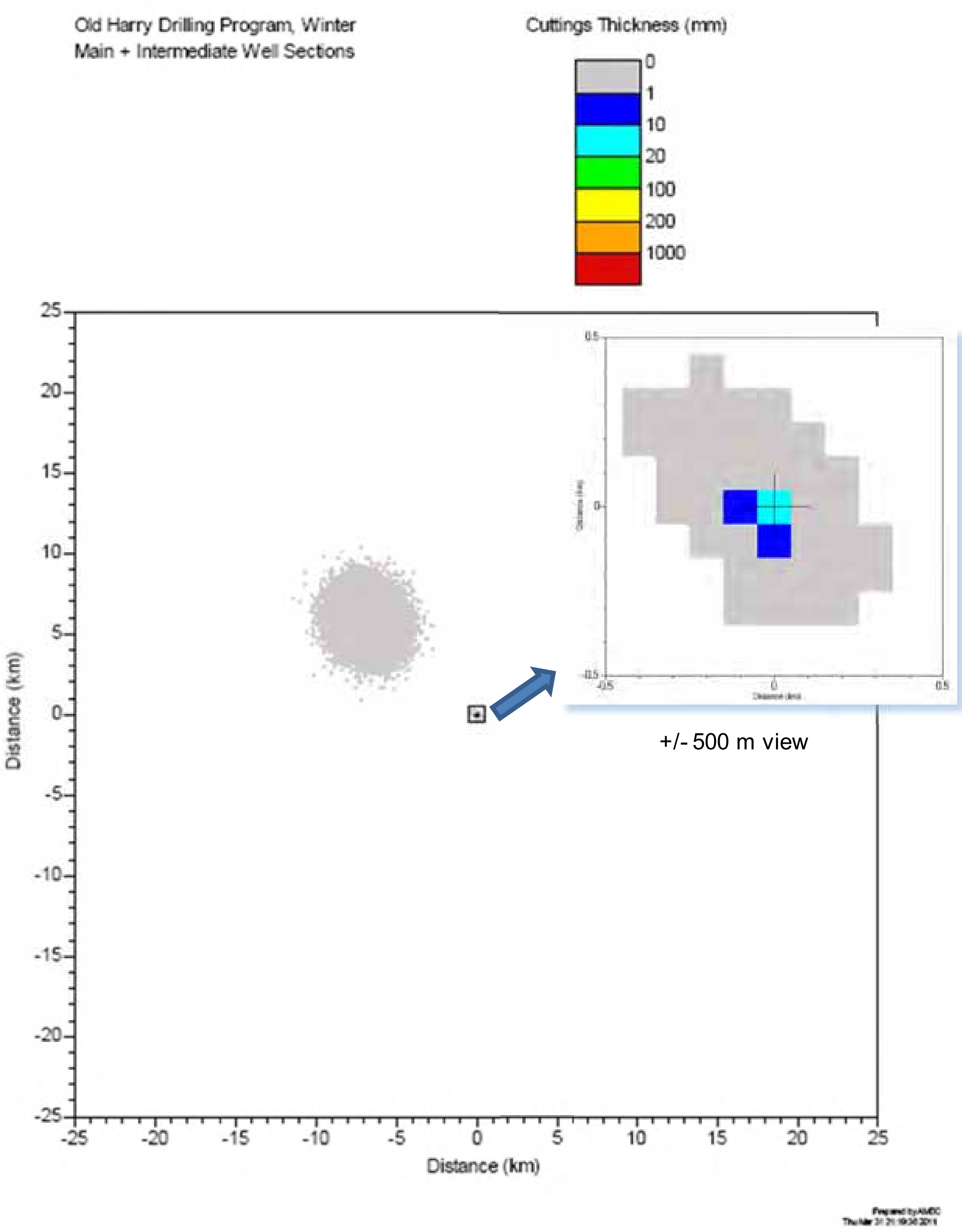
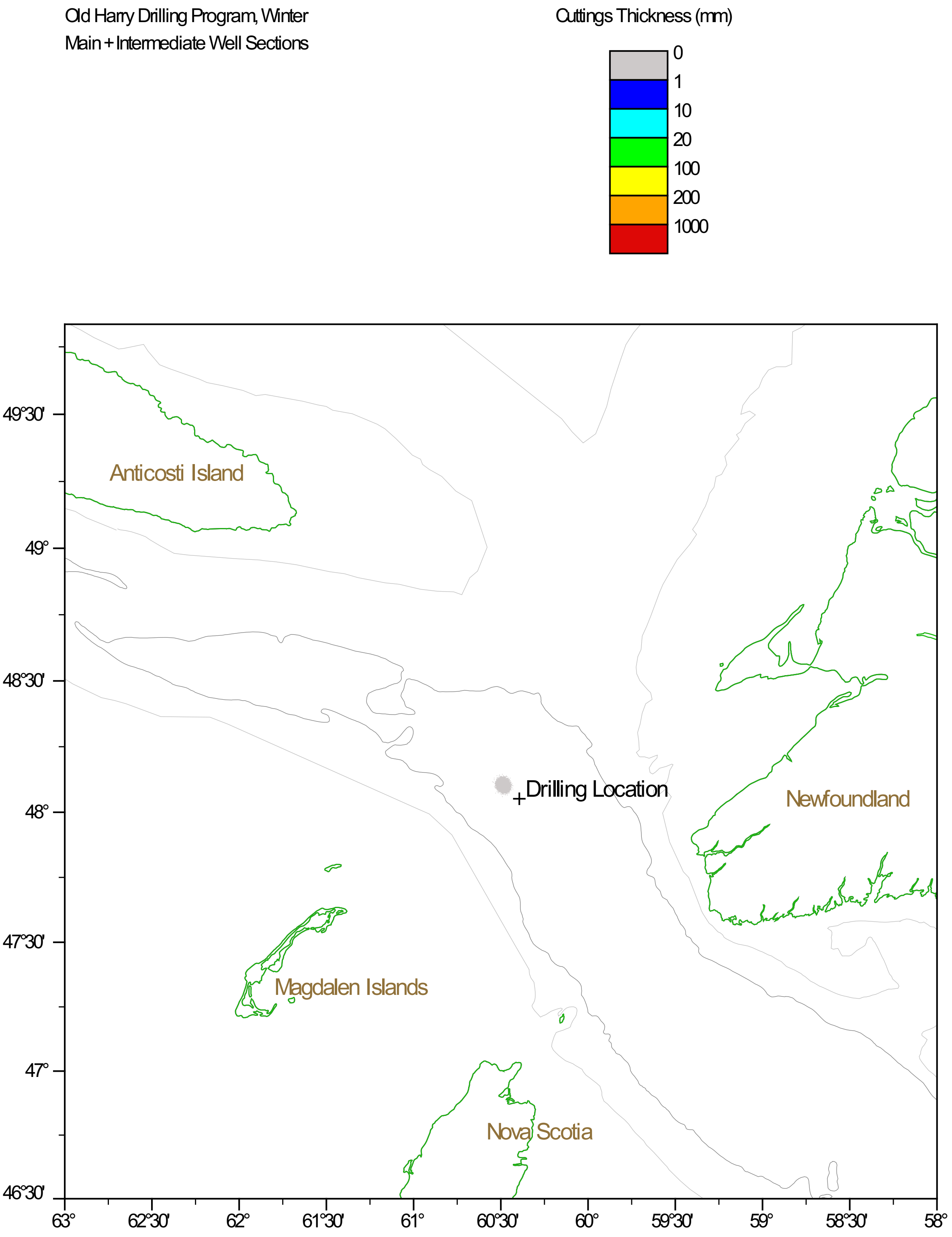


Figure 2.4 **Cuttings Deposition Following Conductor and Surface Hole Section Drilling, Winter Season, 1 km view**



Note: Inset shows a 500 m view centred on the wellsite

Figure 2.5 Cuttings Deposition Following Main and Intermediate Hole Section Drilling, Winter Season, 25 km View



Note: 200 and 400 m Depth Contours Shown

Figure 2.6 Cuttings Deposition Following Main and Intermediate Hole Section Drilling, Winter Season, Gulf of St. Lawrence View

It is difficult to quantify the exact dispersion path that a particular puff will experience, but the process can be described in general terms based on the expected physical processes and the ambient current. For the purposes of this assessment, it is assumed that the WBM is forced out of the hole at speeds on the order of 1 m/s, while the ambient ocean currents are between 3 and 26 cm/s. Therefore, the initial dilution calculated from conservation of momentum is 4:1 to 33:1, depending on the phase of the tide. Because its density is larger than that of the ambient sea water, the diluted puff will tend to collapse into the benthic boundary layer. In the deep sea, this layer has a typical thickness on the order of 1 m (Wimbush and Munk 1970). Due to the current shear and turbulence in the boundary layer, the puff will tend to stay in suspension above the seabed. Assuming a pill-box shape for the initial plume, a discharge volume of 15 m^3 (a typical sweep volume), and an initial dilution of 4:1, the puff will have an average diameter of approximately 9 m at this time. As it is advected away, the diameter of the diluted puff will continue to grow and the mud concentrations will decrease due to dispersion and mixing. Based on a typical small scale horizontal diffusivity of 0.01 m^2/s (Okubo 1971), additional dilution by a factor of two will require on the order of two hours, at which time the cloud will have been advected by the ambient mean currents a distance between 200 and 1,700 m. Other factors not taken into account here, including the effects of seabed roughness and topography, will tend to provide additional dispersion. While necessarily not rigorous, the above description provides a reasonable picture of the process by which bottom releases of mud during jetting and drilling of the upper hole sections result initially in small clouds of fine particles in the benthic boundary layer. These clouds will continue to be diluted by turbulence and will be dispersed to the northwest of the well site as they are advected by the mean current.

Surface Discharge of Mud

The planned release of 400 m^3 of WBM at the end of the drilling program introduces suspended sediment into the water column. The bulk release of WBM is expected to occur approximately 30 m below the surface, and it is expected to last for a relatively short time, on the order of seconds. The material is initially expected to fall through the water column as a well-defined jet of density that is higher than the ambient.

Water-based Mud Short-term Fate

The evolution of the plume from release to end of cloud collapse is illustrated in Figure 2.7, based on the simulation run for the Spring season spring-ebb tidal scenario. In these plots, the convective descent phase and the cloud collapse phase are delineated in both the side view and the top view of the cloud progression. The release of WBM is centred at the origin of the coordinate system. It is apparent that the plume initially descends downward while expanding and entraining increasing amounts of the ambient seawater. At the end of the descent phase, the lowermost edge of the cloud reaches a depth of approximately 185 m. The sediment material then collapses into a flat generally ellipsoid cloud and levels off at a depth of approximately 150 m to the southeast of the point of release.

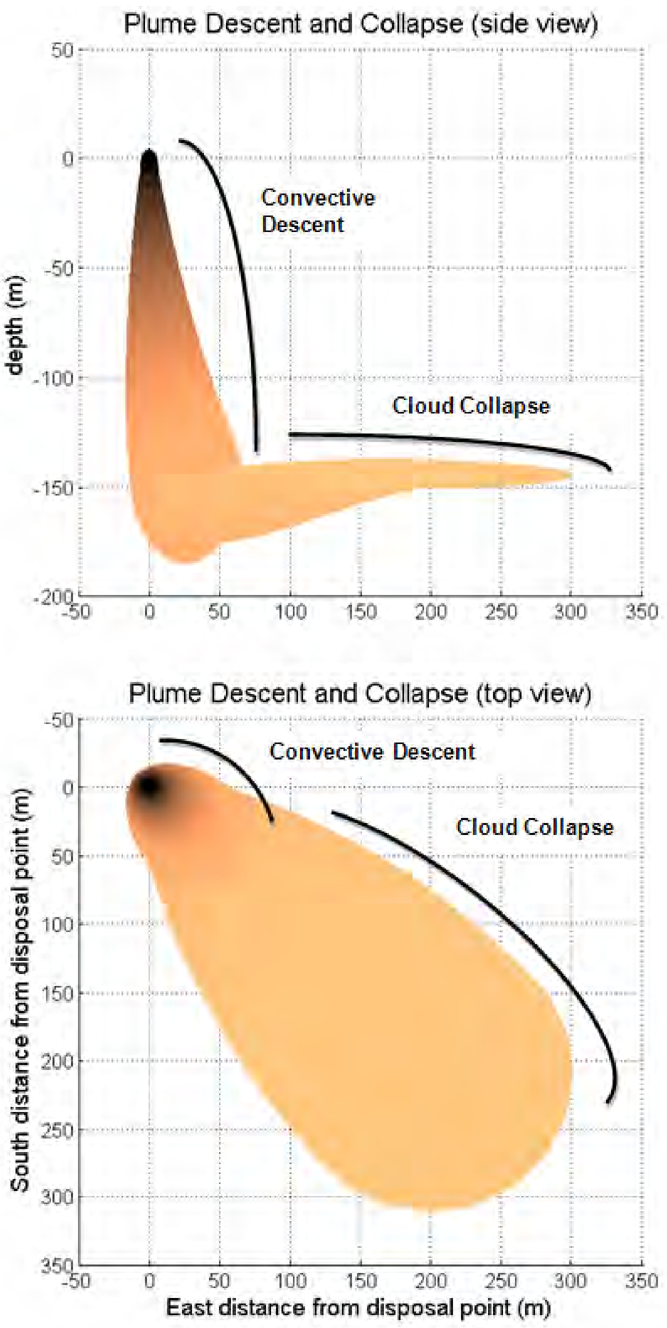


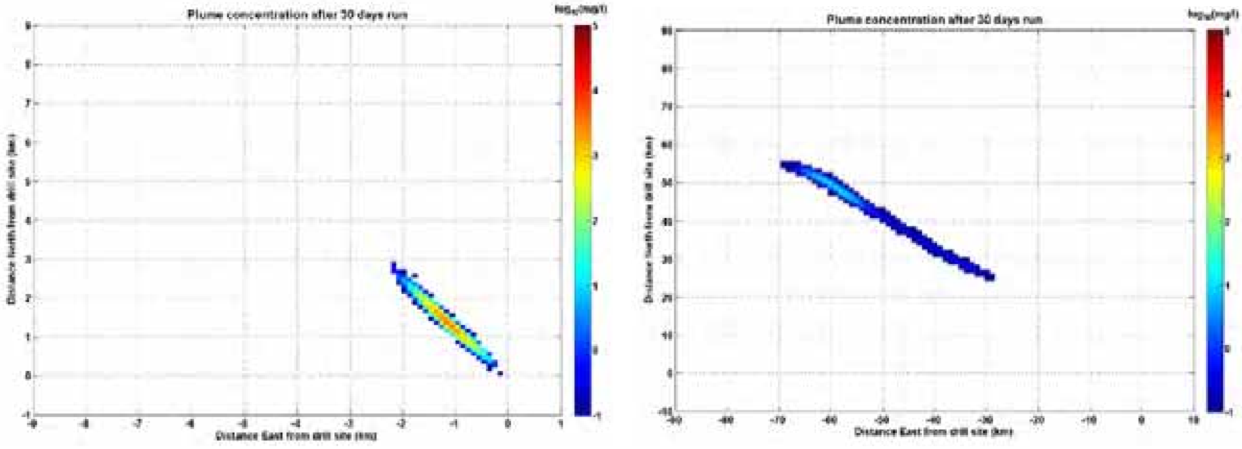
Figure 2.7 Plume Descent and Collapse Diagram for Spring Spring-Ebb Tidal Phase Scenario

The depth reached and the size of the cloud in each phase were similar for all tidal phases within a given season. Thus, the cloud centroid descended to the deepest level of 151 m in the winter scenarios, and to the shallowest level of 124 m in the summer scenarios, reflecting the higher ambient water stratification in the summer months. The cloud collapse ended at similar depths as the respective convective descent phases for all scenarios, indicating that once a state of neutral buoyancy was reached at a given depth, the cloud tended to stay close to that depth. The largest horizontal width at the end of the cloud collapse phase was found in the winter scenarios (210 m), and the smallest in the summer scenarios (170 m). The maximum horizontal extent of the outer edge of the collapsed cloud (425 m from origin) was reached in the winter scenarios. The different tidal scenarios showed that the clouds generally travelled to the southeast (ebb tide) and to the northwest (flood tide) of the point of release, with the excursions being larger during the spring tides than during neap tides.

At the end of the cloud collapse phase, the behaviour of the WBM sediment clouds is no longer governed by the dynamics of the release, and they are expected to be subjected to further dispersion by the ambient residual and tidal currents. The sediment concentrations at the cloud centres at the end of each phase indicate that minimum dilution factors between 20 and 30 were achieved within half an hour from release time, and minimum dilution factors between 60 and 80 were achieved within one hour from release time for all scenarios. The reduced concentration of both the barite and clay results in further reduced settling velocities. Therefore, they are expected to reach the bottom boundary layer within a period on the order of days.

Long-term Deposition

For the high settling velocity scenario, the final plume size is on the order of 2 to 3 km long and less than 1 km wide. Also, because of this high settling value and low currents on the order of a few cm/s, all the material stays within the first metre of the water column (Figure 2.8). Concentrations are in the range between 250 mg/l and 1 g/l. The highest concentration occurs at the centre of the plume, two to three orders of magnitude higher than at the margins. Overall, the averaged plume concentration time-series shows a stabilization of the concentration near approximately 250 mg/l after approximately 20 to 25 days of the 30 day modelling exercise.



Winter = High settling velocity; Summer = Low settling velocity.
Source: AMEC 2011

Figure 2.8 Greatest Extent of Drill Cuttings Deposition Modelling in Winter Season (left) and Summer Season (right)

2.12.1.3 Summary of Modelling Results

Information in this section is from AMEC (2011), which should be reviewed for more detail on the dill cuttings deposition model. Drilling operations will result in:

- sea floor discharge of 196 m^3 of cuttings;
- surface discharge of 211 m^3 of cuttings;
- sea floor discharge of 1,210 m^3 of WBM of various density and composition; and
- surface discharge of 400 m^3 of WBM combined with 50 m^3 of brine.

Sea floor discharge of cuttings is expected to result in a mound extending approximately 30 m from the well site, with cuttings thicknesses greatest immediately adjacent the well site. Average thickness is approximately 22 cm out to approximately 20 m from the well site; maximum thickness is approximately 4.7 m. From 20 to 50 m out from the well site, the average thickness is less than 1 mm.

Surface release of cuttings is expected to produce a deposit with thickness greatest near the drill origin, due to the most rapid fall of the heavier pebble and sand cuttings particles, and is as thick as 15 mm directly below the point of origin. Out to approximately 100 m from the origin, thicknesses are approximately 2 mm on average with a maximum of approximately 6 mm. From 100 to 200 m, thicknesses average from approximately 0.5 to 1 mm, with a maximum of approximately 6 mm.

If cuttings released from the rig are associated with SBM, maximum synthetic-based oil concentration within 50 m from the point of discharge is predicted to be approximately 25 percent of that of the original treated and released cuttings, or 17,000 mg/kg. Within 100 m, the concentration drops another factor of seven, to approximately 2,400 mg/kg. Outside of 200 m, the concentration is 44 mg/kg or less. Outside of 500 m, this concentration is 3 mg/kg or less.

The surface bulk release of WBM at the end of the well is expected to result in a plume reaching a depth of approximately 150 m, thereby not reaching the bottom. Dilutions of 20 to 30 times the original concentration are expected within 30 minutes from discharge and dilutions of 60 to 80 times are expected within 60 minutes of discharge. Subsequently, material in the plume is expected to sink slowly and eventually reach the bottom boundary layer after several days.

Simulation of the long-term fate of all the mud released over the entire drilling program considered the conservative scenario where there is no interruption between each phase of drilling operations, in which case, all the mud would be released over a period of 15 days.

Results show that dispersion of the mud by the ambient tidal and mean currents result in an elongated plume varying from 2 to 3 km to approximately 40 km in length, depending on settling velocity, with widths from less than one to a few (numbers) kilometres, respectively. This variability is typical of the range of behaviour of drilling mud, and is consistent overall with other similar studies.

The concentration in those plumes, averaged over 1 m above the bottom, vary with their size and ranges from approximately 1 g/l initially for the high settling rate scenario a few kilometres away from the site down to approximately 1 mg/l for the low settling rate scenario a few tens of kilometres away from the drilling site. It was noted as well that the concentration varies greatly (one order of magnitude or more) within the plumes due to the suspension / deposition cycle induced by variations of current strength over the tidal cycle.

Considering the high settling velocity scenario, the particles are found to basically stay very close to the sea bed (less than 1 m). Were all the particles to settle on the sea floor, an area of approximately 1 km^2 would be covered by a very thin veneer of 64 µm.

Under the low settling velocity scenario, the particles are found to travel over relatively large distances of approximately 80 km over the 30-day simulation (Figure 2.7). Considering a 40 km long plume and a residual current of 2.5 cm/s, a fixed point within the trajectory of the plume would experience maximum continuous exposure to suspended material of the order of approximately 20 days.

If during the drilling program, interruptions of the order of a few hours to a few days were to take place, the plumes would be more elongated, more patchy, and their concentrations more variable in space and time; however, mean concentrations and exposure durations would not differ significantly from the results of the continuous discharge operation simulations considered herein.

Overall, the results of mud dispersion simulations presented in this study are found to be consistent with the results of previous generic and site-specific studies for similar discharges and receiving environment (Thomson et al. 2000; Hannah et al. 2003; Tedford et al. 2003).

2.12.2 Hydrocarbon Spill Fate and Behaviour Trajectory Modelling

Information in this section is from SL Ross (2011), which should be reviewed for more detail on the fate and behaviour model. As well, a detailed description of the SL Ross Oil Spill Model (SLROSM) is available at www.slross.com/publications/SLR/Description_of_SLROSM.pdf. Corridor geoscientists have selected Cohasset crude oil as a surrogate to the Old Harry oil. The Cohasset oil is high gravity oil (47° API) produced from the Cohasset / Panuke / Balmoral Fields on the Scotian Shelf (Kidston et al. 2005). The reservoir in these fields comprise fluvial and shallow marine, stacked, sandstone sequences that are analogous to the fluvial sandstone reservoir rocks at Old Harry. A detailed description of the rationale for the selection of Cohasset crude as a surrogate to Old Harry is provided in Appendix A of SL Ross (2011).

2.12.2.1 General Oil Spill Behaviour

The following sections describe the general behaviour of oil associated with the key spill scenario types that may occur during an exploration drilling operation: small fuel oil batch spills; subsea crude oil blowouts; and above surface crude oil blowouts from exploration activities.

Small Batch Spills from the Drilling Installation

Small batch spills of diesel fuel from hose ruptures during transfer operations from a supply vessel or from drilling installation storage facilities are a possibility during drilling operations. These spills are considered instantaneous events and are modelled by considering the surface spreading, evaporation, dispersion, emulsification and drift of a single patch or slick of oil.

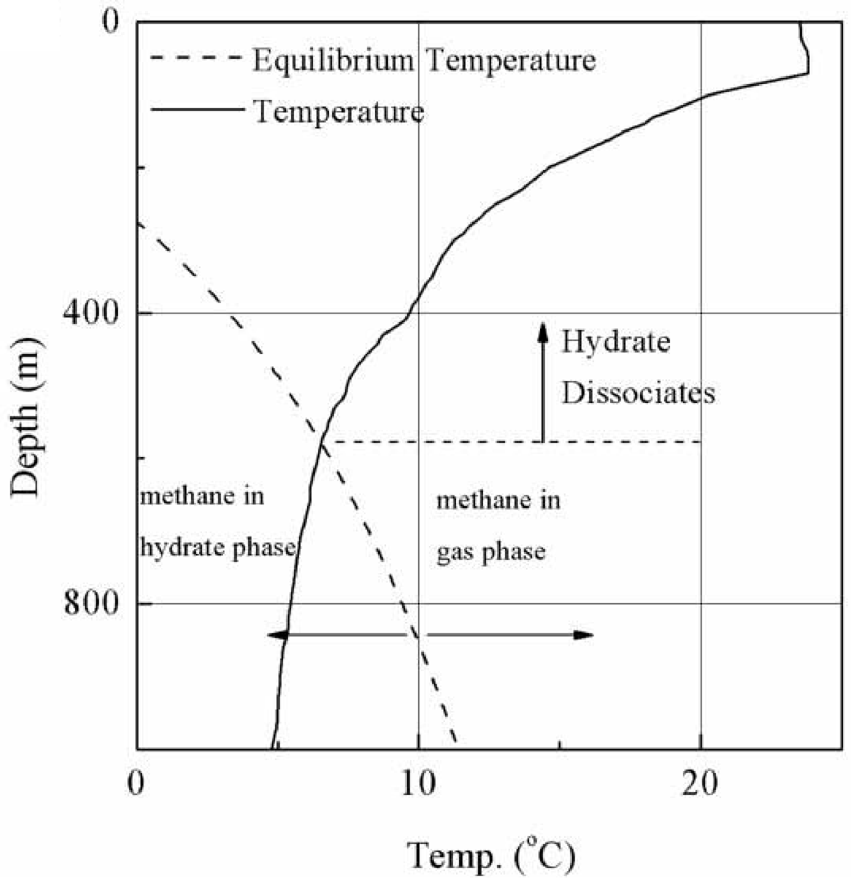
Subsea Blowouts

Well blowouts generally involve oil and natural gas where the volume ratio of the oil and gas is a function of the characteristics of the fluids and the producing reservoir. The natural gas, being a compressible fluid under pressure at reservoir conditions, provides the driving force for an uncontrolled blowout. As the well products flow upwards, the gas expands, finally exiting at the well head at very high velocities. At this point, oil often makes up only a small fraction of the total volumetric flow.

The behaviour of subsea blowouts can be very different depending on the water depth and temperature of the water at the release point. Because of this very different behaviour, they are often referred to as either shallow- or deep- water blowouts. Descriptions of the behaviour of the natural gas and oil released from these two situations follow.

Deep-water blowouts are those where the natural gas exiting from the subsea release point quickly combines with water to form a solid ice-like substance known as hydrates. These form under high pressure and cold temperatures and deplete the volume of gas rising in the gas bubble plume. The natural gas volume may also be depleted through dissolution into the water. With the loss of natural gas through either or both of these processes, the driving buoyancy of a rising gas bubble plume may be completely lost, which will result in the oil droplets rising slowly under gravity forces alone without the assistance of more buoyant gas. The movement of the oil droplets is affected by cross currents during their rise. This will result in the separation of the oil droplets based on their drop size. The large diameter oil drops will surface first close to the release point and smaller drops will be carried further down current away from the release point prior to reaching the surface. Oceanic diffusion processes will result in additional separation of the oil drops due to their varying residence times in the water column.

In 5°C waters deeper than about 700 to 800 m, complete conversion of the natural gas to solid hydrates is likely whereas in 5°C waters less than about 500 m deep little hydrate formation is likely. The phase diagram for methane presented in Figure 2.9 provides guidance in the likely formation of hydrates as a function of water depth (pressure) and temperature. The phase diagram for methane is used since it is by far the most significant component (>90 percent) in natural gas. The formation of hydrates is also dependent on the actual composition of the natural gas and impurities in the gas and water so there is some uncertainty in the prediction of hydrate formation in water depths between 400 to 800 m. Because the water depth at the proposed drilling site is less than 500 m deep and the water temperature is 5°C or more, it has been assumed that a subsea blowout would behave as a shallow-water event in this situation and substantial conversion of gas to hydrate will not occur. The behaviour of a shallow water gas and oil blowout is discussed below.



Source: Yapa et al. 2010

Figure 2.9 Methane Phase Diagram

In a shallow water blowout, the majority of the gas does not convert to hydrates and a gas bubble plume develops that powers the movement of oil and gas and entrained water quickly to the water surface. Oil and gas released from a shallow subsea blowout pass through three zones of interest as they move to the sea surface (Figure 2.10 side view). The high velocity at the well head exit generates the jet zone dominated by the initial momentum of the gas. This highly turbulent zone is responsible for the fragmentation of the oil into droplets ranging from 0.5 to 2.0 mm in diameter (Dickins and Buist 1981). Because water is also entrained in this zone, a rapid loss of momentum occurs a few metres from the discharge location. In the buoyant plume zone, momentum is no longer significant relative to buoyancy, which then becomes the driving force for the remainder of the plume. In this region, the gas continues to expand due to reduced hydrostatic pressures. As the gas rises, oil and water in its vicinity are entrained in the flow and carried to the surface.

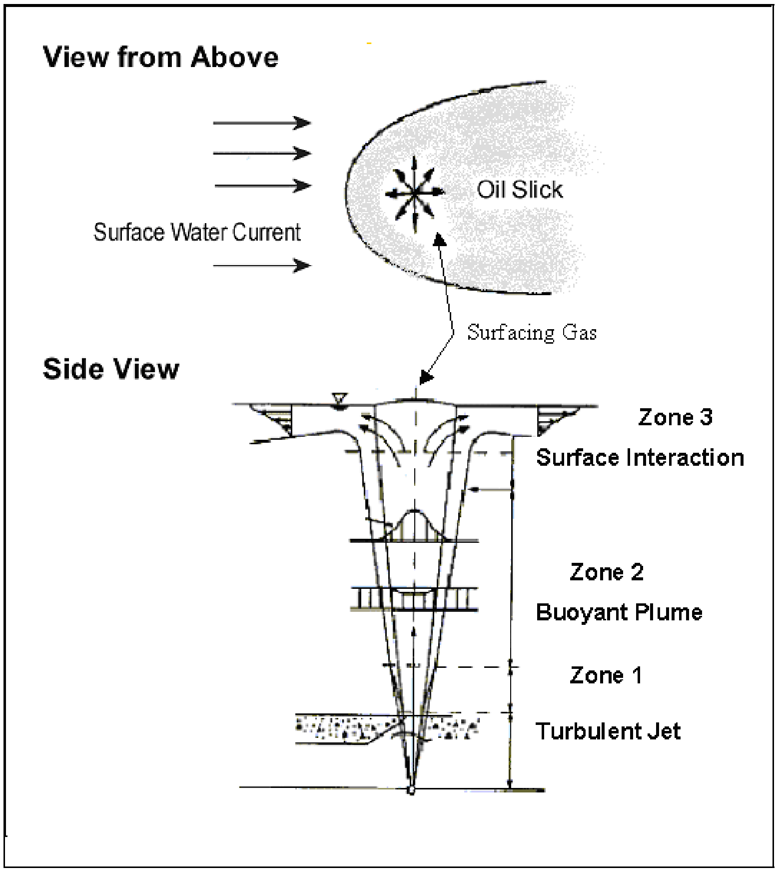


Figure 2.10 Subsea Blowout Schematic

Although the terminal velocity of a gas bubble in stationary water is only about 0.25 m/sec, velocities in the center of blowout plumes can reach 5 to 10 m/sec due to the pumping effect of the rising gas in the bulk liquid. That is, the water surrounding the upward moving gas is entrained and given an upward velocity, which is then increased as more gas moves through at a relative velocity of 0.25 m/sec. When the plume becomes fully developed, a considerable quantity of water containing oil droplets is pumped to the surface.

In the surface interaction zone, the upward flow of water created by the blowout turns and moves in a horizontal layer away from the center of the plume. The prevailing ocean surface water current pushes against this blowout-driven radial flow and turns it down-current to form a surface influence as illustrated in Figure 2.10 (above view). This surface influence carries the oil and spreads it over the surface up to the point where the water, oil and gas flow generated by the blowout no longer affects the surface water motion (between 1- to 1.5-slick widths down-current). At this point, the oil moves with the prevailing currents and spreads as any batch spill of oil would. The gas exits from the center of the blowout driven plume and causes a surface disturbance identified by the arrows in the top view of Figure 2.10. At the surface, the oil is spread much faster than conventional batch oil spill spreading rates by the water flow generated by the gas bubble plume. This results in an initial slick that is larger in area but much thinner than would be experienced in a typical surface batch spill of oil.

If a blowout occurs under moving pack ice, the oil will thinly coat the underside of the ice and rise to the water surface between the ice pieces with a thickness and area similar to those for the open water condition. The oil present under the ice will travel with the ice and remain relatively fresh until released to the surface water when the ice melts. It is important to note that Corridor plans to drill during ice-free periods.

The equations of motion and supporting parameters developed by Fannelop and Sjoen (1980) have been used to model the behaviour of subsea gas and oil releases. These equations and their numerical solution form the basis for the subsea modelling component of the SL Ross Oil Spill Model (SLROSM) used in this report to estimate the oil slick characteristics from shallow subsea blowouts.

Above-Surface Blowouts

Oil released during a blowout from an offshore drilling installation above the water's surface will behave differently than that from a subsurface discharge. The gas and oil will exit at a high velocity from the discharge location and will be fragmented into a cloud of fine droplets. The height that this cloud rises above the release point will vary depending on the gas velocity and the prevailing wind velocity. Atmospheric dispersion processes and the settling velocity of the oil particles determine the fate of the oil and gas at this point.

A simple Gaussian model of this behaviour that can be used to predict the concentrations of oil and gas downwind from the release point is illustrated in Figure 2.11. Atmospheric dispersion is controlled in part by atmospheric turbulence that is influenced by solar radiation, wind speeds and temperatures. On clear, sunny days, with light winds, solar radiation will create highly turbulent conditions.

Overcast conditions regardless of the winds will result in a neutral atmospheric stability. Low winds will tend to make mixing more prominent whereas high winds tend to reduce the vertical and lateral mixing conditions. The shape of the concentration profile of the plume will vary depending on the atmospheric stability. In very stable conditions, the spread both vertically and laterally will be less than in very turbulent conditions.

The atmospheric plume representation shown in Figure 2.11 can also be used to illustrate the behaviour of oil droplets with the following two modifications. The plume centerline is sloped down to account for the oil droplets' fall velocities. The oil will "rain" down, with the larger droplets falling closer to the release point. As oil drops fall, they will also be spread by atmospheric turbulence. A portion of the falling oil evaporates and the remainder eventually lands on the water and is carried down current. As water passes under the area of falling oil, it will be "painted" by the falling oil and an accumulation of oil over the width of the fallout zone will occur. Changing wind and water current directions will affect the ultimate distribution of the oil on the water surface in the fallout zone. If the gas and oil are blowing through the drilling rig derrick or some other obstruction, some of the oil droplets may agglomerate on the obstruction(s) and flow down onto the rig floor and eventually to the water surface. This portion of the oil will then behave more like a continuous surface release of oil.

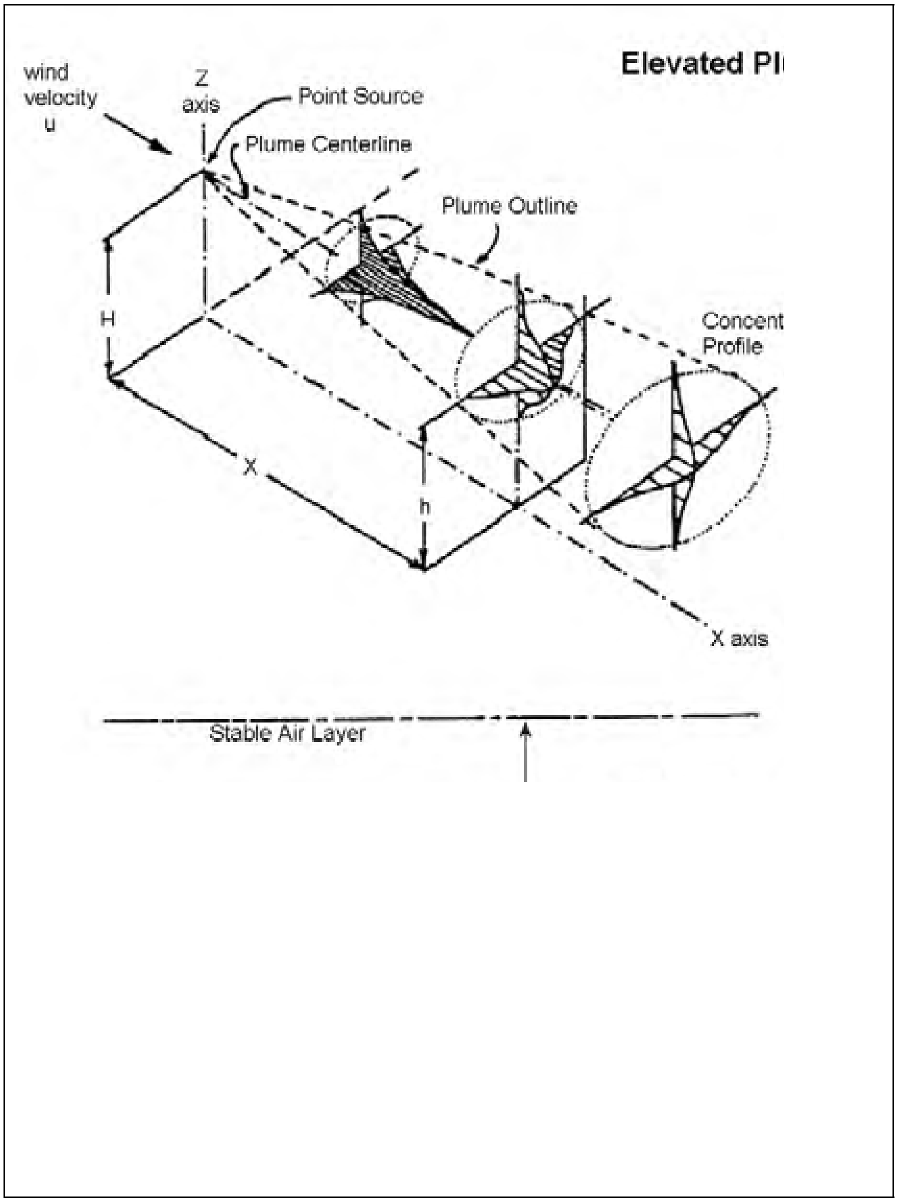


Figure 2.11 Above-sea Blowout Plume Behaviour Schematic

If the surface blowout occurs in the presence of pack or drift ice, some percentage of the oil will fall onto the surface of the ice passing by the blowout zone. The amount that reaches water or ice will depend on the ice cover concentration. Some portion of the oil will evaporate from the ice surface dependent on the amount of snow present and the remainder will be released to the water surface when the ice melts.

2.12.2.2 Fate and Behaviour Modelling Inputs

The oil property data, spill flow rates and volumes, air and water temperatures, winds and water currents used in the spill behaviour and trajectory model for this project are described in the following sections.

Oil Properties

Several characteristics of the geology in the Maritimes Basin (Old Harry area) compare favourably to the geological conditions encountered in the Scotian Basin. The clastic reservoir rocks in the fields on the Scotian Shelf typically comprise fluvial and shallow marine, stacked, sandstone sequences that are analogous to the fluvial sandstone reservoir rocks at Old Harry. Of particular note is the known kerogen type in both basins is Types II-III and III. In addition, light oil was produced from the Cohasset / Panuke / Balmoral Fields on the Scotian Shelf. Consequently, Corridor geoscientists have selected the Cohasset oil from the Scotian Basin as an appropriate surrogate for the oil that could be found at Old Harry. Summaries of the fresh and weathered oil property data for Cohassett crude oil are provided in Table 2.15.

Table 2.15 Fresh and Weathered Properties of the Surrogate Cohasset Crude Oil

Cohassett Crude	**API° gravity 47.5**			
Oil Property	**Temperature °C**	**Weathered State of Oil**		
		0% Evaporated	**11% Evaporated**	**26% Evaporated**
Density (g/cm^3)	0	0.800	0.815	0.847
	15	0.790	0.805	0.837
Dynamic Viscosity (mPa.s)	0	3	4	7
	15	2	3	5
Kinematic Viscosity (mm^2/s)	0	4	5	8
	15	3	4	6
Interfacial Tension (dyne/cm)	Oil/Air	27.6	30.2	31.4
	Oil/Sea Water	17.2	16.7	17.5
Pour Point (°C)		-30	-18	-12
Flash Point (°C)		32	40	82
Emulsion Formation and Tendency				
Tendency		Unlikely	Unlikely	Unlikely
Stability		Unstable	Unstable	Unstable
Water Content		0%	0%	0%
Data source: http://www.etc-cte.ec.gc.ca/databases/OilProperties/oil_C_e.html				

Property data for diesel oil was taken from Environment Canada's online oil property database (www.etc-cte.gc.ca/databases/spills/oil_prop_e.html) for use in the diesel spill scenario modelling.

The oil property modelling parameters that were used in the SLROSM are listed in Table 2.16. These parameters were derived using the fresh and weathered oil property data shown in Table 2.15.

Table 2.16 Oil Property Parameters Used in SLROSM Spill Modelling

Oil Property	Surrogate Crude Oil	Diesel Fuel
Initial Density (kg/m3)	790.00	827.0
Standard Density Temperature (°K)	288.00	288.0
Density Constant 1	174.30	200.0
Density Constant 2	0.731	0.733
Initial Viscosity (cP)	2.607	5.0
Standard Viscosity Temperature (°K)	288.00	313.0
Viscosity Constant 1	3.350	8.755
Viscosity Constant 2	974.00	1607.0
Oil Water Interfacial Tension (dynes/cm)	15.0	37.0
Water Interfacial Tension Constant	-0.765	0.0
Oil Air Interfacial Tension (dynes/cm)	25.6	22
Air Interfacial Tension Constant	0.2280	0.0
Initial Pour Point (°C)	244.916	243.0
Pour Point Constant	0.1524	0.139
ASTM Distillation Constant A (slope)	244.9163	285.0
ASTM Distillation Constant B (intercept)	443.00	473.0
Emulsification Delay	999999999.	999999999.
Fv Theta A	6.3	Diesel Fuel
Fv Theta B	10.3	827.0

Discharge Volumes and Flow Rates

Instantaneous batch spills of 1.59 m^3 and 15.9 m^3 (10 and 100 petroleum barrels) have been modelled for marine diesel. These two spill sizes have been chosen as representative of medium and large sized batch spills from offshore drilling operations. To put these volumes in perspective, in the 14 years of operations at the Hibernia facility the maximum fuel oil spill size from a vessel transfer operation has been approximately 0.2 m^3 and the maximum fuel oil spill from all operations was approximately 2 m^3 (C-NLOPB 2011).

The modelling of the continuous release of gas and crude oil from well blowouts has been completed using the gas and crude oil flow rates shown in Table 2.17. The blowout flow rates identified in Table 2.17 were determined by Corridor Resource Inc. engineers based on the best available reservoir information.

Table 2.17 Spill Flow Rates and Volumes Used in Modelling

Spill Type	Source	Flow	Gas-to-Oil Flow Ratio m^3/m^3
Crude oil Blowout	Subsea (470 m water depth)	(817.6 m^3/day) (5,143 BOPD)	89
	Surface Drilling Installation	(2102.7 m^3/day) (13,226 BOPD)	89
Batch Diesel Fuel Spills	Drilling Operations	1.6 m^3 (100 bbl)	na
	Vessel Transfer	0.16 m^3 (10 bbl)	na
BOPD = barrels of oil per day			

Water Currents

Surface water current fields developed by the Ocean Sciences Division, Maritimes Region of DFO (Tang et al. 2008) were used in the spill trajectory modelling. Seasonal mean surface water velocities were provided by DFO and these were converted to a map format used by the SLROSM. These water currents were combined with wind data to determine the initial slick characteristics and their subsequent movement.

Air and Water Temperatures

The monthly average air and water temperatures used in the detailed fate and trajectory modelling are shown in Table 2.18. Air and water temperatures used in the seasonal oil fate modelling are also shown in Table 2.18. These data are from LGL (2007).

Table 2.18 Average Monthly and Seasonal Air and Water Temperatures

	Average Temperatures (°C)											
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Air	-4.5	-6.5	-3.0	1.0	6.0	10.0	14.5	16.0	13.0	7.5	4.0	-2.5
Water	0.5	-1.0	-1.0	0.0	1.5	5.0	10.5	15.2	15.5	12.0	7.0	3.5
Season	Winter			Spring			Summer			Fall		
Air	-4.7			5.7			14.5			3.0		
Water	-0.5			2.2			13.7			7.5		
Source: derived from Figure 2.17, LGL 2007												

Winds

The MSC50 Wind data set (Swail et al. 2006) was used in the detailed spill trajectory modelling completed in this study. The data set has wind and wave data for the years 1954 to 2005. Six-hourly wind speed and direction data were extracted from the full MSC 50 data set at grid points with 0.5 degree spacing over the study area. The seasonal spill behaviour modelling used the average wind speeds shown in Table 2.19. These data are from LGL (2007).

Table 2.19 Seasonal Average Wind Speeds

Average Wind Speeds by Season (m/s)			
Winter	**Spring**	**Summer**	**Fall**
7.96	5.72	5.72	8.59
Source: derived from Table 2.3, LGL 2007			

Additional details on the algorithms employed in the SLROSM spill model used in the simulations are provided in Tables 2.20 and 2.21. The modelling parameters provided in Table 2.15 were used in the oil property change relationships shown in Tables 2.20 and 2.21.

Table 2.20 Comparison of Model Oil Fate and Behaviour Equations

Batch Spill	Above-Sea Blowout	Subsea Blowout
INITIAL SLICK CHARACTERISTICS		
a) Initial thickness of thick slick = 2 cm	a) Volume mean diameter of oil spray droplets calculated using atomization equations of Deyson and Karian (1978) as described in S.L. Ross and Energetex (1985)	a) Volume mean diameter of oil droplets produced at wellhead calculated using atomization equations of Deyson and Karian (1978) as described in S.L. Ross and Energetex (1985)
b) Initial thick slick area = spill volume/2 cm	b) Atmospheric dispersion and settling of droplets estimated using Turner’s (1970) equations	b) Initial width and thickness of slick downstream of blowout are calculated using subsea blowout plume equations of Fannelop and Sjoen (1980) as described in S.L. Ross (1982), using gas & oil flowrates, well depth and surface current
c) Initial thin slick area = 8 x thick area	c) Amount of evaporation of oil droplets in air circulated using modified evaporative exposure equation given in S.L. Ross and DMER (1988)	c) If the fresh oil’s pour point exceeds the sea temperature, the slick consists as discrete droplets or “peas”
d) Initial thin volume = thin area x 1μm	d) Initial oil properties are calculated based on initial evaporation and desired sea temperature	d) Initial evaporation, emulsification and natural dispersion are back-calculated from the release point to the time required to reach the initial width based on a geometric mean thickness between the two locations
e) Oil properties corrected to desired sea temperature	e) If the oil’s pour point exceeds the sea temperature, the oil does not form a slick on the sea surface but forms a series of discrete droplets or “peas”	e) The initial slicklet thickness is corrected to account for initial evaporation, emulsification, and natural dispersion
	f) The initial width and thickness of the slick are calculated using a surface current, b) and c) above; a slicklet (of length 100s x surface current) is subsequently modelled	f) Initial oil properties area calculated based on initial evaporation, emulsification, and desired sea temperature
SPREADING		
Thick Slick Modified Mackay et al. (1980) equations, based on Fay gravity-viscous including emulsion viscosity; if oil’s pour point exceeds sea temperature the thick slick spreading ceases: $\Delta A_{thick} = 2.2(1025 - \rho_o) \times 9.82 / (\rho_o \mu_o/10^3)^{1/2})^{2/3} (X_{thick})^{4/3} (A_{thick})^{1/3} \Delta t - (1 \times 10^{-6} \Delta_{thin}/X_{thick})$	Thick Slick Modified Fay “point source” surface tension-viscous equation (for lateral spreading only); include emulsion viscosity; if spreading coefficient falls below 0, thick slick spreading ceases: $\Delta W_{thick} = \frac{3}{4} (\Theta)^{1/2}/(\Lambda_o \mu_o/10^3 t)^{1/2} \Delta t$	Thick Slick As per above-sea blowout

Batch Spill	Above-Sea Blowout	Subsea Blowout
Thin Slick Modified Mackay et al. (1980) equations, based on Fay surface-tension viscous; include oil viscosity; if spreading coefficient falls below 0, thin spreading stops; think slick 'fed' by thick slick: $\Delta A_{thin} = 4.55 (\theta/(\rho_o\mu_o/10^3)^{1/2})^{1/3} \exp (-0.003/X_{thick})\Delta t$	Thin Slick As for thick slick, but using weathered oil properties, instead of emulsion properties	Thin Slick As per above-sea blowout
EVAPORATION		
Uses modified evaporative exposure (Stiver and Mackay 1983) based on S.L. Ross and DMER 1988; includes internal mass transfer resistance if the oil's pour point exceeds ambient temperature by 15°C		
Thick Slick $\Delta F_v= (\Delta t/X_{thick}(HC/10^{-6} X_{thick} + (1/k))(\exp ((6.3 – (10.3(T_0 + T_G F_v)/T_k)$ Where: k= 0.0015 U0.78 (after Mackay et al. 1980) C= 1 for slick C= 6 for droplets of gelled oil H= 0 if the oil's pour point is less than 15°C above the sea temperature H= exp (6.3-10.3 ($T_0 + T_G F_v)/T_k$) if the oil's pour point exceeds sea temperatures by 15°C or more.		
Thin Slick Same as for thick slick, with C=1 and H=0 at all times. Initial fraction evaporated from the slick is 30%; maximum fraction evaporated from thin slick is 75%.		
NATURAL DISPERSION		
Thick Slick $\Delta F_{NDTHICK}= 2.78 \times 10^{-6} (U/8)^2 \Delta t/(\theta_{o/w}\mu_0(1025 – \Lambda_0))X_{THICK}$ If the oil's pour point exceeds the sea temperature by 15°C or more, or the oil is present as droplets, then $\Delta F_{NDTHICK}=0$		
Thin Slick As above except using viscosity, density and thickness of thin slick; no pour point cut-off		
EMULSIFICATION		
Thick Slick $\Delta F_w = 2 \times 10^{-6}(U+1)^2 (1-1.33F_w)\Delta t$ After Zagorski & Mackay 1982. Oil does not begin to emulsify until it has reached a specified degree of evaporative exposure determined based on analysis of oil (Bobra 1989), if the oil is in the form of droplets it does not emulsify.		
Thin Slick No emulsification of thin slick occurs.		

Table 2.21 Expressions Used to Relate Weathering and Temperature to Oil Property Changes in S.L. Ross Model

Property	Units	Expression
Density	Kg/m^3	$\Lambda_o[1-C1 (T-T_o] (1+C2F)$
Emulsion density	Kg/m^3	$\Lambda_o (1-F_w) + 1025 F_w$
Viscosity	mPas (cp)	$\mu[\exp (C3\{1/T – 1T_o\}) \times \exp (C4F)]$
Emulsion Viscosity	mPas (cp)	$\mu[\exp (2.5F_w/\{1-0.65F_w\})]$
Aqueous solubility	g/m^3	S.exp (C5F)
Pour Point	$^{\circ}$K	PP. (1+C6F)

Property	Units	Expression
Flash Point	°C	FIP. (1+C7F)
Fire Point	°C	FiP. (1+C8F)
Oil-Water Interfacial Tension	mN/m (dyne/cm)	θ_{ow} (1+ C69F)
Oil-Air Interfacial Tension	mN/m (dyne/cm)	θ_{oa} (1+ C10F)

2.12.2.3 Fate and Behaviour Modelling Results

Instantaneous batch spills of 1.59 and 15.9 m^3 (10 and 100 barrels) have been modelled for marine diesel. These two spill sizes have been chosen as representative of medium- and large-sized batch spills from offshore drilling operations. To put these volumes in perspective, in the 14 years of operations at the Hibernia facility, the maximum fuel oil spill size from a vessel transfer operation has been approximately 0.2 m^3 (approximately 1.3 barrels) and the maximum fuel oil spill from all operations was approximately 2 m^3 (12.5 barrels) (C-NLOPB 2011c).

The modelling of the continuous releases of gas and crude oil from well blowouts has been completed using the gas and crude oil flow rates shown in Table 2.14. The blowout flow rates identified in Table 2.22 were determined by Corridor engineers based on the best available reservoir information.

Table 2.22 Spill Flow Rates and Volumes Used in Modelling

Spill Type	Source	Flow	Gas-to-Oil Flow Ratio (m3/m3)
Crude oil Blowout	Subsea (470 m water depth)	817.6 m^3/day (5,143 bopd)	89
	Surface Drilling Installation	2,102.7 m^3/day (13,226 bopd)	89
Batch Diesel Fuel Spills	Drilling Platform Operations	15.9 m^3 (100 bbl)	na
	Vessel Transfer	1.59 m^3 (10 bbl)	na

Batch Diesel Spill Fate Modelling

The fate of the “batch” spills for the four seasons (using the average seasonal air and water temperatures and wind speeds described in SL Ross (2011)) are provided in Table 2.23. The ranges reported below reflect the differences due to seasonal temperature and wind variations. Winter-fall and spring-summer results are quite similar due to similar environmental conditions for these seasonal pairings.

The small spills (1.59 m^3) have initial thick oil widths of 10 m, which grow to maximums of 52 to 58 m over the lives of the spills. The surface oil slicks from these small diesel spills will survive between 17 and 36 hours. The spring and summer discharges lose 36 and 40 percent of the diesel to evaporation, respectively, while the winter and fall scenarios lose 27 and 30 percent by evaporation, respectively. The remaining oil is dispersed into the upper water layer, where it further diffuses both laterally and with depth. The surface slicks will travel between 17 and 26 km from the source prior to dissipation from the surface (defined as the point at which the slick reaches a thickness of 10 μm or 0.01 mm).

Table 2.23 Batch Diesel Spill Characteristics

Spill Volume m3 (bbl)	Season	Initial Slick Width (m)	Slick Survival Time (hr)	Max. Slick Width (m)	Total Evap. %	Dist. to Loss of Slick (km)	Peak Disp. Oil Conc. (ppm)	Time to Peak Conc. (hr)	Time to 0.1 ppm (hr)	Dispersed Oil Plume Width at 0.1 ppm (m)	Distance to 0.1 ppm (km)
1.59 (10)	Winter	10	20	55	27	20	0.42	2	7	490	7.0
1.59 (10)	Spring	10	36	58	36	26	0.20	1	4	275	2.8
1.59 (10)	Summer	10	32	56	40	17	0.21	1	4	275	2.3
1.59 (10)	Fall	10	17	52	30	18	0.47	1	7	490	7.5
15.9 (100)	Winter	32	30	133	27	31	0.92	3	24	2,020	24
15.9 (100)	Spring	32	49	139	35	35	0.43	3	14	1,140	10
15.9 (100)	Summer	32	43	134	38	24	0.43	3	13	1,060	7
15.9 (100)	Fall	32	25	127	29	26	1.02	3	25	2,140	26

The oil being dispersed into the water column under the slick will reach maximum concentrations of 0.2 to 0.47 ppm within one to two hours after release. It has been assumed that the oil will mix in the upper 30 m of water, as this is the minimum surface water mixing depth reported in the literature for the region (Drinkwater and Gilbert 2004). The subsurface oil also diffuses laterally as it is moved away from the spill site by the prevailing surface water currents. The oil dispersed into the water column has been tracked until its concentration drops to 0.1 ppm of total petroleum hydrocarbon. This is the exposure concentration below which no significant biological effects are expected for sensitive marine resources (Trudel et al. 1989; French-MacCay 2004). For the small diesel spills, the dispersed oil concentration in the water column will drop to 0.1 ppm within four to seven hours. By the time the dispersed oil drops to 0.1 ppm, the dispersed oil zone will be 275 to 490 m in diameter, 30 m deep and will be between 2.3 and 7.5 km from the spill site.

The large spills (15.9 m^3) have initial thick oil widths of 32 m that grow to maximums of 127 to 139 m over the life of the spill. The surface oil slicks from these larger diesel spills will survive between 25 and 49 hours. The spring and summer discharges lose 35 and 38 percent of the diesel to evaporation, respectively, while the winter and fall scenarios lose 27 and 29 percent by evaporation, respectively. The remaining oil is dispersed into the upper water layer. The surface slicks will travel between 24 and 35 km from the source prior to dissipation from the surface.

Maximum in-water oil concentrations from the dispersed oil will reach 0.43 to 1.02 ppm within three hours after release for these larger diesel spills. The dispersed oil concentration in the water column will drop to 0.1 ppm within 13 to 25 hours. By the time the dispersed oil drops to 0.1 ppm, the dispersed oil zone will be 1,060 to 2,140 m in diameter, 30 m deep and will be between 7 and 26 km from the spill site.

Surface Blowout Fate and Behaviour Modelling

In this scenario, a blowout occurs on the surface drilling rig resulting in a discharge of 2,102.7 m^3/day of crude oil with a gas-to-oil ratio (GOR) of 89 m^3/m^3, as per Table 2.8. The rig is not damaged and remains in position throughout the blowout period. The gas exits at the drill floor (21 m above the water surface) at high velocity and sprays the crude oil into small diameter droplets. These droplets are propelled upward by the jet of gas, contact the derrick and agglomerate to a size of approximately 0.5 mm. This volume median drop size has been selected for the surface blowout modelling based on model calibration results using data from the Shell *Uniacke G-72* blowout that occurred off of Nova Scotia in 1984. These droplets rain down on the surface of the water downwind of the rig. Most of the droplets fall onto the water surface within a few hundred metres of the rig in a narrow swath and re-coalesce to form a thin slick. Minor differences in the initial slick characteristics and change in crude oil property over time will exist depending on the season (due to temperature and wind speed differences). The ranges of values reported below for the slick and dispersed plume characteristics reflect variations due to the seasonal environmental inputs. The results of the fate modelling are summarized in Table 2.24.

Table 2.24 Surface Crude oil Blowout Spill Characteristics

Spill Flow Rate m3/day (bopd)	Season	Initial Slick Width (m)	Initial Slick Thick (mm)	Evap. In Air %	Slick Survival Time (hrs)	Total Evap. %	Peak Disp. Oil Conc. (ppm)	Time to 0.1 ppm Disp. Oil Conc. (hr)	Dispersed Oil Plume Width at 0.1 ppm Disp. Oil conc. (km)	Distance from Source at 0.1 ppm Disp. Oil (km)
Drill site located at 48.051471 N; -60.394274 W (release 21m above water surface)										
2,103 (13,226)	Winter	70	1.0	30	1.6	35	6.0	15	1.2	3.4
2,103 (13,226)	Spring	54	1.6	39	2.6	44	3.4	15	1.2	3.7
2,103 (13,226)	Summer	54	1.6	46	2.4	50	3.8	15	1.2	3.8
2,103 (13,226)	Fall	75	0.8	36	1.1	41	6.8	14	1.1	3.8

Using the flow rates, typical drilling rig height, pipe diameter and environmental conditions appropriate for the Old Harry drilling operation, the model estimates that the slick at source will be between 54 and 75 m wide and 0.8 to 1.6 mm thick. The crude oil making up the slick will have lost between 30 and 46 percent (depending on the season) of its volume through evaporation of the crude oil droplets in the air. The crude oil droplets will re-coalesce to form a thin slick on the water surface and this crude oil will immediately begin to disperse and continue to evaporate. The slicks will survive on the surface for a few hours at most (1.1 to 2.6 hours) as they move away from the spill source under the influence of winds and surface water currents. Peak in-water crude oil concentrations will be between 3.4 and 6.8 ppm and the dispersed oil plume will diffuse to 0.1 ppm concentration within 14 to 15 hours. The dispersed oil plume will be 1.1 to 1.2 km wide at this point and will have travelled 3.4 to 3.8 km from the source.

Subsea Blowout Fate and Behaviour Modelling

The crude oil flow rate modelled was 817.6 m^3/day and the GOR used was 89 m^3/m^3, as per Table 2.25. The fluids erupt from the seabed and the turbulent flow breaks the crude oil up into small droplets. These droplets are then quickly carried to the surface by the water being pumped to the surface by the gas bubble plume.

Table 2.25 Subsea Blowout Spill Characteristics

Spill Flow Rate m3/day (bopd)	Season	Initial Slick Width (m)	Initial Slick Thick (mm)	Slick Survival Time (min)	Total Evap. %	Peak Disp. Oil Conc. (ppm)	Time to 0.1 ppm Disp. Oil Conc. (hr)	Dispersed Oil Plume Width at 0.1 ppm Disp. Oil conc. (km)	Distance from Source at 0.1 ppm Disp. Oil (km)
Drill site located at 48.051471 N; -60.394274 W (470 m water depth)									
817 (5,143)	Winter	1,647	0.028	1	16	0.8	30	4.5	5.1
817 (5,143)	Spring	2,165	0.028	2	25	0.7	35	5.7	6.6
817 (5,143)	Summer	2,537	0.028	2	29	0.7	38	6.4	8.1
817 (5,143)	Fall	1,478	0.028	1	19	0.7	27	4.0	6.3

At the surface, the crude oil drops spread to form a thin slick, since the ambient temperature in all seasons is above the fresh crude oil's initial pour point. The entrained water flow creates an initial slick that extends away from the source. Near the source, there will be a localized zone of surface turbulence created by the exiting gas. The initial oil slick characteristics and ultimate fate of the surfacing oil are summarized in Table 2.25.

In general, the initial oil slicks from these subsea blowouts will be wide, thin and non-persistent due to the radial spreading caused by the outflow of water brought to the surface by the gas bubble plume and the light nature of the surrogate crude oil. The initial width of the slicks will vary between 1,478 and 2,537 m. These widths are estimated at the point where the surface water flow created by the blowout gas plume is no longer influencing the surface oil behaviour. The initial slick thicknesses will be only 0.028 mm, or 28 microns. Because of this very thin initial oil thickness, the model predicts that the surfacing light crude oil will completely evaporate and disperse into the water column within minutes. Traces of surface oil may persist for longer periods but it is unlikely that significant patches of thick oil will survive for extended periods assuming average seasonal environmental conditions.

Between 16 and 29 percent of the oil will evaporate and the remainder will disperse. Surface slicks will not persist for any substantial period of time, but an in-water dispersed crude oil plume will be generated and move away from the source under the influence of the seasonal surface water currents. The plume will expand and diffuse to lower concentration as it moves away from the site. Maximum dispersed crude oil concentrations near the site are estimated to be between 0.7 and 0.8 ppm.

The dispersed oil plume widths where the in-water dispersed oil concentration drops to 0.1 ppm will vary from 4.0 to 6.4 km. The distances from the source where the dispersed oil plume drops to 0.1 ppm will vary from approximately 5.1 to 8.1 km.

2.12.2.4 Surface Oil Trajectory Modelling Results

Currents and wind will move spilled crude oil until it disperses into the water, evaporates or contacts land. As noted in the previous sections, spills of crude oil with characteristics similar to Cohassett will not be persistent, and surface slick survival times of only a few hours at most are likely even under relatively calm winds.

Example surface slick trajectories from the proposed exploration site have been modelled for the four seasons to show the surface area that might be affected by month-long releases of crude oil. The quantity of oil that would be released from six hours of a continuous above sea blowout has been introduced on the surface at the exploration site as a batch spill every six hours over month-long periods. This does not represent a scenario that would actually occur in a continuous blowout but rather, provides a reasonable worst-case assessment of spill behaviour. Each one of these six-hour quantities of oil has been tracked until the surface oil is completely evaporated and dispersed from the surface. This provides a worst-case estimate of surface slick extent from the site because the initial oil slick is thicker than would be produced by either an above-sea or subsea blowout. The entire history of the movement of these six-hourly releases (initiated at the start of each month for February, May, August and November, respectively, and tracked until all of the surface oil is completely dispersed) are illustrated in Figures 2.12 to 2.15. These months were chosen because they represent the middle month in each of the four seasons. These plots do not represent the area of the ocean where crude oil is present at a point in time but merely show the total area that surface oil travelled over during each one-month release of oil.

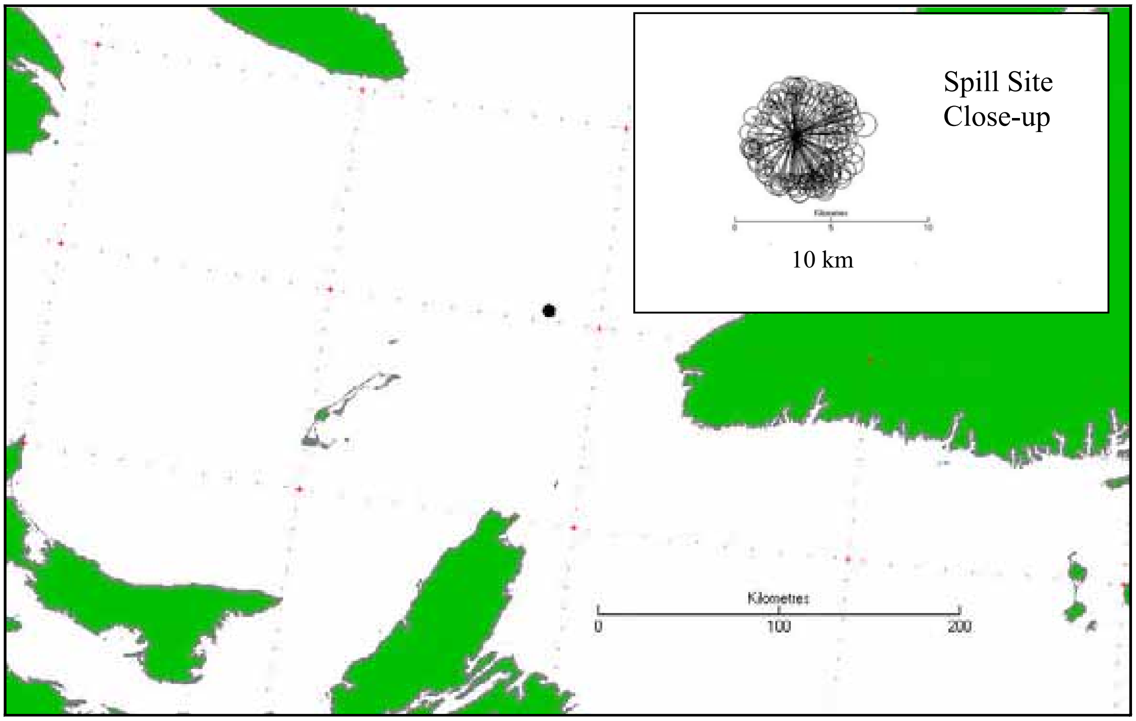


Figure 2.12 Surface Oil Trajectory Envelope for Surface Crude Oil: based on Batch Releases of Six-hour Accumulations from the Blowout, February

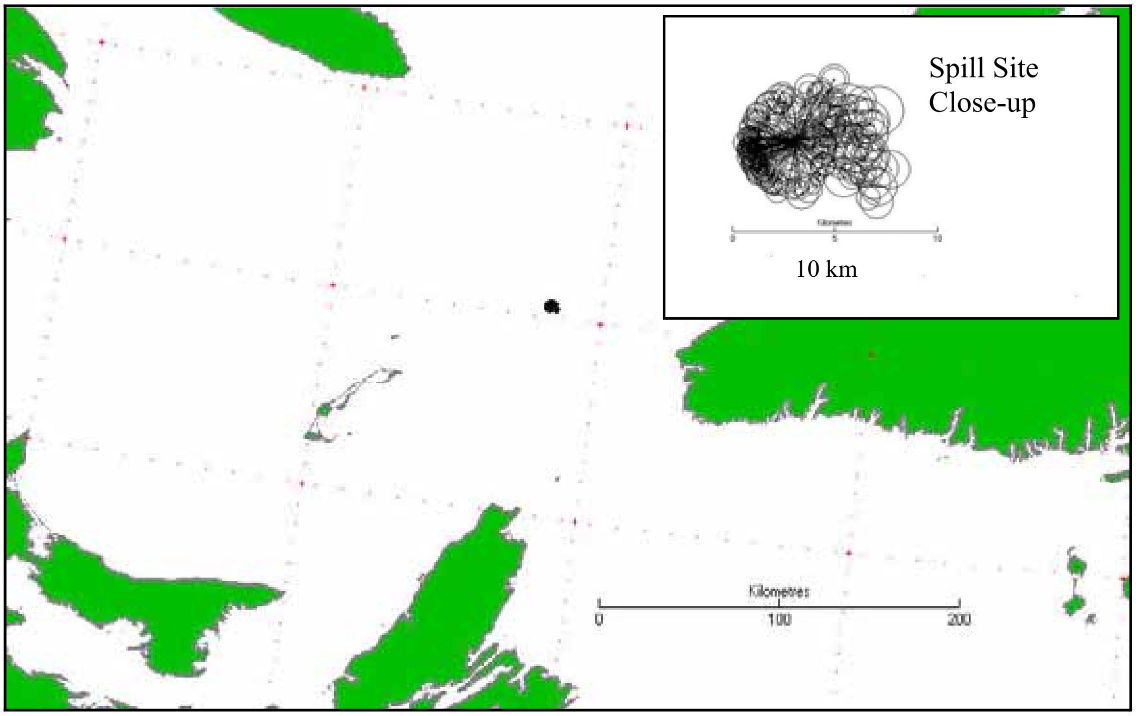


Figure 2.13 Surface Oil Trajectory Envelope for Surface Crude Oil: based on Batch Releases of Six-hour Accumulations from the Blowout, May

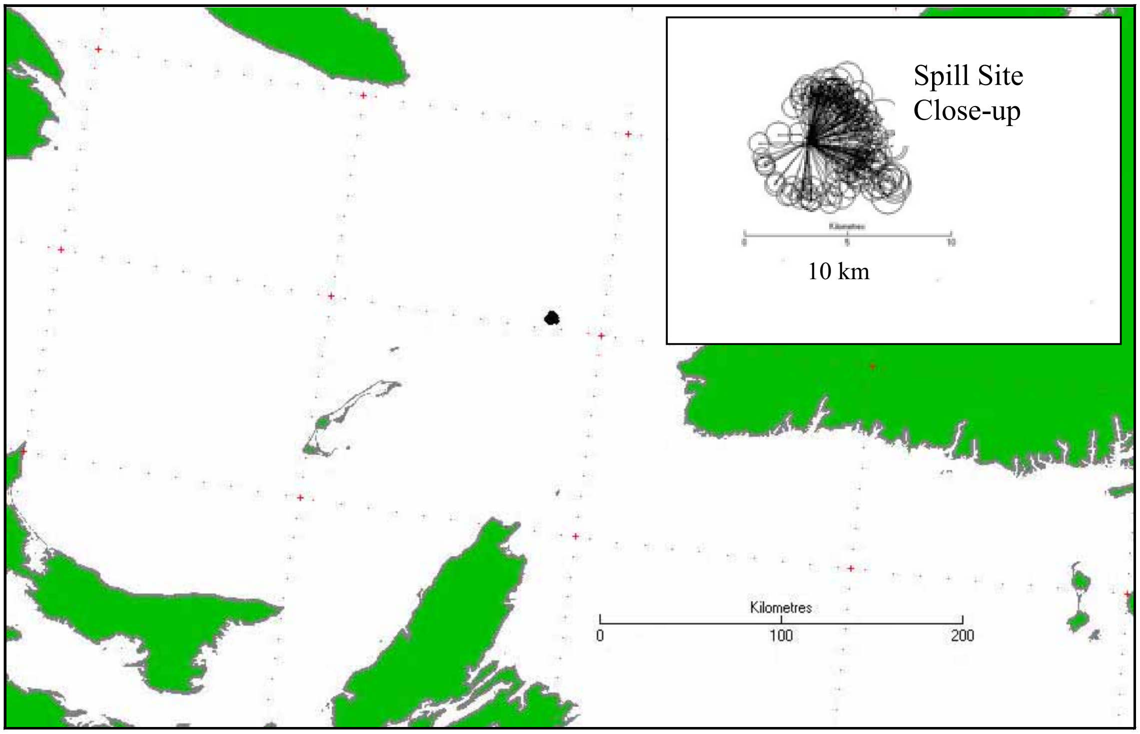


Figure 2.14 Surface Oil Trajectory Envelope for Surface Crude Oil: based on Batch Releases of Six-hour Accumulations from the Blowout, August

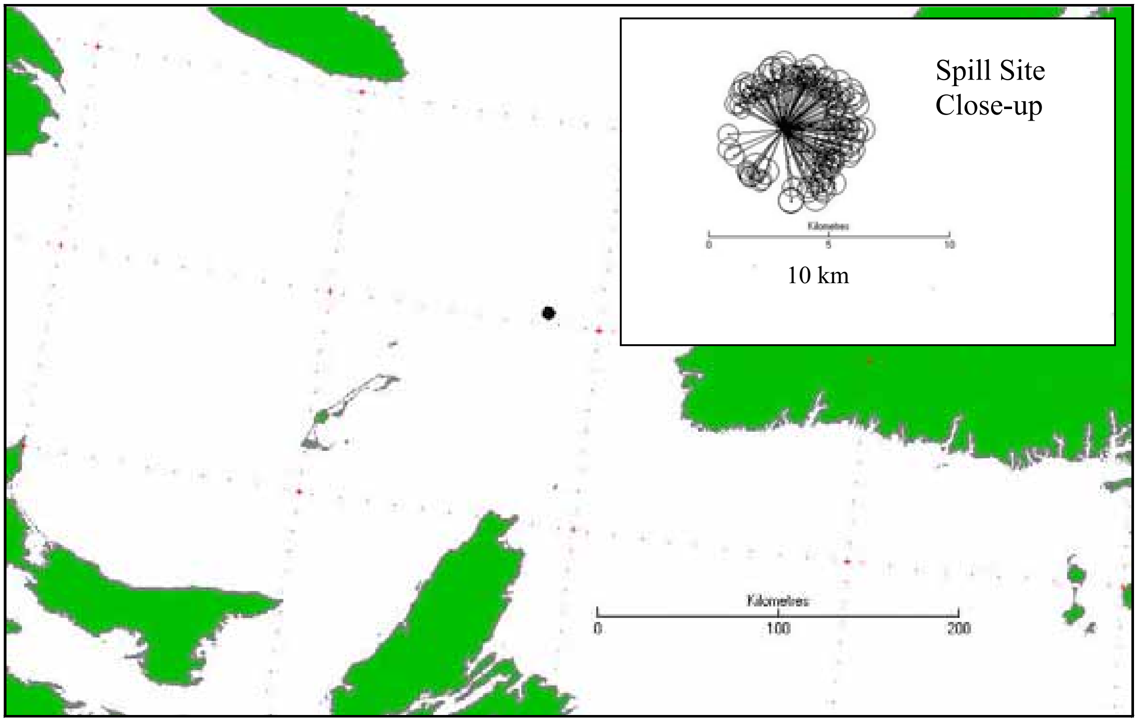


Figure 2.15 Surface Oil Trajectory Envelope for Surface Crude Oil: based on Batch Releases of Six-hour Accumulations from the Blowout, November

The circles in the figures represent the positions of 112 (28 days x 4 slicks per day) to 124 (31 days x 4 slicks per day) slicks of crude oil reported every 1.5 hours. The total areas of ocean surface that the slicks passed over during the one-month releases of crude oil, as represented by the composite line work shown in the close-up views, are relatively small. The radii of the total surface areas where surface oil passed through are only approximately 3 km from the spill source in all seasons. The areas swept by surface oil during the month-long releases are small because the light crude oil evaporates and disperses rapidly under typical weather conditions. Each six-hourly release of oil is subjected to different wind speeds and directions so each surface slick will move along a different path.

SL Ross (2011) also conducted an historical surface oil spill trajectory assessment for surface oil trajectory of above-sea blowouts (including alternative trajectory assessments using conservative above sea blowout and accumulated six-hour batch spills reasonable worst-case oil fate modelling). The full trajectories (from source to complete loss of surface slick) of all 75,920 slicks (i.e., the maximum modelled extent of the slick) are shown in Figures 2.16 and 2.17.

Even in the most conservative modelling approach, no oil slicks reached shore; 53 percent of the slicks survived for five hours or less and only 16 percent lasted for more than 10 hours (Table 2.26). As was the case for the conservative modelling approach, no crude oil slicks reached shore; 51 percent of the slicks survived for five hours or less and only 19.3 percent lasted for more than 10 hours (Table 2.26).

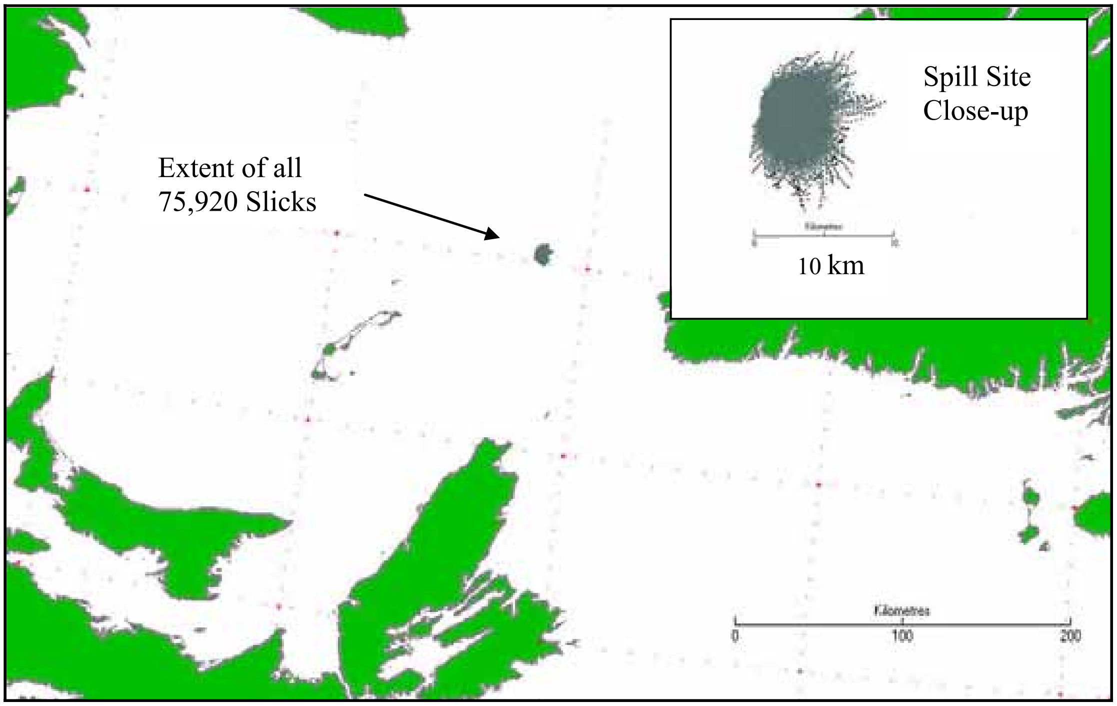


Figure 2.16 Maximum Area of Ocean Surface Swept by Oil from 52 Years of Above Sea Blowout Simulations

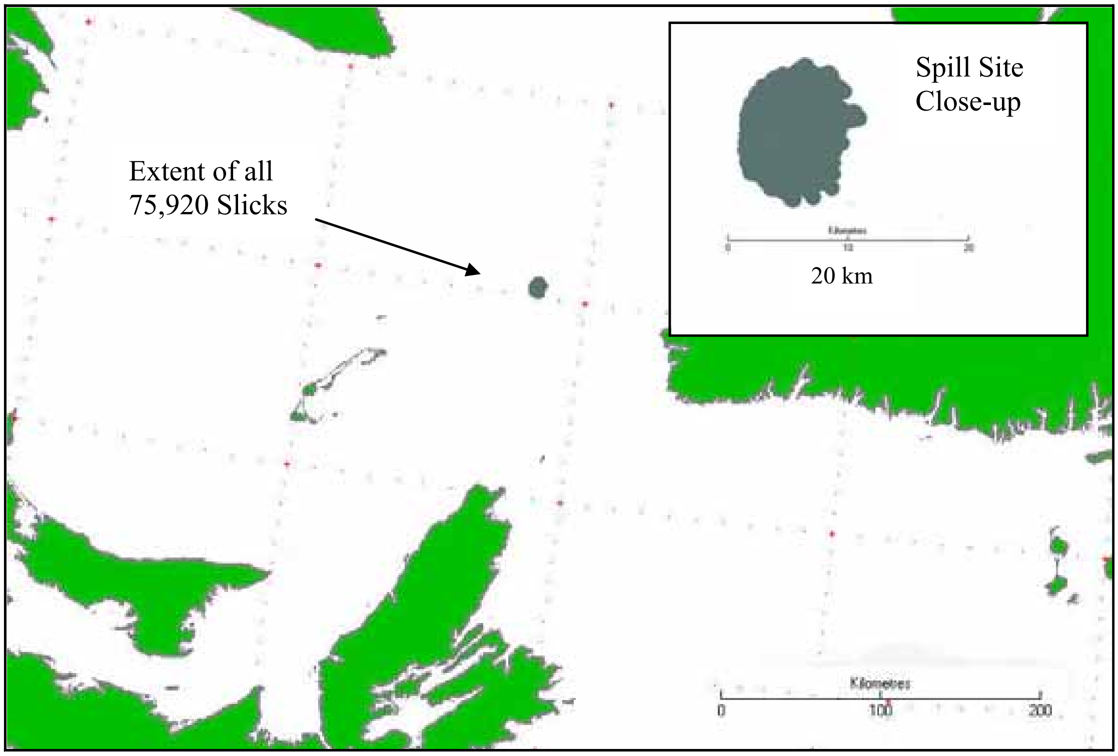


Figure 2.17 Maximum Area of Ocean Surface Swept by Oil from 52 Years of Simulations Using a Reasonable Conservative Modelling Approach

Table 2.26 Slick Shoreline Contact and Slick Life at Sea: Conservative and Reasonable Worst-case Modelling Approach

Month	Number of Slicks Tracked	% of Slicks Tracked Reaching Shore		Minimum Slick Life at Sea (hours)		Maximum Slick Life at Sea (hours)	
		Conservative	Worst-Case	Conservative	Worst-Case	Conservative	Worst-Case
January	6,448	0.0	0.0	0.11	0.5	16.6	18.4
February	5,824	0.0	0.0	0.13	0.6	25.0	25.6
March	6,448	0.0	0.0	0.14	0.7	27.8	29.5
April	6,240	0.0	0.0	0.15	0.7	35.7	34.7
May	6,448	0.0	0.0	0.17	0.8	56.1	51.4
June	6,240	0.0	0.0	0.22	0.9	39.0	38.3
July	6,448	0.0	0.0	0.21	0.8	37.3	36.7
August	6,448	0.0	0.0	0.15	0.7	38.0	34.7
September	6,240	0.0	0.0	0.12	0.6	34.4	31.5
October	6,448	0.0	0.0	0.10	0.5	22.8	24.3
November	6,240	0.0	0.0	0.11	0.6	24.7	24.9
December	6,448	0.0	0.0	0.09	0.5	14.6	15.3

2.12.2.5 Typical Monthly Dispersed Oil Plume Trajectories Modelling Results

The movement and extent of the oil dispersed into the water column below the surface slicks is discussed in this section. The dispersed oil plumes resulting from the simulations described in Section 2.12.3.2 are discussed in this section. Example dispersed oil plume trajectories from the proposed exploration site have been modelled for the four seasons to show the subsea regions that might be affected by month-long releases of crude oil. In these simulations, the quantity of oil that would be released from six hours of a continuous above sea blowout has been introduced on the surface at the exploration site as a batch spill every six hours over month-long periods. As discussed previously, this does not represent a scenario that would actually occur in a continuous blowout situation but rather provides a reasonable worst-case assessment of dispersed oil behaviour.

The dispersed oil is assumed to mix into the upper 30 m water layer under the slick and is then diffused laterally by ocean diffusion processes. The entire histories of the movement of the dispersed oil plumes from these six-hourly releases during the months of February, May, August and November are illustrated in Figures 2.18 to 2.21, respectively. The total volumes of ocean swept by the plumes during the one-month releases of crude oil are represented by the areas shown in the close-up views (times the 30 m mixing depth). The dimensions of the swept areas in Figures 2.18 to 2.21 vary from 18 to 22 km for the plume widths and 25 to 40 km for the plume lengths. The spill source is located at the narrow end of the plots and the general direction of movement of the plumes reflects the direction of the seasonal surface water currents in the vicinity of the drilling site. Again, these plots do not represent the extent of the in-water oil plume at any given point in time.

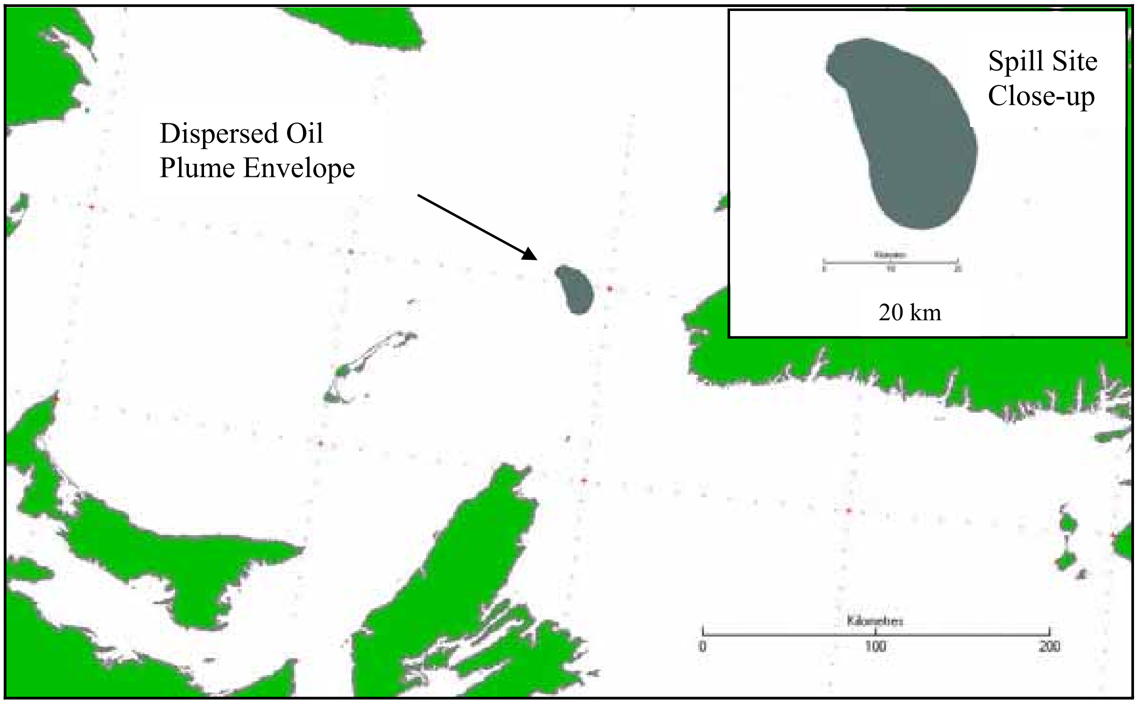


Figure 2.18 **Reasonable Worst-case Dispersed Oil Plume Trajectory Envelope: Based on Batch Releases of Six-hour Accumulations, February**

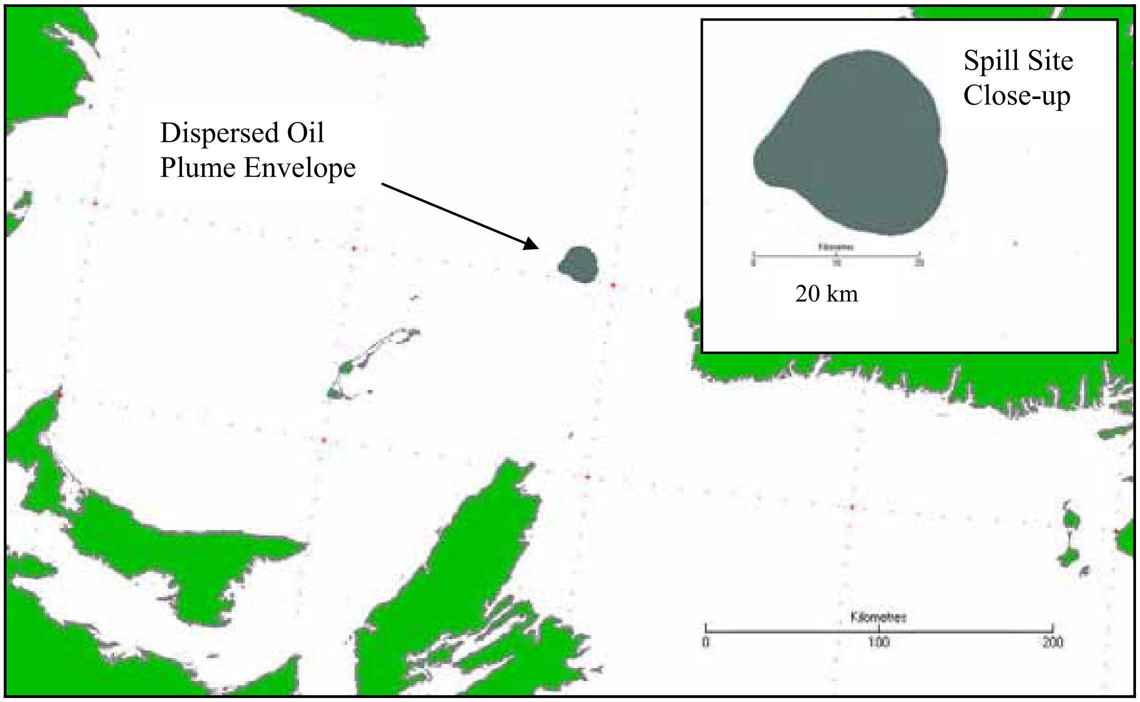


Figure 2.19 **Reasonable Worst-case Dispersed Oil Plume Trajectory Envelope: Based on Batch Releases of Six-hour Accumulations, May**

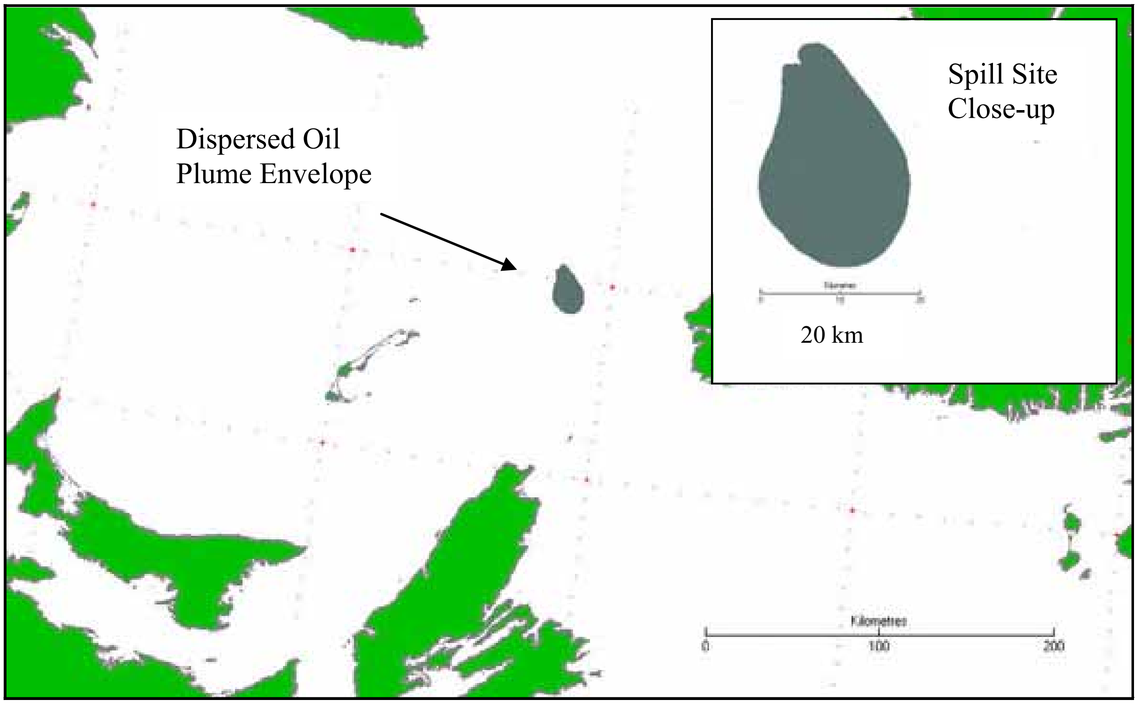


Figure 2.20 Reasonable Worst-case Dispersed Oil Plume Trajectory Envelope: Based on Batch Releases of Six-hour Accumulations, August

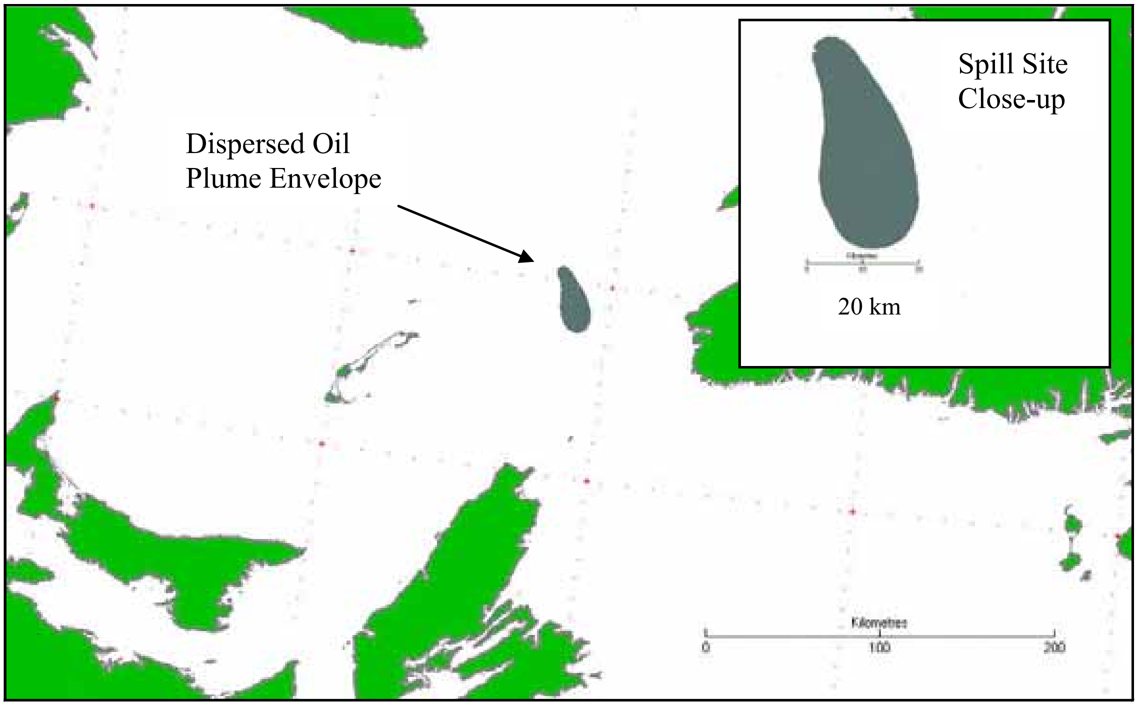


Figure 2.21 Reasonable Worst-case Dispersed Oil Plume Trajectory Envelope: Based on Batch Releases of Six-hour Accumulations, November

SL Ross (2011) also conducted an historical dispersed oil plume trajectory assessment for dispersed oil plumes from above-sea blowouts. The same two sets of simulations reported for the surface slick trajectories, the above-sea blowout release and the reasonable worst-case six-hourly batch releases, are also provided for the dispersed oil plumes (The full trajectories (from source to complete loss of surface slick) of all 75,290 slicks (i.e., the maximum modelled extent of the slick) are shown in Figures 2.22 and 2.23.

The best estimate of the maximum possible region swept by the dispersed oil plume, out to 0.1 ppm is presented in Figure 2.22 and is based on the detailed modelling of an above-sea continuous blowout as described in Section 2.12.2.3. The areas do not represent the extent of the dispersed oil plume from a single blowout event; rather the area on Figure 2.22 shows the maximum extent of dispersed oil plumes with concentrations greater than 0.1 ppm for all of the 75,290 simulations completed using 52 years of wind data. Note that the surface footprint in Figure 2.23 is larger than the continuous above-sea blowout estimate provided in Figure 2.18 due to the larger volume of oil being considered in each six-hour release.

The maximum modelled trajectory was superimposed on the Project Area (red rectangle) / Study Area (dotted line) to indicate the maximum extent to the spill in relation to these areas (Figure 2.24). As indicated in Figure 2.20, the predicted maximum extent of a spill only just extends beyond EL 1105 and does not extend much into the Study Area.

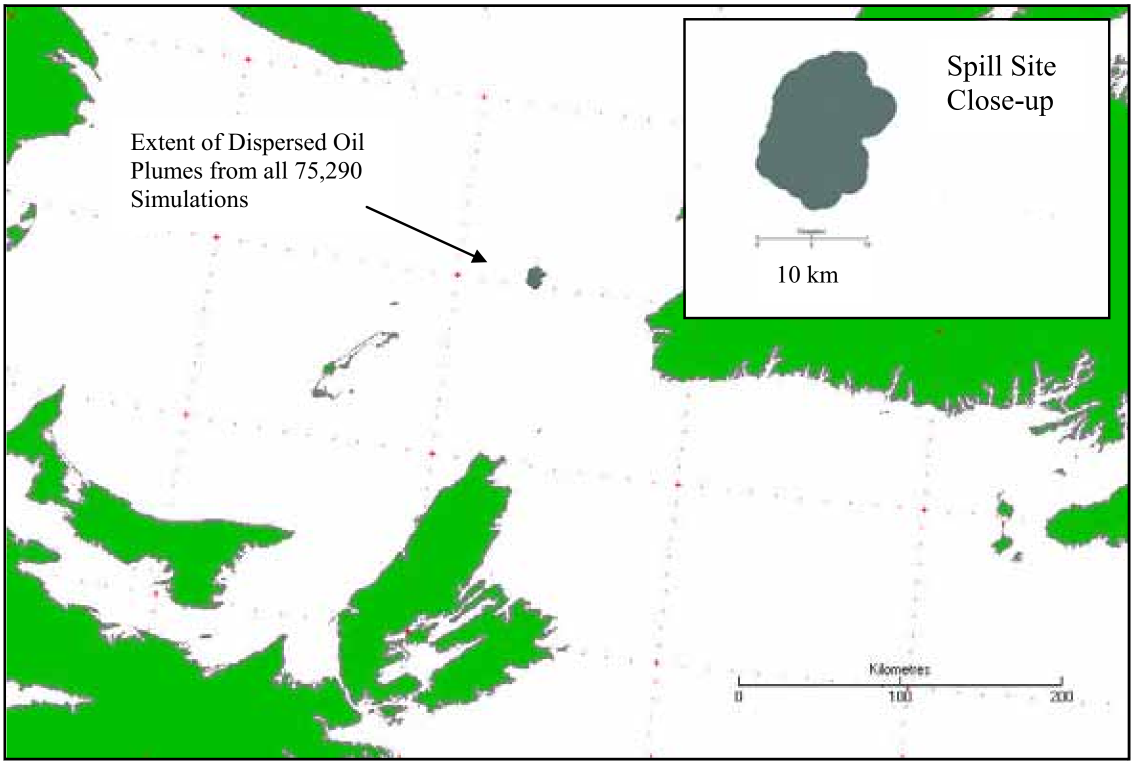


Figure 2.22 Maximum Extent of Ocean Swept by >0.1 ppm Dispersed Oil from 52 Years of Above Sea Blowout Simulations

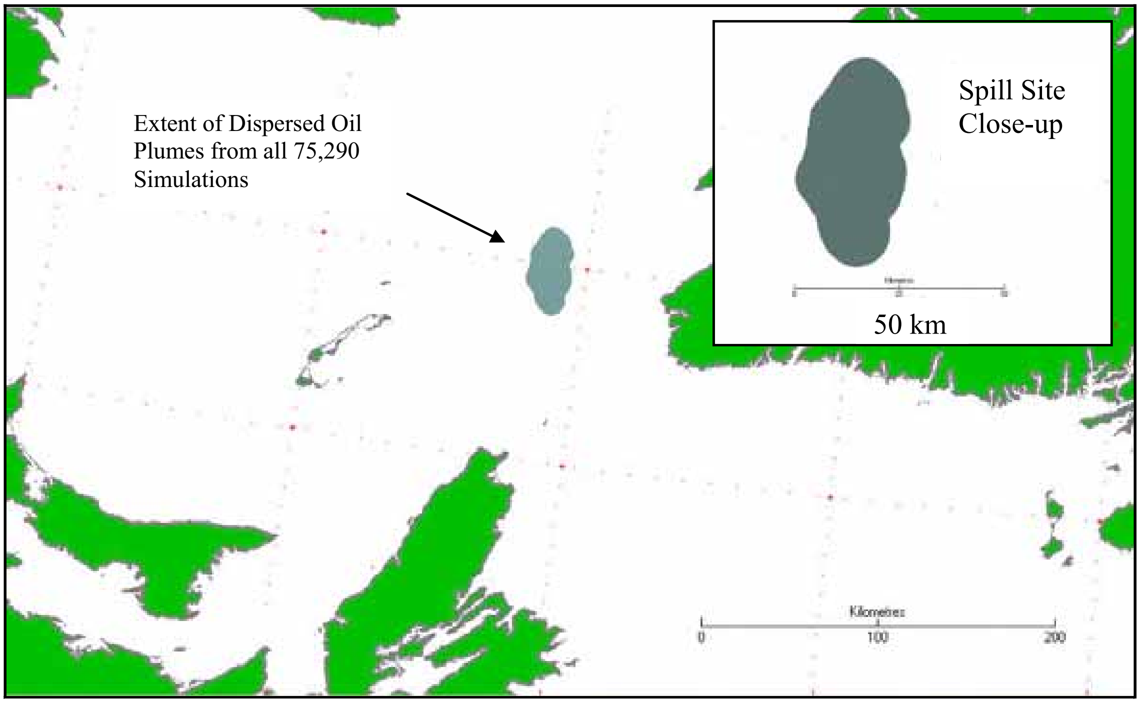


Figure 2.23 Maximum Extent of Ocean Swept by >0.1 ppm Dispersed Oil from 52 Years of Simulations Using a Conservative Modelling Approach: Six-hourly Accumulations Released as Batch Spills

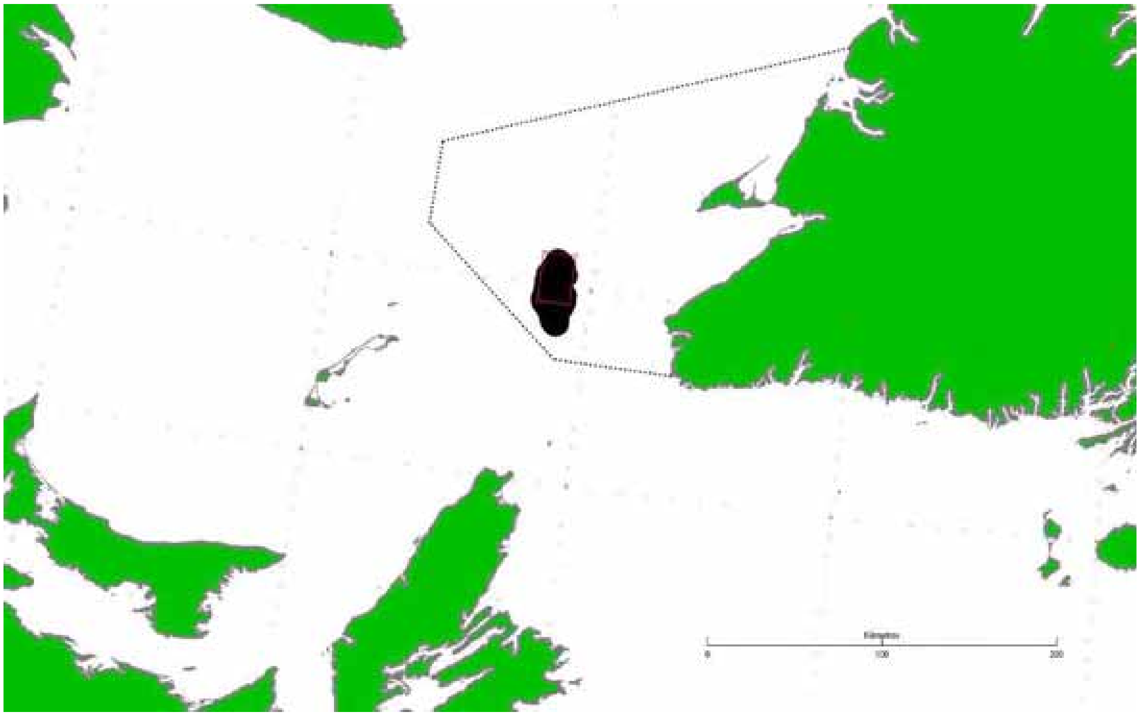


Figure 2.24 Predicted Maximum Extent of Oil Plume Trajectory in Relation to Exploration Licence 1105

3.0 STAKEHOLDER CONSULTATION

Corridor understands the importance of communicating with key stakeholders, including fisheries organizations, environmental organizations, First Nations representatives, regulators, provincial, federal and municipal governments, media and others. Corridor began the consultation process early and continues with its efforts throughout the Environmental Assessment process.

The Corridor website is also used as an information tool. A description of the proposed exploration well is posted, as well as regular updates.

Overall, the consultation for the proposed exploration project is designed to foster open, two-way dialogue with key stakeholders. Through this process, Corridor has identified important issues and reflected those in its planning for this proposed exploration well. The results of the public consultation program have been compiled in this Environmental Assessment report.

3.1 Legislated Requirements

CEAA requires that public consultation be conducted at three points during an Environmental Assessment:

- during the preparation of the Scoping Document;
- during the conduct of the Environmental Assessment; and
- during a review of the completed Environmental Assessment prior to the Minister's issuance of an Environmental Assessment decision statement.

The Scoping Document was made available by the C-NLOPB for public review and comment, for the period from February 25 to March 28, 2011. A public notice was placed on the Canadian Environmental Assessment Registry internet site (Registry reference number 11-01-60633) to initiate the public comment period; the public notice was also placed on the C-NLOPB internet site and was advertised in certain newspapers. The C-NLOPB, on behalf of the RAs, invited the public to comment on the draft Scoping Document for the Old Harry Project. Also, a notice was posted on the C-NLOPB web site and the draft Scoping Document and Project Description were made available electronically on the C-NLOPB website; hard copies were available from the C-NLOPB upon request. Comments were requested to be provided, either electronically or via post, by March 28, 2011. The majority of the comments received were outside the scope of the Environmental Assessment of a single exploration well within EL 1105 and instead focused on broader policy issues.

A consultation program was designed and carried out by Corridor during the preparation of the Environmental Assessment. Questions and issues relevant to the single exploration well proposal raised by stakeholders throughout the consultations are addressed in this Environmental Assessment.

The consultation program focused primarily on the geographic region most likely to be affected by the Project, the west coast of Newfoundland, as well as the Magdalen Islands due to their level of interest in the Project. The consultation program during the preparation of the Environmental Assessment involved:

- reviewing the SEA and Amendment prepared for the Western Newfoundland Offshore Area (LGL 2005b, 2007);
- reviewing issues raised during consultations held for the Western Newfoundland SEA;
- consulting community members, fishers, businesses and organizations, environmental non-governmental organizations and the general public;
- meetings with government departments and agencies;
- open houses;
- media communications and monitoring;
- distributing Project information through traditional and electronic media; and
- establishing a Project website [http://www.corridor.ca/oil-gas-exploration/gulf-of-saint-lawrence.html].

An important component of the consultation program was the recording of issues and comments raised at meetings and events. Consultations conducted to date during the preparation of the Environmental Assessment are detailed in the rest of this section. Corridor will continue open dialogue with interested stakeholders with questions or concerns.

On June 3, 2011, the C-NLOPB referred the Environmental Assessment to the Minister of the Environment with the recommendation for either a mediator or a review panel. On August 15, 2011, the Minister of Environment determined that the Environmental Assessment should proceed as a screening, but requested that extensive public consultation be conducted in conjunction with the screening-level environmental assessment. In addition, the Minister of Environment also requested an update of the 2007 Strategic Environment Assessment (SEA) for the Western Newfoundland Offshore Area. The C-NLOPB has appointed an independent review that will focus on the potential environmental effects of the proposed drilling of a single exploration well on EL 1105. Public consultations will be held in the five jurisdictions bounded by the Gulf and the Independent Reviewer will present a report to the C-NLOPB at the conclusion of the independent review, which will also be made public by the C-NLOPB. In addition, the C-NLOPB will establish a working group to oversee the process of updating the SEA for the Western Newfoundland Offshore Area, which begins with the development of a scoping document for the SEA. An integral part of the SEA process is public consultation and the C-NLOPB will ensure that this will be conducted as part of the review process.

3.2 Consultation in Local Municipalities

Corridor met with several local municipal governments on the west coast of Newfoundland and on the Magdalen Islands including:

- Zone 10 - Marine and Mountain Zone Corporation;
- Town of Channel-Port aux Basques;
- Port aux Basques Chamber of Commerce;

- Zone 9 - Long Range Regional Economic Development Board;
- Federation of Newfoundland Indians;
- Corner Brook Board of Trade;
- City of Corner Brook; and
- Corner Brook Port Corporation.

Corridor also met with Magdalen Islands municipality representatives and made a presentation to the Hydrocarbon Working Committee. While not considered official consultation by the Working Committee, it provided Corridor with an opportunity to provide Project information and for Committee members to comment on the proposed Project.

3.3 Commercial Fisheries

Fisheries groups and civic leaders in Newfoundland and Labrador include One Ocean, the Fish Food and Allied Workers (FFAW), the Seafood Producers' Association and fishers in Western Newfoundland and the Magdalen Islands also has a number of fishing associations (see Section 3.3.2).

3.3.1 One Ocean, FFAW and Other Fisheries Groups in Newfoundland

One Ocean is a liaison organization to facilitate communication between the fishing and oil and gas industries in Newfoundland and Labrador. Corridor met with One Ocean and FFAW in St. John's and also met with the west coast Newfoundland FFAW representative in Corner Brook. Both meetings provided a presentation of the proposed Project and an opportunity for the organization representatives to ask questions and voice any issues or concerns about the Project.

3.3.2 Magdalen Island Fishing / Fisheries Representatives

In addition to the Magdalen Islands municipality representatives, Corridor met with the following Magdalen Island fishing organizations:

- Regroupement des Pecheurs Professionnels des Iles (RPPIM);
- Regroupement des Palangriers et Petoncliers Unique Madelinots (RPPUM);
- Association des pêcheurs propriétaires des Îles-de-la-Madeleine (APPIM); and
- Association of Inshore Fishermen of the Magdalen Islands.

The meetings included a presentation on the Project and it provided an opportunity for fishing representatives to comment on the proposed Project.

3.4 Meetings with Government Departments and Agencies

In order to assist in the scoping of the effects assessment, the identification of appropriate mitigation and addressing of any issues of concern, Corridor and its consultants undertook a consultation program with key regulatory stakeholders, including but not limited to:

- C-NLOPB;

- DFO (including the Regional Manager Major Projects - Gulf Region, the Senior Advisor Oceans and Habitat Division - Gulf Region, the Environmental Assessment Senior Analyst - Gulf Region, the Environmental Assessment Manager and the Acting Regional Manager Environmental Assessment and Major Projects - Ecosystem Management) (note that this meeting was a presentation on the project and did not include any discussion on the Environmental Assessment);
- Environment Canada in Newfoundland and Labrador;
- Transport Canada and Navigable Waters Protection in Newfoundland and Labrador;
- Canadian Environmental Assessment Agency (CEA Agency);
- National Energy Board;
- Assembly of First Nations' Chiefs in New Brunswick;
- Mi'kmaq Confederacy Prince Edward Island; and
- Government officials and elected representatives, in particular inside the provincial governments of Newfoundland and Labrador and Quebec, including the Newfoundland and Labrador Department of Natural Resources and Quebec Department of Natural Resources.

The Corridor study team have been consulting with key government officials and regulators both formally and informally on an ongoing basis. The objective of these consultations is to provide information and updates on the Project and the Environmental Assessment, and also to receive input and guidance as appropriate. The C-NLOPB and RAs have been regularly consulted since filing of the Project Description.

Corridor has met with the Premier of Newfoundland and Labrador and there have also been ongoing meetings with the Newfoundland and Labrador Minister of Natural Resources and the deputy ministers and assistant deputy ministers to keep them apprised of Project developments.

These consultations have involved one-on-one meetings (locally and in Ottawa), telephone conversations and e-mail correspondence.

3.5 Other Consultation Methods

Corridor held a series of open houses on the West Coast of Newfoundland. Corridor also provided information to the public and tracked issues using press releases and the Project website.

3.5.1 Open Houses

Open houses were held on the west coast of Newfoundland in Port aux Basques (14 attendees, including local media), Stephenville (9 attendees) and Corner Brook (6 attendees, including local media). The open houses consisted of a handout and display panels and the chance to discuss the information in the handouts / on the panels with representatives of Corridor and their environmental consultant (Stantec). All of the attendees expressed support for the Project.

3.5.2 Update Letters

Corridor has provided ongoing communication via letters to the following organizations:

- Atlantica Centre for Energy;
- City of Corner Brook;
- Corner Brook Board of Trade;
- Federation of Newfoundland Indians;
- Mayor of Port Saunders;
- Mayor of the Town of Souris, PE;
- Newfoundland and Labrador Oil and Gas Industries Association (NOIA);
- Offshore / Onshore Technologies Association of Nova Scotia;
- Port-aux-Basques Chamber of Commerce;
- Port Harmon Authority Ltd.;
- Sustainable Development;
- Town of Channel-Port-aux-Basques;
- Zone 9: Long Range Regional Economic Development;
- Zone 10: Marine and Mountain Corporation; and
- Two First Nations groups (Assembly of First Nations' Chiefs in New Brunswick and Mi'kmaq Confederacy Prince Edward Island).

Corridor continues to provide updated information via letters.

3.5.3 Media Communication

Corridor responds to media inquiries as appropriate and has provided information about the project to local, national and international media. Corridor regularly monitors the provincial and national media, including print, broadcast and electronic news media.

3.5.4 Project Website

To increase accessibility and enhance communications with the general public, Corridor provides information on the Old Harry prospect on their website (http://www.corridor.ca/), which was widely advertised and promoted during presentations at workshops and open houses. The website is updated regularly and the public are able to submit questions and issues through the Corridor email address or toll-free number.

3.6 Issues

Comments raised by stakeholders during the consultation / information exchange process are summarized in Table 3.1, which also indicates the section of the Environmental Assessment where each issue or concern is addressed.

Table 3.1 Comments Raised during the Consultation Program

Comment	Environmental Assessment Section Where Comment / Concern is Addressed
Accidental Events	
Is the oil spill model 2-D or 3-D?	Section 2.12.2; SL Ross 2011 Supporting Document
The Gulf of Mexico spill occurred during exploration.	Section SL Ross 2011 Supporting Document
Will copies of the Emergency Response Plan be available?	Section 13; the ERP will be made available
Birds	
Will seabird observers be stationed on the supply vessels and drilling platform?	Section 7.5.3;
Commercial Fisheries	
Where is the crab grounds for Zone F on the Project Maps?	Figure 5.62[A]
Endangered or Special Status Species	
How does drilling noise affect species around the drilling platform?	Section 7.2.2.5
Fish and Fish Habitat	
What is the redfish larval extrusion zone?	Section 5.7.2
What are the pockmarks identified from the geohazard survey?	Discussed in the Geohazard Survey Report that was submitted to the C-NLOPB
Can the timing of the drilling program be scheduled to avoid migration and spawning	Table 5.11 indicates timing of migration and spawning
How does drilling noise affect species around the drilling platform?	Section 7.4.2.5
Marine Mammals	
How does drilling noise affect species around the drilling platform?	Section 7.6.2.5
Sensitive Areas	
Ile Brion is a sensitive area	Section 5.7.3; Table 5.18
Public Involvement	
Consultation has been restricted to Newfoundland and the Magdalen Islands. Why not PEI, NS, NB?	Section 3.1
Why was there no formal "public consultation" in Magdalen Islands?	The presentations made on the Magdalen Islands are described in Section 3.3.2
Technical / Project Description	
Is it just oil or is there gas?	Section 2.3
Will drilling be restricted to certain times of the year?	Section 2.6
Can the drilling platform withstand the environment	Chapter 12
What chemicals will be used during fracture gradient evaluation?	Any chemicals used will be evaluated under the OCSG as per Section 7.1.2.1
Miscellaneous	
Identified data gaps	Data gaps in various places in the document
A Zone F is not specifically labelled in Figure 5.62; it is the snow crab harvesting area in NAFO Area 4Tf closest to EL 1105.	

3.7 Participation in Conferences

Corridor has also participated in the several conferences, including:

- 6th International Symposium on Oil and Gas Resources in Western Newfoundland in Corner Brook (August 23 to 25, 2011) – provided a presentation on the one well exploration program and the hydrocarbon potential of Old Harry;
- 5th International Symposium on Oil and Gas Resources in Western Newfoundland in Corner Brook (September 31 to 24, 2010) – provided a presentation on the one well exploration program and results of the geohazard survey;
- Oil and Gas Forum in mid-April 2011 organized by the municipality of the Magdalen Islands – provided a presentation on its proposed one well exploration program;
- NOIA's Playing on the Edge Conference in St. John's (June 21 to 23, 2011) – provided a Project update; and
- CORE All Energy Conference and Trade Show in Halifax (October 3 to 6, 2011) – provided a Project update.

4.0 PHYSICAL ENVIRONMENT

This section provides details of the physical environment related to the Old Harry prospect, including geology, physical oceanography and meteorology. A detailed discussion of the physical environment near the Project can be found in the 2005 Western Newfoundland and Labrador Offshore Area Strategic Environmental Assessment (SEA) (LGL 2005b) and the 2007 Western Newfoundland and Labrador Offshore Area SEA Amendment (LGL 2007). The physical environment description in this document has been summarized using in part information from Western Newfoundland and Labrador Offshore Area SEA (LGL 2005b) and Corridor's geohazard survey environmental assessment (Stantec 2010), with more recent data and information included where available.

4.1 Geology

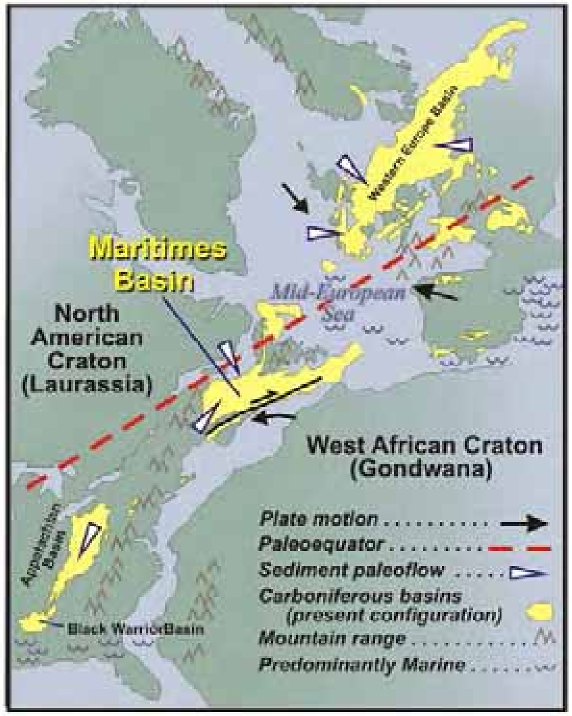
Geological formations in the Gulf are an essential component of marine habitats, as they influence oceanic circulation. The geological formations that form the foundations of the Gulf are millions of years old and straddle three major geological regions, including the Canadian Shield, the St. Lawrence Platform and the Appalachians. Some of these geological formations lay exposed to the ocean, while others are covered by sediment layers varying in depth from a few meters to hundreds of metres. Over the past two million years, four glacial and interglacial periods have transformed these geological formations as a result of erosion and sediment deposition. Natural phenomenon, including the movement of icebergs, and human activities (i.e., fishing trawls) have also played a role in transforming the seafloor of the Gulf to how it exists today (DFO 2005a).

4.1.1 Maritimes and Magdalen Basin Geology

Underlying the Gulf, Cabot Strait, southwestern Grand Banks and northeastern Newfoundland continental shelves, including onshore extensions covering five eastern Canada provinces, is a large sedimentary basin known as the Maritimes Basin (Lavoie et al. 2009) (Figure 4.1). The basin developed in equatorial latitude, within a collision zone between the Laurassia and Gondwana cratons (Figure 4.2) during the final stages of assembly of the Pangea supercontinent (Lavoie et al. 2009). The rocks in the Maritimes Basin consist of mostly sandstone, siltstone and shale, with minor amounts of limestone, gypsum and salt. These rocks range in age from middle Devonian to Permian (Upper Paleozoic), but are generally regarded as mostly Carboniferous in age. Similar age rocks occur in the United States (Appalachian Basin) and in Western Europe (Figure 4.2). Hence, the Maritimes Basin is considered to be part of a series of sedimentary basins between Laurassia and Gondwana (Figure 4.2).

Source: Adapted from Lavoie et al. 2009.
Note: Maritimes basin is the light yellow and light brown shading / colours.

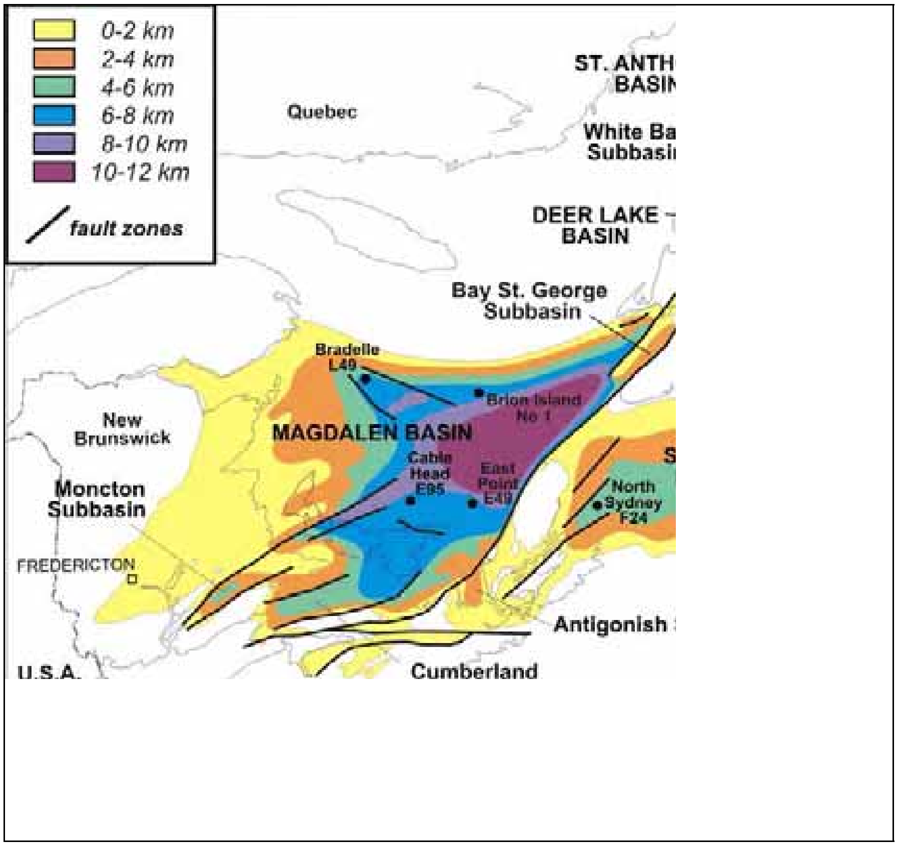
Figure 4.1 Regional Setting of the Maritimes Basin with Location of Magdalen Basin



Source: Lavoie et al. 2009.

Figure 4.2 Plate Tectonic Setting of the Maritimes Basin

The rocks on the Maritimes Basin underlie all of Prince Edward Island and the Magdalen Islands and extend onshore in eastern New Brunswick, northern Nova Scotia an Cape Breton Island and western Newfoundland (Figure 4.1) (Lavoie et al. 2009). The Maritimes Basin comprises several basins, including the Magdalen and Sydney Basins and local subbasins. It encompasses an area of 250,000 km^2, with approximately 75 percent of the basin offshore (Lavoie et al. 2009). The geological history of the Maritimes Basin includes extensional and strike-slip settings in the Late Devonian to Early Carboniferous, as well as a wrench-foreland basin setting in the Late Carboniferous to early Permian (Lavoie et al. 2009). The Maritimes Basin contains middle Devonian to early Permian continental and shallow marine strata of a thickness of approximately 12,000 m (Figure 4.3) (Lavoie et al. 2009). Today's Maritimes Basin is an erosional remnant of a more extensive cover of the Upper Paleozoic Strata (Lavoie et al. 2009). EL 1105 is located within the eastern part of the Magdalen Basin (Figure 4.1).



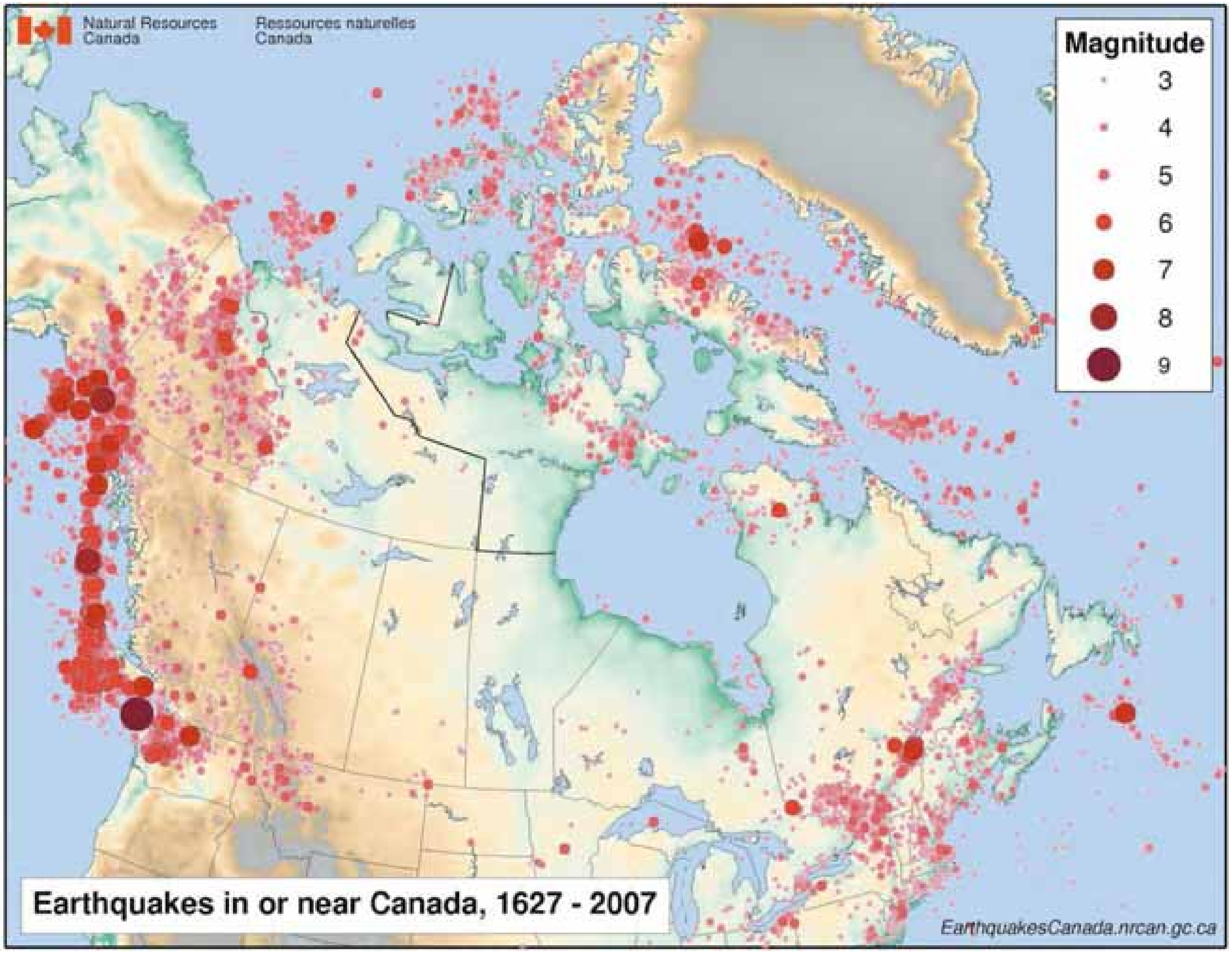
Source: Lavoie et al. 2009.

Figure 4.3 Isopach Map of Upper Paleozoic Strata in Maritimes Basin

4.1.2 Seismicity

Seismicity is the frequency or magnitude of earthquake activity in a given area. Global seismicity maps show that the regions where seismicity is the highest tend to correspond with the edges of the tectonic plates. The continual shifting of tectonic plates accounts for 97 percent of the world's earthquakes (Natural Resources Canada 2011). The causes of earthquakes in eastern Canada are not well understood. Eastern Canada is part of the stable interior of the North American Plate and as such, tectonic plate shifting is not the cause of most observed earthquakes in this region. Seismic activity in areas such as eastern Canada seems to be related to the regional stress fields, with the earthquakes concentrated in regions of crustal weakness (Natural Resources Canada 2011).

Peak accelerations and velocities define seismic zones throughout Canada (Natural Resources Canada 2011), that range from zero (Canadian Shield, which is a relatively aseismic area) to six (areas that are the most seismically active). EL 1105 is located within Zone 1 (based on the 1985 seismic zoning map), and is therefore considered to have a low seismicity (Natural Resources Canada 2011). The historic seismicity for Canada (1627 to 2007) is presented in Figure 4.4 and as indicated, there was no seismic activity ever recorded for in the vicinity of EL 1105.



Source: Mitchell et al. 2010.

Figure 4.4 Historical Seismicity in Canada

4.1.3 Sediment Type

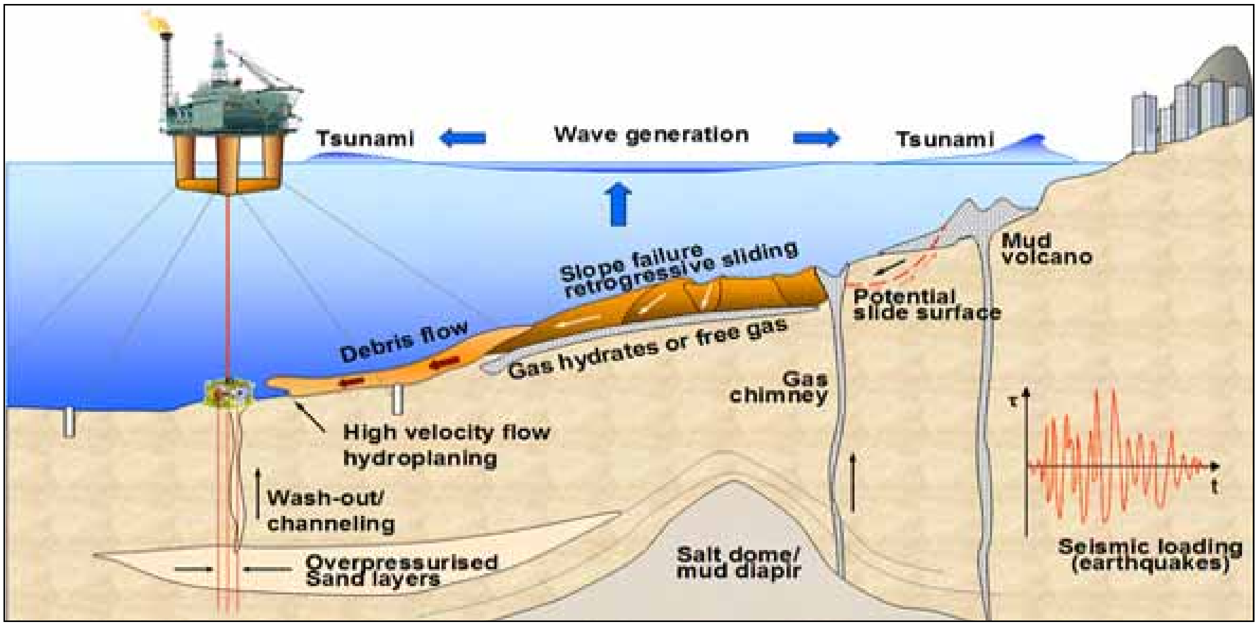
The three-dimensional configuration of the Quaternary sediments in the Gulf was studied by Josenhans and Lehman (1999) via an analysis of high-resolution seismic reflection data and core samples. The results were interpreted and the sediments were subdivided into three seismostratigraphic units, including glacial till-ice-contact sediments, glaciomarine sediments and postglacial sediments. The glacial till-ice-contact sediments lay above bedrock and other older till deposits and their thickness ranges from areas of thin discontinuous deposits to morainal deposits of up to 180 m thick. The glacial till-ice-contact unit was further interpreted to contain a stacking of multiple glacial till-ice-contact deposits, which were sub-divided into the lower, middle and upper till units. Samples taken from the lowermost till unit contained reddish-brown clayey silt with grit and large clasts of clay and pebbles. The middle till unit occurs along the eastern margin of the Magdalen Shallows (Figure 4.5) and extends down the southwestern flank of the Laurentian Channel. Sediments from this unit are dark brown in colour and made up of calcareous, silty-sandy muds with pebbles and red clayballs. The upper glacial till unit extends down the southwestern flanks of the Laurentian Channel and the sediments making up this unit consist of massive, dark grey clayey muds with clasts of limestone, black slate and igneous fragments. The glaciomarine sediments lie above the glacial till-ice-contact unit and consist of massive silty clays with gritty, pebbly sediments and rock fragments. The third seismostratigraphic unit, postglacial sediments, is the uppermost unit and consists of massive, grey clayey to sandy mud with some shell fragments. In general, the thickest deposits of glacial sediments have been deposited on the southwestward slope of the Laurentian Channel.

Source: Dufour and Ouellet 2007.

Figure 4.5 Physical Features Present in the Gulf of St. Lawrence

4.1.4 Natural Hazards Affecting the Seafloor

Natural hazards affecting the seafloor are referred to as geohazards. A geohazard is defined as "A geological state, which represents or has the potential to develop further into a situation leading to damage or uncontrolled risk". Geohazards are found in all parts of the Earth and are always related to specific geological conditions and geological processes, either recent or past. Important offshore geohazards include: (i) seabed instabilities and mass wasting processes including debris flows and gravity flows (submarine slope failures); (ii) pore pressure phenomena (e.g., shallow gas accumulations, gas hydrates, shallow water flows, mud diapirism and mud volcanism, fluid vents, pockmarks); and (iii) seismicity (Figure 4.6).



Source ICG 2010.

Figure 4.6 Main Offshore Geohazards

A drilling hazards and constraints assessment of the proposed Old Harry exploration well was conducted in October 2010 (FGI 2010). Constraints are features or conditions that may affect drilling or installation operations, but do not constitute a safety hazard and include such items as localized near-surface boulders that might cause refusal during drilling or affect structural alignment of casing during installation, thereby requiring respud or reinstallation. A hazard by comparison may present a safety risk, such as the presence of over-pressured shallow gas within the “open hole” drilling interval, which would have potential to cause a blow-out. Hazards may be assessed qualitatively as having either low or high probability of occurrence, based on interpretation of the available geological and geophysical data. High probability is assessed if geologic conditions are conducive and the data support the presence of a specific hazard. In this case, the hazard occurrence is considered probable. In the case of low probability, the observed geologic conditions may be conducive and, although the data do not necessarily support the presence of a hazard, the data do not exclude the possibility of a hazard (FGI 2010).

High-resolution geophysical site survey data were acquired over the proposed well site for the purpose of a shallow drilling hazards assessment (FGI 2010). Geophysical data were acquired within a 22.5 km2 rectangular survey site, aligned north-northwest-south-southeast. The site dimensions are 4.5 km (west-southwest-east-northeast) by 5 km (north-northwest-south-southeast). The assessment was performed to identify geological hazards and constraints on the seabed and in the shallow sub-surface relevant to the safety and efficiency of proposed exploration drilling operations. The assessment was limited to the "open hole" drilling interval (approximately 600 m below seafloor). Natural hazards that may affect the seafloor are described and discussed in the following sections, with results from the Old Harry geohazard survey (FGI 2010) included for appropriate site context.

4.1.4.1 Seabed Conditions

The regional surficial and shallow geology in EL 1005 reflects processes of Pleistocene glaciation and subsequent marine sedimentation (FGI 2010). The ultimate retreat of Late Wisconsinan ice from the Laurentian Channel is recorded by the near-surface sedimentary succession, which consists of glacial diamict (till), overlain by glaciomarine muds (Emerald Silt) and draped by Holocene surficial silty clays (LaHave Clay) (Fader et al. 1982; Grant and Morrison 1996). The LaHave Clays are distal equivalents of sand-rich slope deposits (Sambro Sands) on the flanks of the Laurentian Channel, which were derived from transgressive erosion of St. Pierre Bank and adjacent shelf areas as sea level rose from a post-glacial lowstand of -110 m (Fader et al. 1982; Josenhans and Lehman 1999; Quinlan and Beaumont 1981).

Josenhans and Lehman (1999) describe a typical succession of ice contact and till deposits, proximal and distal glaciomarine clay deposits and surficial marine muds. Three till sub-units relating to multiple glacial advances have been defined, with only the oldest (Lower Till) present in the region of the Old Harry prospect. The tills form a discontinuous cover over bedrock, and are draped by glaciomarine sediments and Holocene muds (FGI 2010).

The Old Harry prospect is situated within the Magdalen Basin (FGI 2010). Basin formation was initiated during the waning stages of the Acadian Orogeny in an extensional setting, with periods of dextral transpression (Williams 1995; Hayward et al. 2002). Within the Old Harry prospect area, the Basin hosts Upper Carboniferous sedimentary strata consisting of multi-storied channel sandstones interbedded with fine-grained siltstones, shales and mudstones (Giles and Utting 1999, 2003). The formerly flat-lying to gently dipping strata have been folded and faulted by salt-motivated tectonism, resulting in a system of fault-bounded anticlines and synclines, providing structural closure for prospective hydrocarbon systems (Hayward et al. 2002).

Within the Laurentian Channel, the strata have been deeply eroded by Pleistocene glaciation. In the Old Harry well site area, the shallow sedimentary succession comprises partially eroded, sandstone-dominant Cable Head Formation at the top, underlain by the finer grained Green Gables Formation, and the more interbedded Bradelle Formation, which is interpreted to host prospective reservoir quality sandstones (Hayward et al. 2002; Hu and Dietrich 2008, 2009;).

The Old Harry site is situated on the floor of the Laurentian Channel, a large-scale, glacially overdeepened u-shaped valley separating the Magdalen Shelf and the narrow shelf of southwest insular Newfoundland (FGI 2010). Water depths within the surveyed Old Harry well site area range from 462 m in the northwest to 482 m in the east; and the seabed dips regionally to the southeast at an average of less than 1°. The seabed displays a gently undulating topography with a broad, low relief “ridge” trending southeastward through the centre of the site, with low-lying troughs on each side. The proposed well surface location is situated near the crest of the “ridge” at 470 m water depth. The local seabed dip is <1° SSW (FGI 2010).

Seabed sediments in the Old Harry site investigation area consist mainly of soft glaciomarine to post-glacial muds with occasional coarse granular material derived from ice rafting (FGI 2010). The muds (>60 percent clay, >30 percent silt and <5 percent sand) are interpreted to have been deposited by gradual, deep-water pelagic sedimentation during the Late Wisconsinan to Holocene period. Far offset piston core data suggest that the surficial muds are bioturbated and contain occasional ice-rafted clasts. Seabed video images show a generally smooth mud seabed with common burrows formed by benthic infauna. Isolated clusters of ice-rafted pebbles are seen in places (FGI 2010).

Anchoring conditions are considered to be generally favourable within the Old Harry well site area. There are no identified or charted man-made features or obstructions to drilling and anchoring in the well site area (FGI 2010).

Boulders

There is potential for occasional ice-rafted cobbles and/or boulders within the near-surface Unit 1 deposits, down to the Base Quaternary glacial unconformity. Holocene surficial marine mud deposits vary from approximately 9 to 28 m thick across the Old Harry site, and are estimated to be 15 m thick at the proposed well location. Potential for coarse granular material generally increases below the Holocene surficial marine muds, within the proximal glaciomarine sediments and basal tills. There may be potential for fragmented bedrock on the glacially eroded, buried bedrock surface. While isolated boulders may occur, there is considered to be a low probability of drilling refusal or casing problems caused by near-surface boulders at the Old Harry well site (FGI 2010).

Faults

A southwest-northeast trending system of normal faults occurs in the southern part of the site investigation area, forming a graben-like structure (FGI 2010). Faulting was likely associated with salt-motivated tectonism and uplift. These faults are not considered active. It is noted that the proposed well site at Old Harry is located approximately 1,200 m northwest of the fault system and does not intersect interpreted faults.

4.1.4.2 Pore Pressure Phenomena

The pore pressure phenomena considered in this report include shallow gas accumulations, gas hydrates, shallow water flows, mud diapirism, mud volcanism, fluid vents and pock marks. While all are individual phenomena, they are related, and are an expression of former or present day activities of fluid flow related to conduits such as faults or sedimentary discontinuities. Fluid flow within sediments, exploiting pathways of permeable sediments or faults, results in upward migration of gas and water expelled from sediments at depth. The end result of these extrusions is pockmarks and mud volcanoes and diapirisms, which form where entrained sediment erupt at the seafloor. These processes are related to excess pore pressure at depth, which decreases sediment strength and increases slope failure potential. The use of high-resolution seafloor mapping tools has permitted identification of submarine slides, pockmarks, mud volcanoes and active faults in unprecedented detail. The morphologic evidence suggests that all these features should be considered as common rather than exceptional on the seafloor (Cochonat et al. 2007).

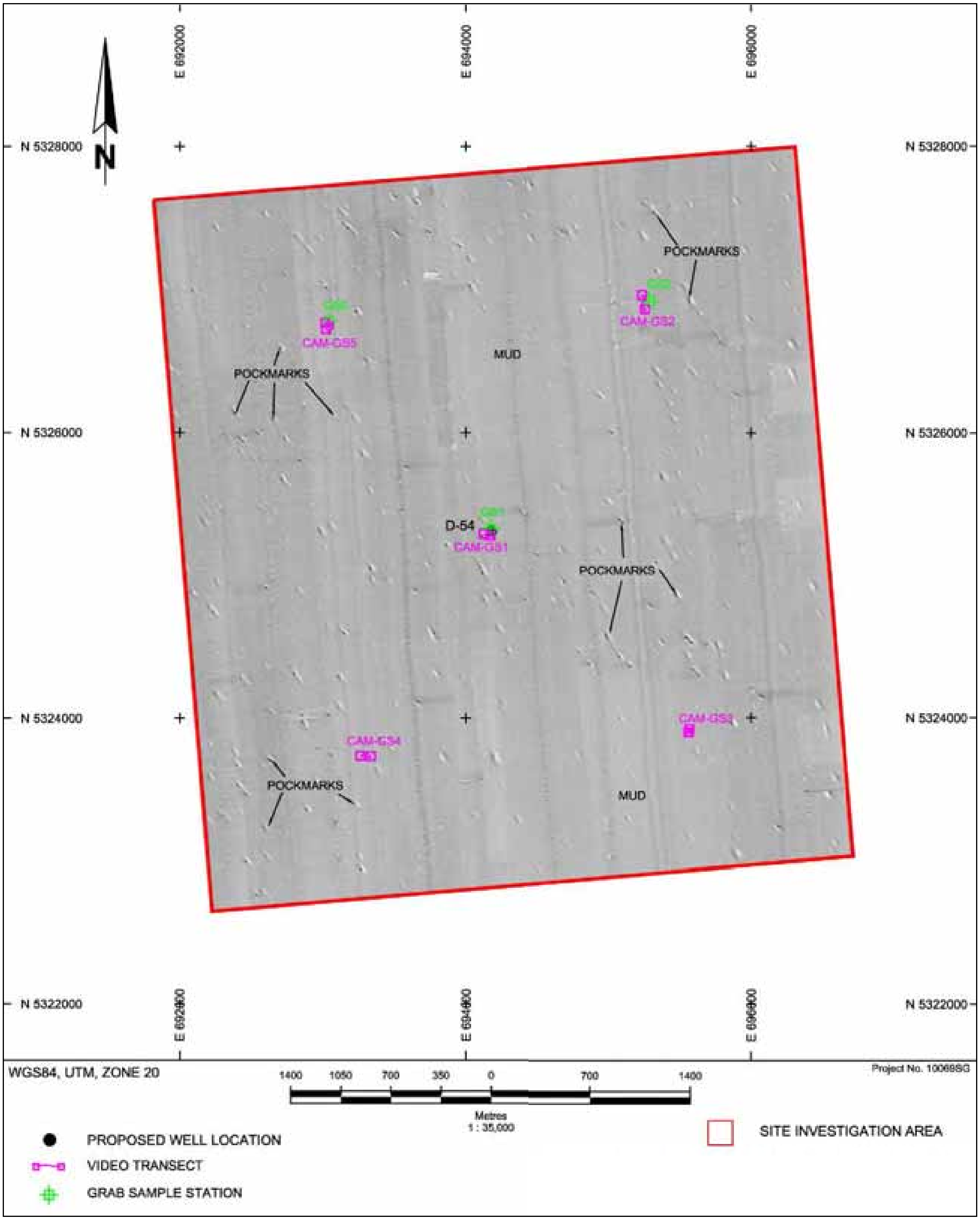
Pockmarks

Pockmarks are concave, crater-like features on the seafloor, generally up to several hundreds of metres in diameter and tens of metres in relief (King and MacLean 1970; Kelley et al. 1994). The formation of pockmarks is mostly caused by the seepage of thermogenic and biogenic gases (Rogers et al. 2006) and the release of pore water (Harrington 1985). Pockmarks have been described in areas that have been affected by the up-drift of ice that detached from the sub-seafloor (Paull et al. 1999) and decomposing gas hydrates (Solheim and Elverhøi 1993). Pockmarks are also induced by grounded moving icebergs or anthropogenic activities such as trawling and ship anchoring (Harrington 1985; Fader 1991).

Approximately 250 seabed pockmark depressions occur across the Old Harry survey site (FGI 2010) and their distribution is shown in multibeam and side scan sonar imagery (Figure 4.7). The features are asymmetrical with a dominant elongation to the south-southeast, in the direction of prevailing bottom currents. They are typically on the order of 50 m wide and 100 m long, and commonly less than 2 m deep. The smallest pockmark features imaged by multibeam data are approximately 20 m in diameter. Isolated pockmark features reach depths of approximately 5 m below the surrounding seabed. The inner sidewall slopes of pockmarks are typically <2° but exceed 5° in places (FGI 2010).

The areal density of pockmarks within the survey site is approximately 11/ km^2. The pockmark distribution does not show well-defined patterns, though they appear to be most abundant southeast of the proposed Old Harry well location (FGI 2010). A few of the pockmark features are aligned with each other and have coalesced to form longer seabed depressions oriented with the dominant current direction, as seen mainly in the northeast part of the site. It is not known whether any of the features are actively venting; however, some are distinct while others appear muted and are potentially older (FGI 2010). Fluid expulsion would likely be gradual and intermittent (Grant and Morrison 1996).

Side-scan sonar imagery shows locally high acoustic reflectance in many of the pockmark depressions, suggesting that accumulations of coarse granular material may have formed at the base of the features, due to progressive winnowing of fine-grained sediments by fluid expulsion (FGI 2010). The coarse granular (ice-rafted) material, previously embedded in a mud / clay matrix, settled to the bottom of the pockmarks as the fine sediments were suspended by venting and then transported down-current. Some of the pockmark features show local seabed mounding on the down-current fringes, where some of the suspended sediment load has been rapidly deposited close to source (FGI 2010).



Source: FGI 2010

Figure 4.7 Side Scan Sonar Mosaic Depicting Pockmarks at Old Harry

Pockmarks should be avoided when selecting well spud locations. In the event that an anchored MODU is used for drilling, the deepest pockmarks should be avoided during anchor placement.

Shallow Gas Accumulations

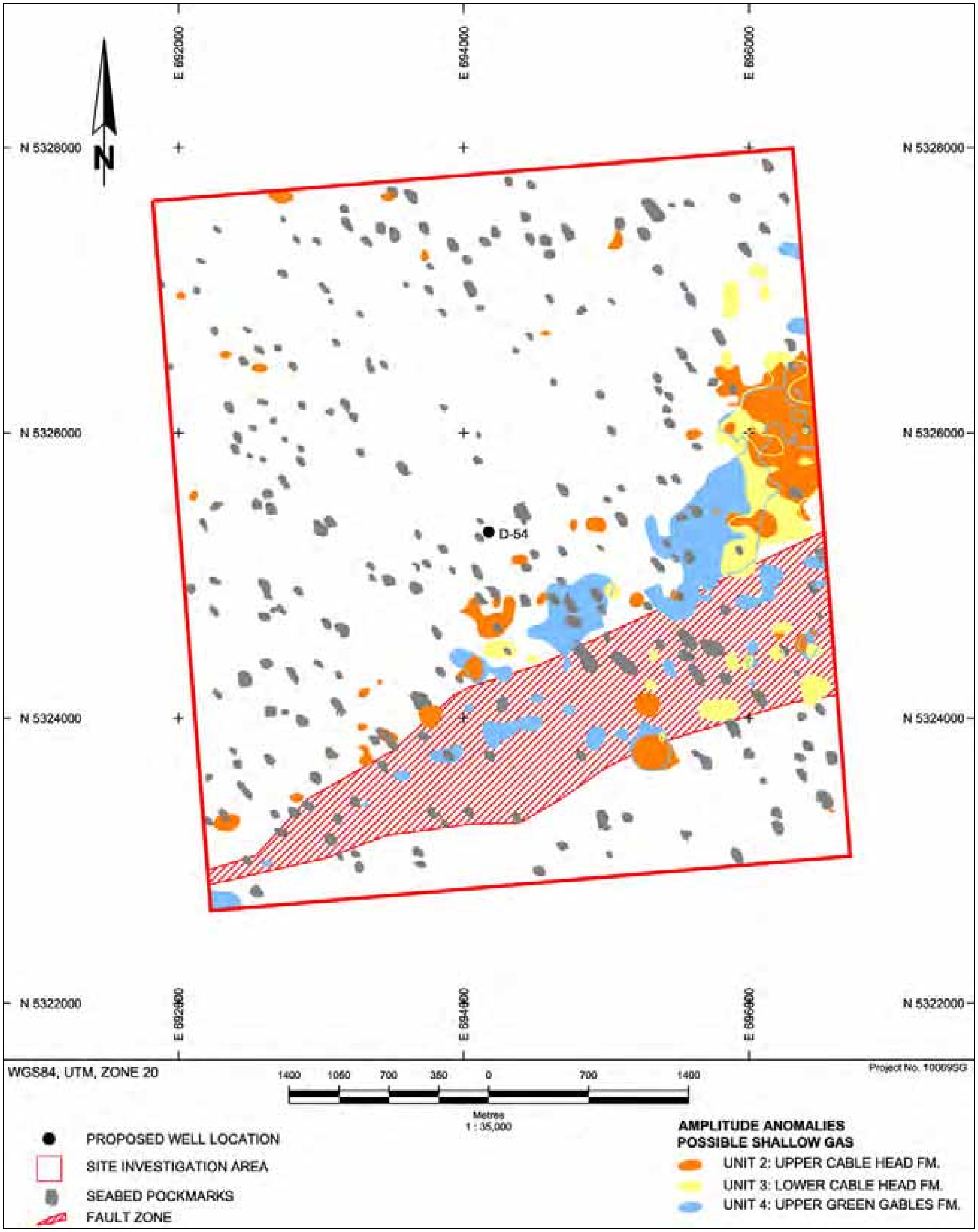
Shallow gas, which occurs at depths less than 1,000 m below seafloor (Floodgate and Judd 1992), may pose a hazard to offshore open-hole or riserless drilling operations, such as geotechnical drilling or drilling of the tophole section of oil and gas wells. There are two different types of shallow gas, defined by origin: thermogenic and biogenic. Thermogenic gas forms at depth under high temperatures and pressures. It may be present in the shallow subsurface where it has migrated up from a deeper reservoir (Floodgate and Judd 1992). Thermogenic gas can migrate upward along natural pathways, through porous strata or along faults, or along leaking wells. Biogenic gas forms at shallow depths through bacterial activity.

Biogenic gas is by far the most common gas in shallow sediments (Lin et al. 2004). Biogenic gas requires a sufficient supply of organic matter and a rapid sedimentation rate to bury organic material before it is oxidized. The gas accumulates when it can migrate in a free gas phase (Rice 1993), with this occurring when the concentration in the pore fluid exceeds gas solubility, or when gas exsolves due to reduction of hydrostatic pressure, which could be caused by erosion of the seabed or a fall in relative sea level.

Shallow gas accumulations require a reservoir, a seal and gas. Shallow gas reservoirs are most commonly formed by coarser-grained materials such as sand, and seals by fine-grained sediments such as clay (Kortekaas et al. 2011).

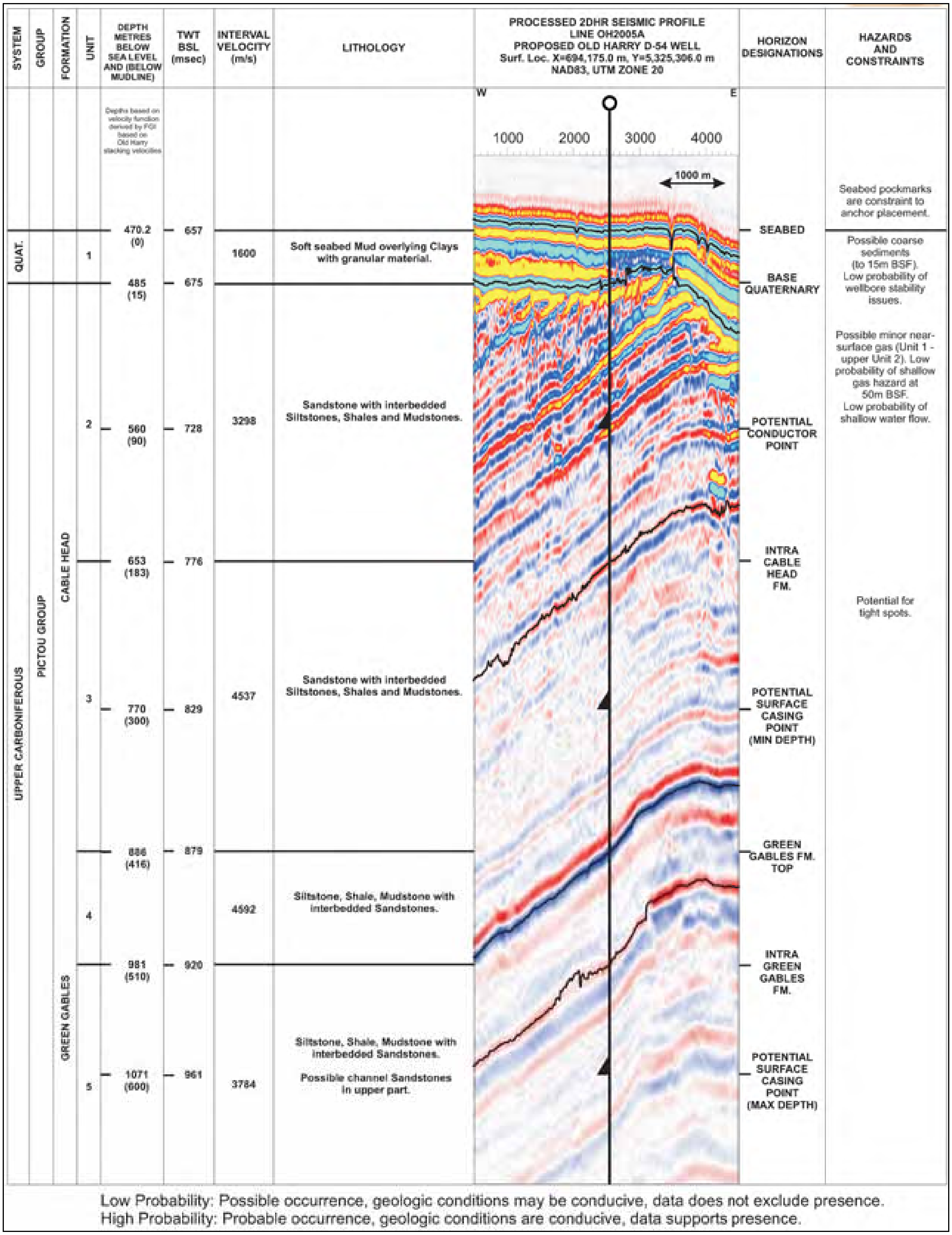
Geophysical observations suggest that there is possible near-surface gas in places within the Old Harry survey site, as indicated by seabed pockmarks and localized columns of attenuated amplitudes in Huntec sub-bottom profiler data, which commonly occur below the pockmark features (FGI 2010). Acoustic attenuation in proximity to pockmarks suggests the possible occurrence of gas (probably methane) within the dominantly fine-grained near-surface sediments, with potential seepage at the seabed. However, it is noted that the possible near-surface gas interpreted within the Old Harry survey area does not produce widespread acoustic wipe-out with loss of acoustic stratigraphy and structure, which typically occurs in high frequency sub-bottom profiler data where shallow sediments are extensively gas-charged.

Localized, subsurface high amplitude anomalies indicative of possible shallow gas have been mapped within the Old Harry survey site (FGI 2010). These anomalies occur within shallow Carboniferous bedrock along a southwest-northeast trend through the southern part of the site; mostly coincident with the mapped fault zone along the anticlinal structure that shallows to the north-northeast. High amplitude anomalies indicative of possible gas occur more than 200 m southeast of the well site location. These anomalies display a number of gas attributes, including trough-overpeak reflection pairing, sharp lateral gradients and possible frequency effects (FGI 2010). The anomalies occur up-dip of the proposed well site, within the truncated anticlinal structure. These anomalies, delineated on the hazards and constraints map, do not pose a hazard to drilling at the proposed well site (Figures 4.8 and 4.9) (FGI 2010).



Source: FGI 2010

Figure 4.8 Hazards and Constraints Map of Old Harry Study Area



SYSTEM	GROUP	FORMATION	UNIT	DEPTH METRES BELOW SEA LEVEL AND (BELOW MUDLINE)	TWT BSL (msec)	INTERVAL VELOCITY (m/s)	LITHOLOGY	HORIZON DESIGNATIONS	HAZARDS AND CONSTRAINTS
				Depths based on velocity function derived by FGI based on Old Harry stacking velocities					Seabed pockmarks are constraint to anchor placement.
				470.2 (0)	657			SEABED	
QUAT.			1			1600	Soft seabed Mud overlying Clays with granular material.		Possible coarse sediments (to 15m BSF). Low probability of wellbore stability issues.
				485 (15)	675			BASE QUATERNARY	
UPPER CARBONIFEROUS	PICTOU GROUP	CABLE HEAD	2	560 (90)	728	3298	Sandstone with interbedded Siltstones, Shales and Mudstones.	POTENTIAL CONDUCTOR POINT	Possible minor near-surface gas (Unit 1 - upper Unit 2). Low probability of shallow gas hazard at 50m BSF. Low probability of shallow water flow.
				653 (183)	776			INTRA CABLE HEAD FM.	Potential for tight spots.
			3	770 (300)	829	4537	Sandstone with interbedded Siltstones, Shales and Mudstones.	POTENTIAL SURFACE CASING POINT (MIN DEPTH)	
				886 (416)	879			GREEN GABLES FM. TOP	
			4			4592	Siltstone, Shale, Mudstone with interbedded Sandstones.		
				981 (510)	920			INTRA GREEN GABLES FM.	
		GREEN GABLES	5	1071 (600)	961	3784	Siltstone, Shale, Mudstone with interbedded Sandstones. Possible channel Sandstones in upper part.	POTENTIAL SURFACE CASING POINT (MAX DEPTH)	

Low Probability: Possible occurrence, geologic conditions may be conducive, data does not exclude presence.
High Probability: Probable occurrence, geologic conditions are conducive, data supports presence.

Source: FGI 2010

Figure 4.9 Hazards and Constraints at Old Harry Proposed Drill Site

It is noted that anomalous amplitudes occur near the up-dip limit of the trough reflector (Figure 4.8), which implies the possibility of gas migration up-dip along bedding planes (FGI 2010). The possibility of communication between the moderate amplitude bedding, the shallow amplitude anomalies (up-dip) and apparent fluid or gas escape pockmark features at the seabed suggests that the presence of gas cannot be excluded on the basis of the available data. However, the observed seismic attributes do not appear to be indicative of an overpressured gas zone below the Old Harry proposed well site. The reflector below the well site is therefore interpreted to have a low probability for shallow gas that is hazardous to drilling. As potential for shallow gas at the proposed well location cannot be excluded, it is suggested that mitigation options be considered (FGI 2010).

Gas Hydrates

Gas hydrates occur naturally onshore in permafrost and at or below the seafloor in sediments where water and gas combine at low temperatures and high pressures to form an ice-like solid substance. Methane, or natural gas, is typically the dominant gas in the hydrate structure. In a gas hydrate, frozen water molecules form a cage-like structure around high concentrations of natural gas; specifically, they are non-stoichiometric, solid compounds similar to ice crystals (Sloan 1998).

Gas hydrates are found abundantly worldwide in the top few hundred metres of sediment beneath continental margins at water depths between a 100 and 1,000 m (few hundred and a few thousand feet). The gas hydrate stability zone in the marine environment is determined by water depth, seafloor temperature, pore pressure, thermal gradient and the gas and fluid composition. The base of the zone in which hydrate can exist is limited by the increase in temperature with depth beneath the seabed (Sloan 1998). Currently, the principal indicator of marine methane hydrates is the detection of bottom-simulating reflectors on seismic data (CGG Veritas 2011).

The presence of pockmarks at the seabed and locally attenuated amplitudes in sub-bottom data suggests potential for localized near-surface gas within the Old Harry site. If temperature and pressure conditions are favourable, there would be potential for gas hydrate formation (FGI 2010). Estimated parameters for the Old Harry site were plotted on the phase equilibrium curve(s) to provide an indication of potential for gas hydrate formation. Water depth at the Old Harry well site is 470 m. A water bottom temperature (near seabed) of 5°C was found at the Old Harry site. The subsurface geothermal gradient is not well constrained for the well site area. These parameters and assumptions confine the Old Harry site to the shallow limit of the gas hydrate phase equilibrium curve(s). For the "saline water" case, the geothermal trend is nearly tangential to the upper limb of the phase equilibrium curve and does not intersect, suggesting that conditions for hydrate formation are not satisfied. Given that near-surface sediment pore waters at Old Harry are likely to be saline to some depth, there is considered to be a low probability of gas hydrates forming and remaining stable on or near the seabed (FGI 2010).

In addition, near-surface (Quaternary) sediments within the well site area are interpreted to be predominantly fine-grained with a clay matrix, and therefore lack sufficient porosity for the development of massive hydrates. Also, there is no apparent bottom-simulating reflector that would indicate the presence of free gas accumulation beneath a potential gas hydrate stability zone (FGI 2010).

If gas hydrates are present, they are likely localized and disseminated within the fine-grained sediment in the form of small crystals, small to large nodules, lenses and partings, or thin veins. If free-phase gas (or mixed gas and hydrate) are present locally in the unconsolidated near-surface sediments, it is not expected to be overpressured (FGI 2010).

Potential hazards associated with gas hydrates include ground subsidence, methane release, seabed and slope instability. Offshore drilling operations that disturb gas hydrate-bearing sediments could fracture or disrupt the bottom sediments and compromise the wellbore, pipelines, rig supports and other equipment involved in oil and gas production from the seafloor. Problems stem from decreases in pressure and/or increases in temperature, which can cause the gas hydrate to dissociate and rapidly release large amounts of gas into the well bore during a drilling operation (Folger 2008). However, as noted above, there is a low probability associated with gas hydrates forming and remaining stable on or near seabed at Old Harry (FGI 2010).

Shallow Water Flow

Shallow water flow is defined as water flowing within and around the outside of structural well casing to the seabed (Alberty et al. 1997). Shallow water flows occur when fluids under greater than hydrostatic pressures are present in unconsolidated sands between approximately 90 and 500 m (300 and 5,000 feet) below the mudline. These highly permeable sands are widely referred to as shallow water flows because they are sufficiently geopressured to force water and sand into the lower-pressured well bores (Von Flatern 1997). Common deepwater shallow sediment traits are low fracture gradients with pore pressures greater than a seawater gradient. The high pore pressure relative to the fracture gradient causes difficult drilling conditions in the shallow regions of the well.

In the Old Harry well site area, the shallow stratigraphy is comprised of thin (<20 m) unconsolidated clay-dominant Quaternary deposits overlying truncated and dipping Carboniferous sandstone and mudstone beds. The sandstones may be sufficiently porous to host pore fluids. However, the Quaternary deposits are too thin to exert substantial overburden pressure, and the lithified sandstones are effectively incompressible. Any potential for shallow flow would likely arise from deeper geopressures causing upward fluid migration through porous (or fractured) sandstone beds. There is interpreted to be a low probability of shallow water flow associated with the high amplitude beds in the conductor interval at the Old Harry site (FGI 2010).

Other Pore Pressure Phenomena

Mud diapirism and volcanoes are other pore pressure phenomena that may occur but are not expected to occur at the Old Harry site, based on the Old Harry Geohazard Survey (FGI 2010). A brief description of these pore pressure phenomena are included for completeness.

Mud diapirism is the extrusion of fluid rich, fine-grained sediment through an overlying lithologic succession with seismicity and/or hydrocarbon generation causing the timing and amount of extruded material (Yassir 1989). The actual location of the mud upwelling is often directed by confining structural elements or pre-existing weak zone (faults), which serve as dewatering pathways and conduits (Shipley et al. 1990).

Mud volcanoes can be large and long-lived geological structures that morphologically resemble magmatic volcanoes. Mud volcanoes are of two types, those associated with magmatic complexes and those related to petroleum provinces. The presence of mud volcanoes is distributed throughout the globe in both passive and predominantly active margins, often located along faults, fault-related folds and anticline axes. Mud volcanoes act as the preferential pathway by which deep fluids gather and ultimately reach the surface. Mud volcanoes episodically experience violent eruptions of large amounts of gas mixed with water, oil, mud and rock fragments, forming the ‘‘mud breccia’’. The periodic eruptions can produce volcano-shaped mountains that can reach kilometres in size (Mazzini 2009). The main cause of the eruptions is overpressured methane rising from source rocks and hydrocarbon reservoirs at greater depths.

Mud volcanoes may pose a geohazard for drilling and platform constructions due to the potentially violent release of large amounts of hydrocarbons and mud breccia. Eruption of greenhouse gases via mud volcanoes may influence global climate regimes and several attempts to estimate their contribution have been made. Offshore mud volcanoes are frequently associated with the presence of gas hydrates (Mazzini 2009).

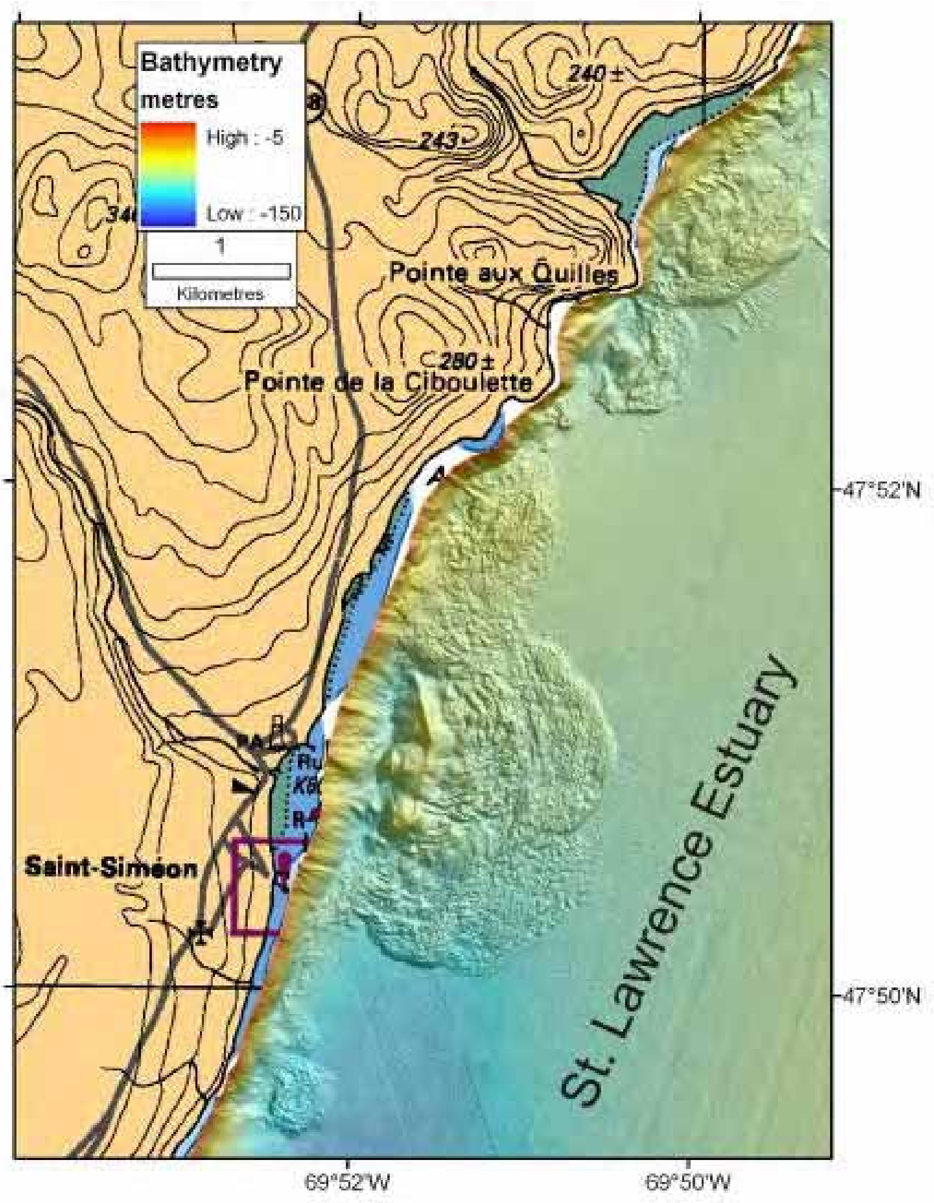
4.1.4.3 Other Geohazards

Canada’s coastline is over 243,000 km long, which is the longest in the world. As noted in Section 4.1.4.1, important offshore geohazards include seabed instabilities, pore pressure phenomena (discussed in Section 4.1.4.2), and seismicity (Section 4.1.2). Seabed instabilities including submarine slope failure is the most serious geohazard on both local and regional scales. Seabed instabilities have not been well researched because of their inaccessibility and general lack of direct societal consequence. With increasing awareness of the potential for offshore seabed instabilities (including slope failures) to potentially generate tsunami there is a need for better understanding of offshore seabed instabilities processes and potential (Locat and Lee 2002). The seabed instability geohazards are included for completeness and are not anticipated to occur at the Old Harry site for reasons noted below.

Seabed Instabilities

Seabed instabilities may occur near a coastal region and along continental slopes. Coastal seabed instabilities present a particular hazard as a result of their potential for tsunami generation as well as proximity to societal infrastructure. Coastal regions often exhibit a variety of factors that could result in the establishment of conditions for sediment mass-failure (Mosher 2008). As a result of wave, long-shore current and glacial erosion, coastal regions may have steep slopes. Coastal sediments arising from quaternary glaciations deposition have mixed lithologies that often lack cohesive strength as well as having endured episodes of sea level rise and fall, thus the sediments are of marine and lacustrine origin. This history results in sediments of variable adjacent geotechnical competency.

After British Columbia, the second highest earthquake prone area in Canada is the Laurentian Valley of Quebec (Mazzotti et al. 2005), which is located approximately 700 km from Old Harry. Numerous examples of sediment failure (Figure 4.10) can be found along the banks and submarine slope of the St. Lawrence estuary and the Saguenay Fjord (Urgeles et al. 2001; Levesque et al. 2006; Cauchon-Voyer et al. 2007). Most of the sediment failures are pre-historic but a few are recent events, 1663 and circa 1860 (Cauchon-Voyer et al. 2007). Depending upon conditions of failure and location, a modern instability event in these areas could readily cause damage to underwater structures and generate waves that will damage coastal infrastructure within a limited area.



Source:Mosher 2009.

Figure 4.10 Physical Features Present in the Gulf of St. Lawrence

It should be noted that the Old Harry site is not considered to be located in a coastal area as it is in the Gulf, approximately 80 km west of Cape Anguille, western Newfoundland, and 88 km northeast of the Magdalen Islands, Quebec, at a water depth of approximately 470 m (FGI 2010). The seabed slope at Old Harry is not steep, with the seabed dipping regionally to the southeast at an average of less than 1° (FGI 2010). The seabed at the Old Harry site displays a gently undulating topography with a broad, low relief "ridge" trending southeastward through the centre of the site, with low lying troughs on each side. The proposed well surface location is situated near the crest of the "ridge" at 470 m water depth and the local seabed dip is <1° south-southwest (FGI 2010).

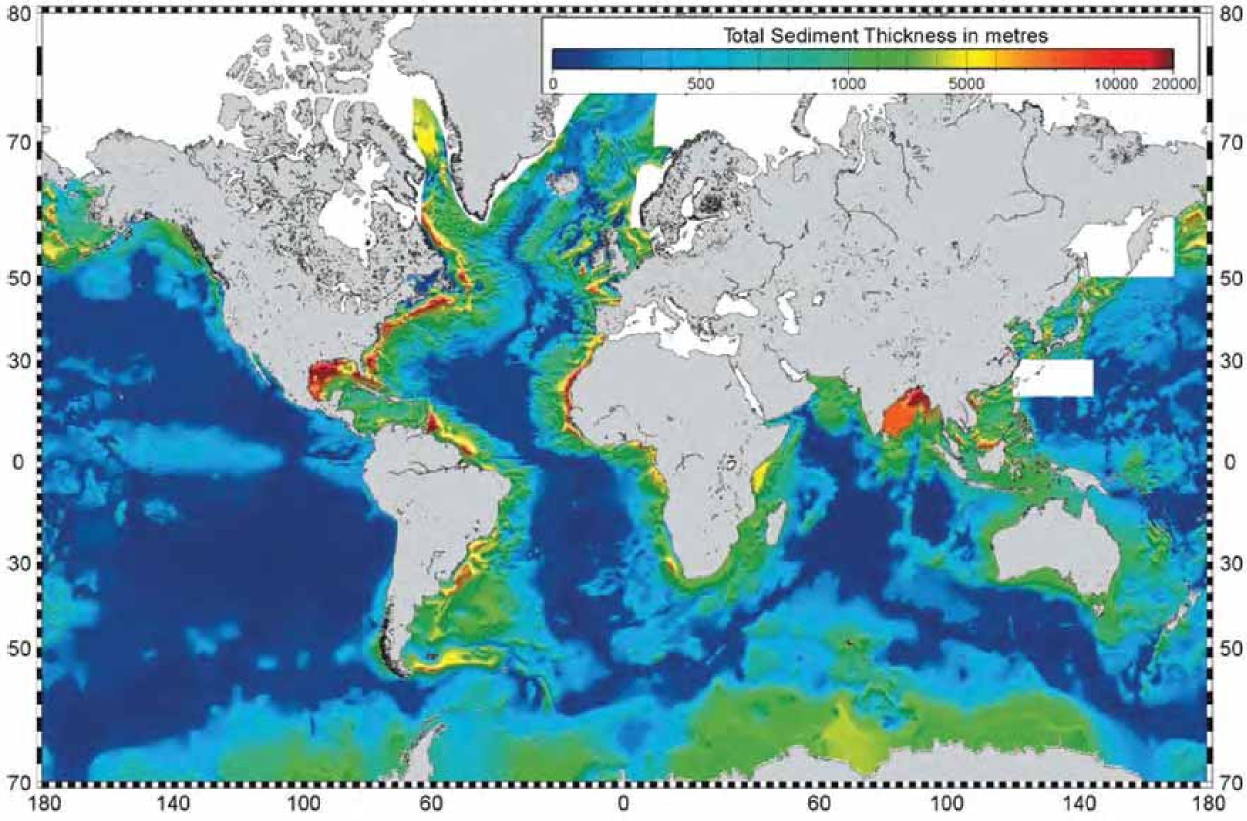
Continental Shelf Seabed Instabilities

Canada's underwater landmass below the 200 m (approximate depth of the shelf break) and above the 3,000 m isobath represents an area of 2,960,000 km^2, which is the largest of any country in the world. The seabed slope angles within this zone typically range between <1° and 4°, although canyon and channel wall or subduction thrust ridge slope angles can exceed 45° (Mosher et al. 2004a). The continental slope typically supports a stable, thick, unconsolidated sediment overburden (Mosher et al. 1994). Other factors that may result in seabed and slope instability potential include interstitial biogenic or hydrocarbon free gas, gas hydrate, salt mobility, high sedimentation rates (e.g., deglacial periods), high pore pressures and vertical lithologic (porosity / permeability) variability (Mosher et al. 2004b). Lykousis et al. (2007) indicate that for continental margin settings, seismicity, or ground shaking due to earthquakes, is required to initiate seabed instability. It is acknowledged that the main triggering mechanisms of sediment failures are seismic shaking, overloading, gas hydrate dissolution and excess pore pressure (coastal flow regime), wave loading, erosion and human activities such as coastal construction (Locat and Lee 2009).

Canada's eastern continental margin is a tectonically-passive margin where seismicity is rare (Adams and Halchuk 2003). However, earthquakes up to M7+ can be expected (Mazzotti and Adams 2005) and have occurred, such as the 1929 M7.2 event off the southern tail of the Grand Banks (Bent 1995). In the past, seismicity was probably more common due to deglacial isostatic rebound, or periods when possible ocean basin scale tectonism was active (Weaver 2003). The 1929 Grand Banks landslide is perhaps the most famous historic submarine mass-transport deposit. It led both to the first formal recognition of naturally-occurring turbidity currents (Piper et al. 1988), and that seafloor displacements due to seabed sediment failure can cause damaging tsunamis at great distance from their source (Ruffman and Tuttle 1995; Ruffman 2001; Fine et al. 2005).

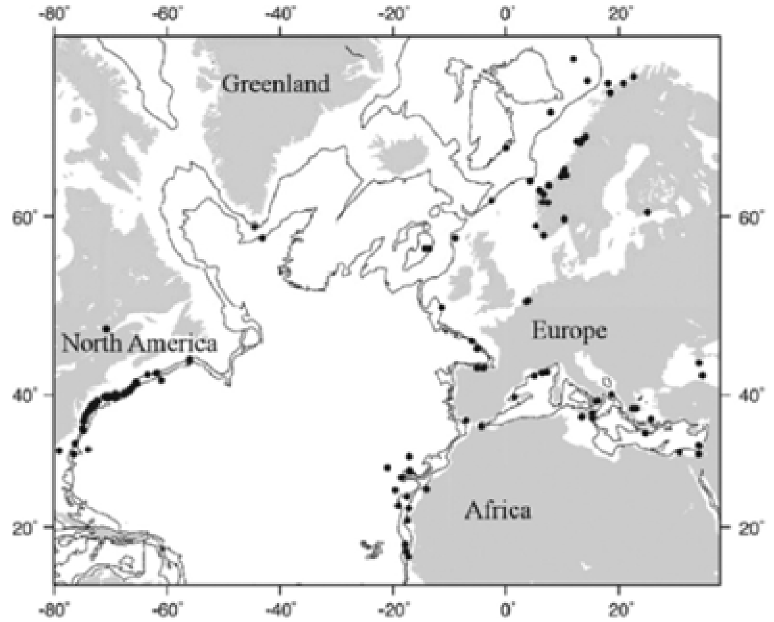
Lee et al. (2007) noted that submarine landslides (sediment instabilities) are not distributed uniformly over the world's oceans, but instead tend to occur commonly where there are thick bodies of soft sediment, where the slopes are steep and where the loads exerted by the environment are high. It should be noted that Old Harry is not situated in an area with this type of seabed morphology. A compilation of sediment thickness for the main oceans is illustrated in Figure 4.11 (areas coloured red denote a zone of substantial deltaic accumulation (such as the Gulf of Mexico) or thick glacial sequences (that would be found off the eastern coast of Canada)). The St. Lawrence Estuary is located in a glaciated area in which the land has risen faster than sea level, resulting in large terraces that were cut and are now exposed. A compilation of landslide distribution for the North Atlantic had been described in Hunerbach and Masson (2004) and is presented in Figure 4.12. Since the production of this figure, the St. Lawrence estuary was mapped and more than 30 slides were identified in that area (Campbell et al. 2008).

Slope instabilities occur mainly in two settings, on open continental margins and on oceanic island flanks, which appears to be a function of specific aspects of the geology and morphology of these areas. Slope failures associated with continental margin slopes are typically of low gradient with gentle topography; however, the 'drop' from shelf edge to basin floor can be up to 5 km over distances of a few hundred kilometres (Masson et al. 2006). Parallel-bedded sediment sequences with little variability over large areas characterize their subsurface structure, with the result that, should the conditions for slope failure occur, they can simultaneously affect large areas.



Source: Locat and Lee 2009

Figure 4.11 Total Sediment Thickness for Main Oceans



Source: Locat and Lee 2009

Figure 4.12 Slope Failures in Western and Eastern North Atlantic and Adjacent Seas

The hazard posed by submarine landslides will vary according to landslide scale, location, type and process and are such that even small submarine landslides can be dangerous when they occur in coastal areas. Slope failures can be divided into two types, those related to the geological characteristics of the landslide material (e.g., overpressure due to rapid deposition or the presence of a weak layer) and those driven by transient external events (e.g., earthquakes or climate change).

Many sedimented slopes prone to submarine landslides show a history of landsliding that extends back through geological time. This observation can often be applied at quite local scales, with areas showing stacked landslide deposits sharply demarcated from those showing long-term stability (Solheim et al. 2005). The importance of tsunamis generated by slope instabilities has only become widely recognized during the last 15 years or so, when it became apparent that a landslide source could explain the unusual run-up distributions and propagation characteristics of certain particularly deadly tsunami, such as the 1998 PNG event (Ward 2001; Okal and Synolakis 2004).

Seabed Instabilities Generated Tsunamis

Considerable evidence suggests that ‘unusual’ tsunamis, particularly those with high near-field run-ups that decay rapidly away from source, are directly caused by seabed and slope failures (landslides) (Bardet et al. 2003; Okal and Synolakis 2004). Rotational slides (often referred to as slumps), where a thick slide block with a steep headwall can move rapidly downward, may be particularly effective in generating tsunamis, even when the lateral distance moved is small and little effect is seen on the seafloor downslope of the immediate landslide site. As noted previously, the Old Harry site displays a gently undulating topography with a broad, low relief “ridge” trending southeastward through the centre of the site, with low lying troughs on each side. The proposed well surface location is situated near the crest of the “ridge” at 470 m water depth and the local seabed dip is <1° south-southwest (FGI 2010). This type of topography generally does not support seabed or slope failures.

Slope failure volume, velocity, initial acceleration, length and thickness all contribute to the determination of tsunami character (Masson et al. 2006). The best indicator of tsunamigenic potential is the product of volume and initial acceleration (Lovholt et al. 2005). An abrupt deceleration might also contribute to larger surface elevations. The slide length affects both the wavelength and the maximum surface elevation (Haugen et al. 2005), while the wavelength is also determined by the travel time or run-out distance of the slide. Submarine slides are normally clearly subcritical, implying that the tsunami will run away from the wave-generating slide, limiting the build-up of the wave. Slides in shallow waters are more critical, since the speed of wave propagation is lower. Moreover, shallower water normally means less distance to the coast and a shorter distance available for radial damping (Masson et al. 2006). In contrast, tsunamis generated by earthquakes are more critical when the seabed displacement occurs in deeper waters, as the initial wave will become shorter and more dangerously amplified when propagating from deeper to shallower waters (Masson et al. 2006). The area in which Old Harry is located is of low seismicity potential and in an area with gentle undulating topography, so slope failures in the immediate area would not be expected.

4.1.5 Physical Oceanography

The Gulf is a semi-enclosed sea (Koitutonsky and Bugden 1991), having two openings to the Atlantic Ocean, the Cabot Strait and the Strait of Belle Isle (Figure 4.5). The Gulf has a surface area of approximately 240,000 km^2, a volume of 3,553 km^3, an average depth of 152 m and maximum depths up to 535 m (Dufour and Ouellet 2007). The Gulf exchanges salt water with the North Atlantic Ocean and receives considerable input of fresh water from the St. Lawrence River and other nearby rivers. As a consequence, the Gulf acts like a large estuary where Coriolis effects (from force generated by the Earth’s rotation), geostrophic currents, baroclinic processes, formation of eddies and wind stress effects are all important.

Present within the Gulf are numerous shallow areas and deep troughs. One particularly well-known trough, called the Laurentian Channel, is a long, continuous trough that has a maximum depth of 535 m and extends approximately 1,500 km from the Continental Shelf in the Atlantic Ocean to its end point in the St. Lawrence Estuary. The Gulf is also characteristic of two secondary troughs, the Esquiman and the Anticosti Channels. Another predominant feature is the Magdalen Shallows, which is a plateau located in the southern Gulf (Dufour and Ouellet 2007). The physiographical features of the Gulf greatly influence the circulation, mixing and characteristics of water masses within this area (Dufour and Ouellet 2007).

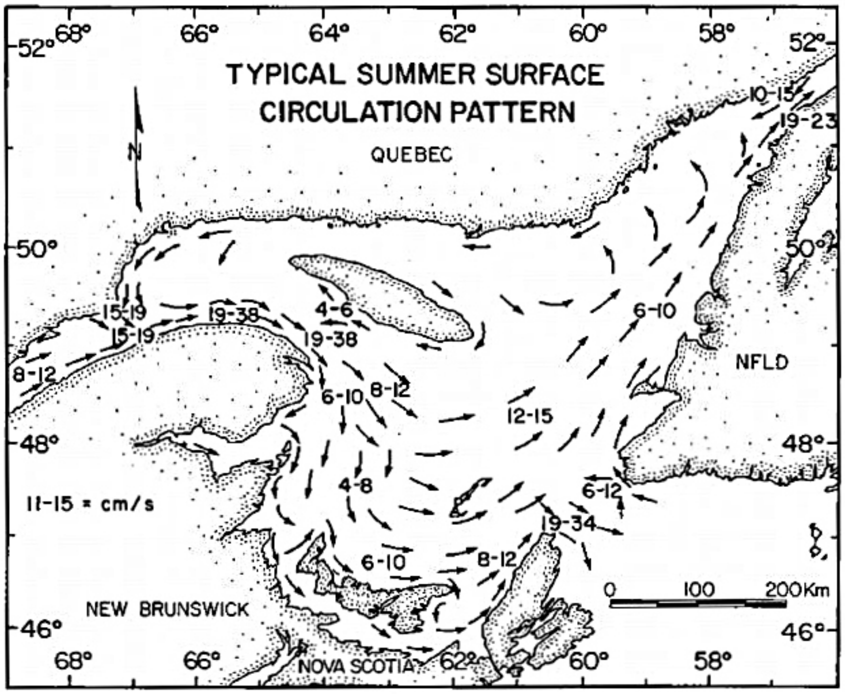
4.1.6 Bathymetry

Water depths within EL 1105 and the vicinity of the Project range from 400 to 500 m (see Figure 1.2).

4.1.7 Ocean Currents

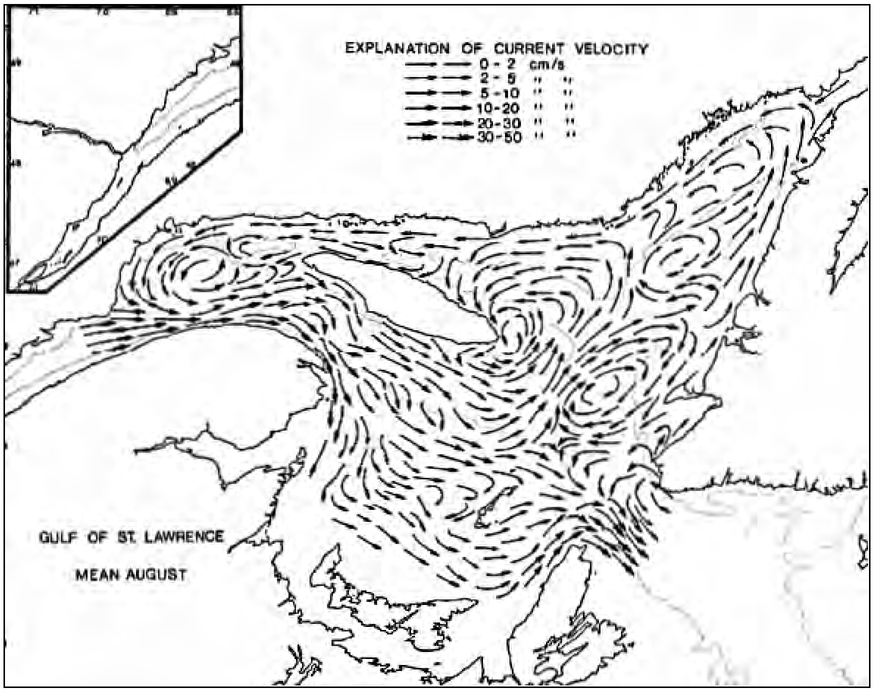
Knowledge of ocean currents is essential to the planning of oil and gas related operations in any area. Currents in the Gulf are influenced by a number of factors, including tides, regional meteorological events, freshwater runoff and water exchange through the Strait of Belle Isle and the Cabot Strait. Generally, the movement of water follows through the Cabot Strait, flowing counter clockwise around the Gulf to the mouth of the St. Lawrence River, across the Magdalen Shallows, and exits via the Cabot Strait. There are large, seasonally-variable runoffs of fresh water into the Gulf, mainly from the St. Lawrence River and rivers of the northern shore and southern shores, which strongly influence the circulation of the Gulf.

Driven by wave and tidal movement, cold, dense water flows into the Gulf through the Strait of Belle Isle from the Arctic via the Labrador Current. Waters from the Atlantic Ocean enter the Gulf via the Cabot Strait, in the Laurentian Channel (Figure 4.13). The surface circulation of the Gulf exhibits strong features such as coastal currents, gyres, large eddies in the Estuary and tidal fronts (Dufour and Ouellet 2007). The St. Lawrence River outflow produces a strong coastal current that flows along the length of the Gaspé Peninsula (the Gaspé Current), flowing seaward and dispersing the St. Lawrence runoff in the northwestern and the southern Gulf (Dufour and Ouellet 2007). The waters of the southern Gulf (between the Magdalen Islands, Prince Edward Island and the western side of Cape Breton) form the main outflow of the Gulf on the western side of Cabot Strait. On the eastern side of Cabot Strait, an inflow from the Atlantic flows northeastward along the west coast of Newfoundland (Dufour and Ouellet 2007). The waters from the Strait of Belle Isle move westward along the northeastern shore (Dufour and Ouellet 2007) (Figure 4.14).



Source: Trites 1972, in LGL 2005b.

Figure 4.13 Typical Summer Circulation in the Gulf of St. Lawrence

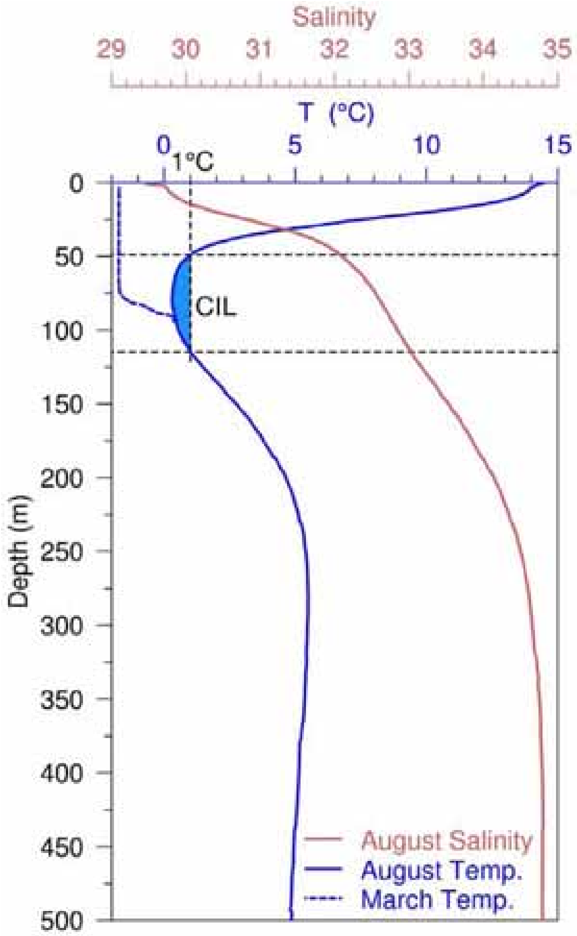


Source: LGL 2005b.

Figure 4.14 Geostrophic Surface Currents in the Gulf of St. Lawrence in August

The surface circulation is cyclonic, that is, the surface current moves in a counter-clockwise fashion (Figure 4.13). The similarities between this cyclonic circulation pattern and the surface salinity distributions in the Gaspé and Magdalen Shallows regions indicate that the surface currents are a result of the geostrophic balance (Figure 4.14) between the horizontal pressure gradient field and Coriolis effects (Koutitonsky and Bugden 1991) and are indicative of a complex circulation pattern.

Oceanographic conditions in the Gulf are complex. Masses of water with acutely contrasting temperature and salinity come together and mix. The Gulf can be considered a three-layer system (Figure 4.15) during summer (surface layer, cold intermediate layer and deep water layer); the two upper layers undergo seasonal variations and become one during the winter months (DFO 2005a; Dufour and Ouellet 2007). Surface temperatures typically reach maximum values in mid-July to mid-August (Galbraith et al. 2011). Gradual cooling occurs thereafter, and wind mixing during the fall leads to a progressively deeper and cooler mixed layer, eventually encompassing the cold intermediate layer. During winter, the surface layer thickens as a result of buoyancy loss (due to cooling and reduced runoff) and brine rejection associated with sea-ice formation. However, the primary force driving the surface layer thickening is wind-driven mixing prior to ice formation (Galbraith 2006).



Source: Galbraith et al. 2011.

Figure 4.15 Typical Depth Profile of Temperature and Salinity Observed during the Summer in the Gulf of St. Lawrence (based on 2007-2008 data)

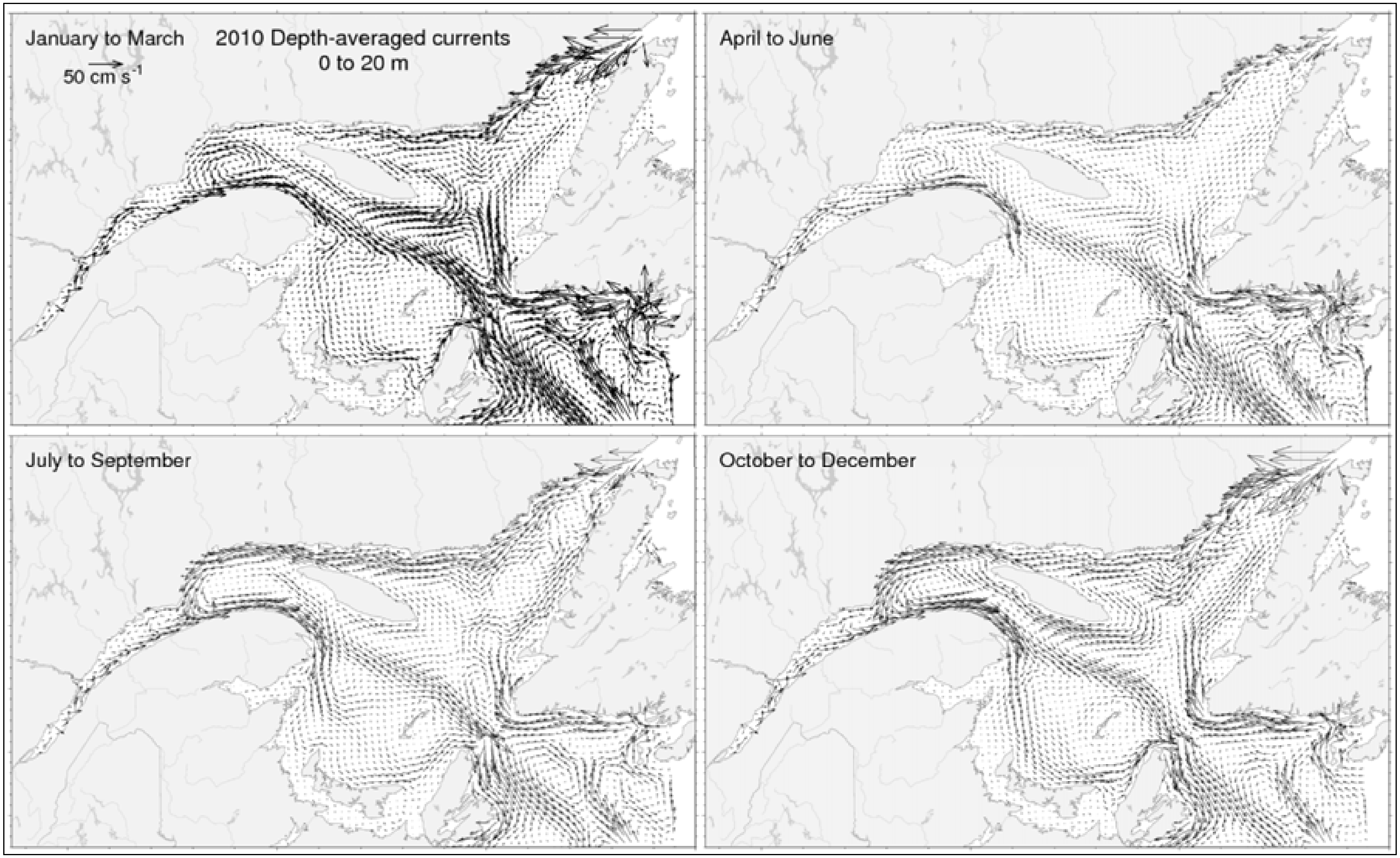
The surface winter layer reaches an average depth of 75 m with depths up to 150 m and deeper in the northeast Gulf, where waters from the Labrador Shelf at the Strait of Belle Isle may intrude into the Gulf and extend the surface winter layer from the surface to the bottom (>200 m) in Mécatina Trough by the end of March. The surface winter layer exhibits temperatures near freezing (-1.8 to 0ºC) (Galbraith 2006).The warmer, low salinity surface layers produced during the spring when an increase in freshwater flow enters the Gulf via the St. Lawrence River, the Saguenay River and other smaller rivers along the shores. The surface layer flows out of the Gulf into the Atlantic. Additional freshwater runoff occurs in the fall, driving circulation patterns in the Gulf, and causing the area to show properties of an estuarine environment (Dufour and Ouellet 2007). At the start of winter the warmer, low salinity surface layer flowing into the Atlantic becomes less buoyant, due to the drop in air temperature and ice formation, and moves downward in the water column. Once spring arrives, a new summer surface layer is created causing the winter layer to be trapped below. This is referred to as the Cold Intermediate Layer (Dufour and Ouellet 2007).

Currents are strongest in the surface mixed layer, generally 0 to 20 m, except in winter months when the 20 to 100 m averages are almost as strong (the surface layer and cold intermediate layer have merged as one layer) and the deep layer (100 m to the bottom) averages are very high. Currents are strongest along the slopes of the deep channels. The Anticosti Gyre is always evident but strongest during winter months, when it even extends strongly into the bottom-average currents (Galbraith et al. 2011). Figure 4.16, 4.17 and 4.18 present the seasonal depth-averaged currents for 0 to 20 m, 20 to 100 m, and 100 m to the bottom for 2010 (Galbraith et al. 2011).

Maurice Lamontagne Institute, Canadian Hydrographic Service and DFO issue ocean forecasts for the Gulf (St. Lawrence Global Observatory (SLGO) 2011). The surface current forecast is extracted from a three-dimensional numerical model computing the oceanic circulation under the influence of tides, the St. Lawrence River fresh water runoff, atmospheric forcing and the sea ice drift, growth and melt (SLGO 2011). This model has been validated under a series of scientific and operational research and development programs within DFO. The validation process was done against a number of oceanographic observations including currents, water level, water temperature and salinity (SLGO 2011). This online program allows for daily forecast of surface currents. The surface currents for EL 1105 are illustrated in Figure 4.19 and is an example output of the model described above is presented for February 4, 2011 @ 1100 hours.

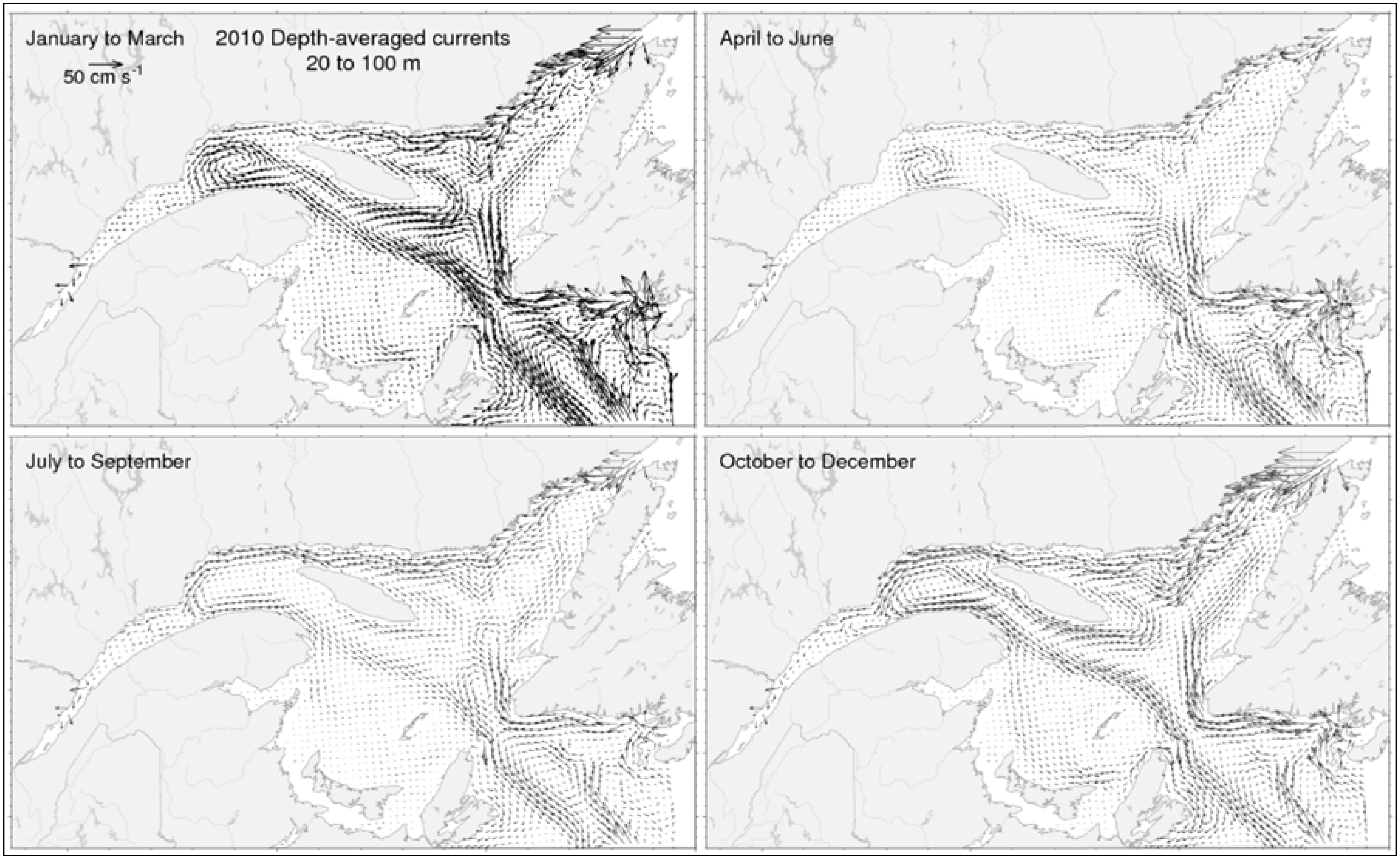
Vertical mixing is an important process affecting water masses as it plays an important role in marine habitats, thereby having a direct affect on productivity and biodiversity. Tides propagating over the sills at the head of the Laurentian Channel produce strong mixing of the different water masses that converge in this area (Dufour and Ouellet 2007). Tidal mixing is also a permanent and dominant modifier of the intermediate and deeper waters near the head of Jacques Cartier Strait and in the Strait of Belle Isle (Lu et al. 2001; Saucier et al. 2003). The wind-driven mixing coupled with the tidal regime and the local stability of the surface waters will determine the deepening of the summer and winter surface layers (Saucier et al. 2003). A water mass can reside in the Gulf for a few months near the surface or up to a few years in the colder, bottom waters.

Atmospheric conditions in the Gulf also play an important role in the circulation of water, as they have an effect on cloud cover, precipitation, evaporation and air temperature.



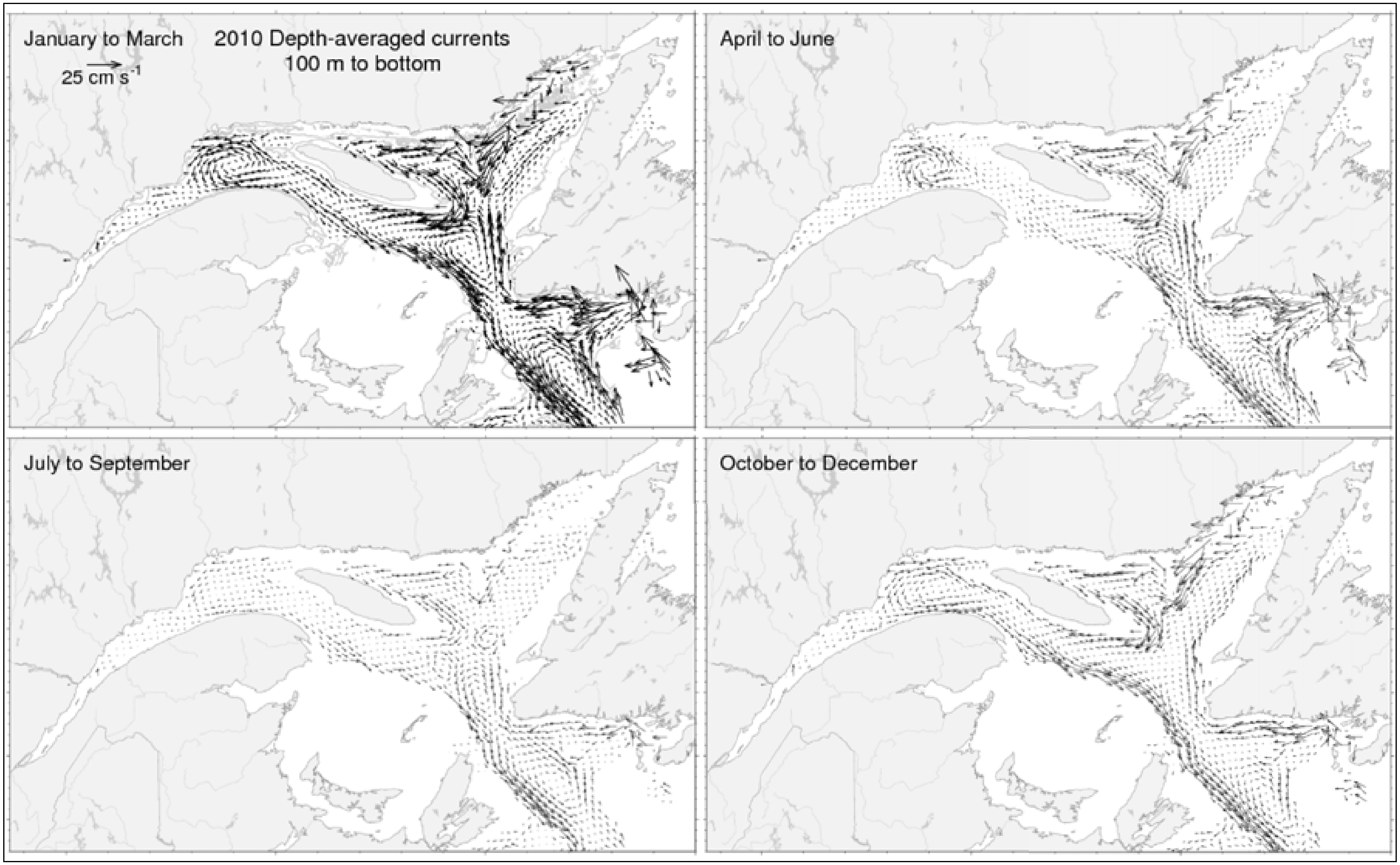
Source: Galbraith et al. 2011

Figure 4.16 Depth-averaged Currents from 0 to 20 m for each Three-month Period of 2010



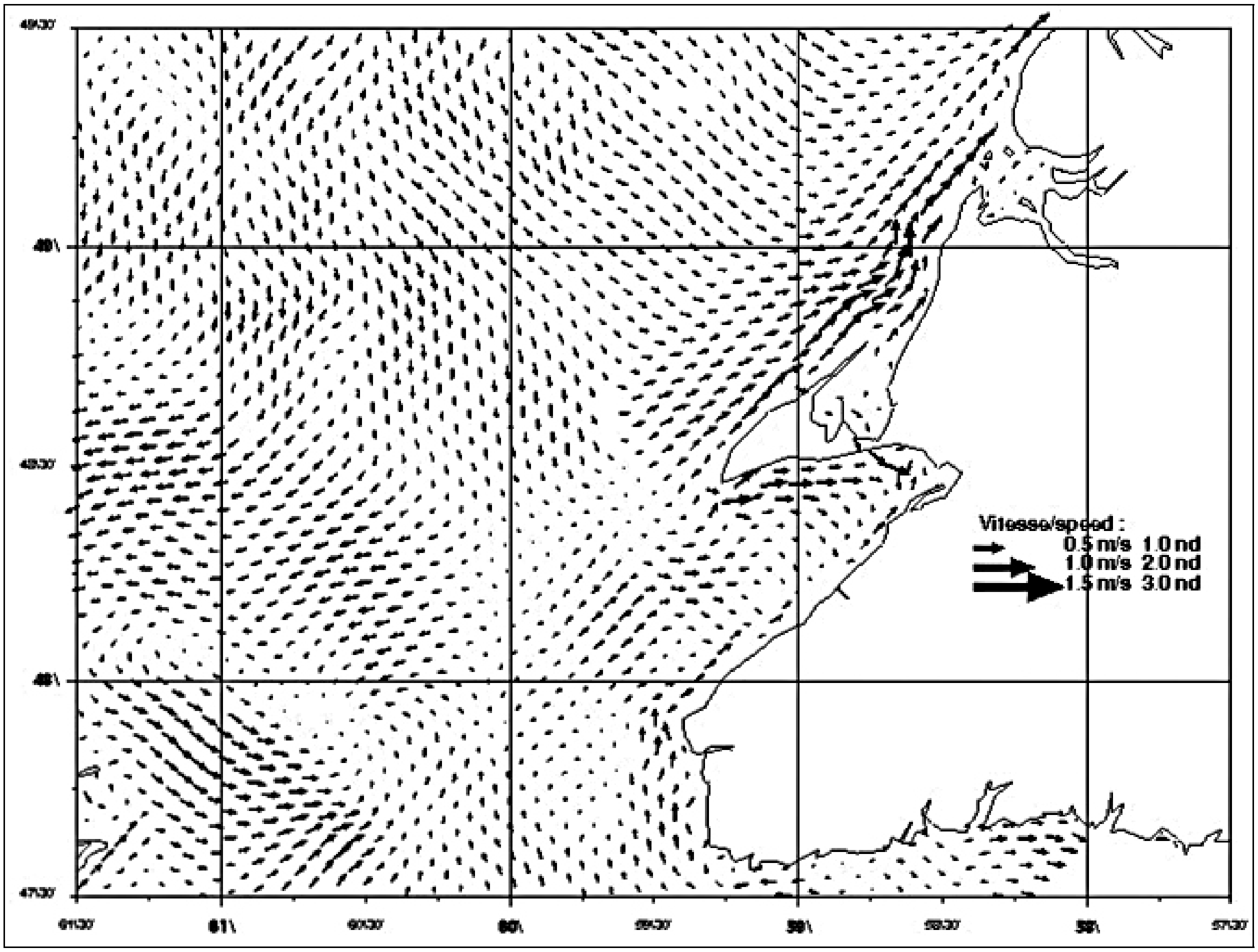
Source: Galbraith et al. 2011

Figure 4.17 Depth-averaged Currents from 20 to 100 m for each Three-month Period of 2010



Source: Galbraith et al. 2011

Figure 4.18 Depth-averaged Currents from 100 m to Bottom for each Three-month Period of 2010

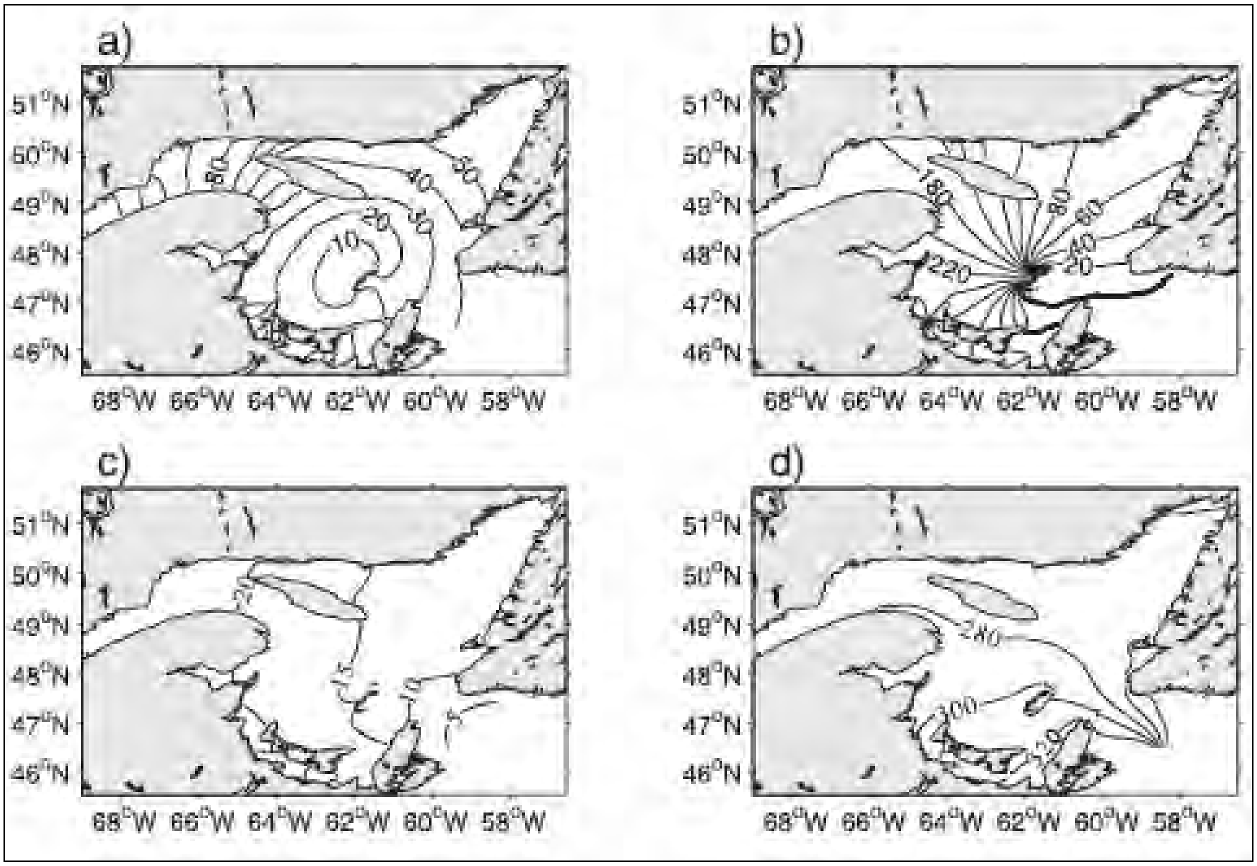


Source: SLGO 2011.

Figure 4.19 Surface Currents in the Gulf of St. Lawrence (top: February 4, 2011 @ 1100 hours and bottom: September 29, 2011 @ 0800 hours)

4.1.8 Tides

The tides in the Gulf are mixed in the centre of the Gulf (LGL 2005b). Tides are forced through the Cabot Strait with minor contributions from the Strait of Belle Isle and direct gravitational forcing (Lu et. al. 2001). There is an anticlockwise rotation of a tidal wave around a point west of the Magdalen Islands (Figure 4.20). Tidal currents seldom exceed 30 cm/sec (Koutitonsky and Bugden 1991).



Source: Lu et al. 2001.
Amplitudes are in cm, and phases are in degrees relative to midnight GMT.
Note: a and c are coamplitude lines; b and d are cophase lines.

Figure 4.20 Semidiurnal (M2) and Diurnal Tide (K1) Lines Calculated using a Complex Model

4.1.9 Waves

The wave climate in the Gulf can be affected by extra-tropical storms occurring during October to March. Tropical storms can also occur between August and October; however, hurricanes tend to have reduced to tropical or extra-tropical storms by the time they have reached the Gulf waters (LGL 2005b). The wave climate in the Gulf was assessed by means of the MSC50 data set for grid point 13511 (within the Project Area). The minimum, maximum, mean and standard deviations of significant wave heights for each season are presented in Table 4.1. Maximum significant wave heights were greatest during the fall and winter seasons. The percent occurrence of peak wave period against significant wave heights for grid point 13511 for each season is presented in Tables 4.2 to 4.5. Wind data from the same grid point are provided in Section 4.3.2.

Table 4.1 Minimum, Maximum, Mean and Standard Deviation of Significant Wave Height at Grid Point 13511 by Season

Season	Minimum Wave Height (m)	Maximum Wave Height (m)	Mean Wave Height (m)	Standard Deviation (m)
Fall (Sept to Nov)	0.15	9.29	1.95	1.09
Winter (Dec to Feb)	0	9.46	2.41	1.35
Spring (March to May)	0	7.05	1.41	0.92
Summer (June to Aug)	0.1	7.56	1.14	0.63

Table 4.2 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 13511: September, October and November

Period	Significant Wave Height (m)										Total
	1	3	5	7	9	11	13	15	17	19	
0 to 0.99	0	2.05	9.82	2.25	2.19	0.72	0.67	0.13	0.02	0	17.9
1 to 1.99	0	0.46	25.1	13.2	2.58	0.95	0.61	0.2	0.05	0	43.1
2 to 2.99	0	0	0.81	20.6	1.29	0.29	0.22	0.01	0.01	0	23.2
3 to 3.99	0	0	0	4.04	5.94	0.12	0.07	0	0	0	10.2
4 to 4.99	0	0	0	0.07	3.76	0.07	0.03	0	0	0	3.92
5 to 5.99	0	0	0	0	0.95	0.31	0.01	0	0	0	1.27
6 to 6.99	0	0	0	0	0.02	0.29	0	0	0	0	0.31
7 to 7.99	0	0	0	0	0	0.08	0	0	0	0	0.08
8 to 8.99	0	0	0	0	0	0.03	0	0	0	0	0.03
9 to 9.99	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**2.51**	**35.7**	**40.2**	**16.7**	**2.87**	**1.6**	**0.35**	**0.08**	**0**	**100**

Table 4.3 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 13511: December, January and February

Period	Significant Wave Height (m)										Total
	1	3	5	7	9	11	13	15	17	19	
0 to 0.99	0.07	2.25	5.22	0.34	1.19	1.03	0.69	0.03	0.01	0.01	10.9
1 to 1.99	0	0.44	19.9	9.95	2.07	1.99	0.68	0.09	0	0	35.1
2 to 2.99	0	0	1.66	21.9	1.44	0.94	0.36	0.06	0	0	26.3
3 to 3.99	0	0	0.01	6.72	8.04	0.4	0.17	0.01	0	0	15.4
4 to 4.99	0	0	0	0.27	6.84	0.22	0.07	0	0	0	7.41
5 to 5.99	0	0	0	0	2.28	0.78	0.02	0	0	0	3.07
6 to 6.99	0	0	0	0	0.17	0.97	0.02	0	0	0	1.16
7 to 7.99	0	0	0	0	0	0.48	0.01	0	0	0	0.49
8 to 8.99	0	0	0	0	0	0.2	0	0	0	0	0.2
9 to 9.99	0	0	0	0	0	0.04	0	0	0	0	0.04
Total	**0.07**	**2.7**	**26.8**	**39.2**	**22**	**7.05**	**2.03**	**0.19**	**0.01**	**0.01**	**100**

Table 4.4 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 13511: March, April and May

Period	Significant Wave Height (m)											Total
	1	3	5	7	9	11	13	15	17	19	21	
0 to 0.99	0.63	7.59	15	6.95	5.48	1.93	1.66	0.11	0.04	0.02	0.01	39.4
1 to 1.99	0	0.62	24.7	9.29	3.25	1.39	0.27	0.03	0	0	0	39.5
2 to 2.99	0	0	0.9	12.3	0.97	0.32	0.08	0	0	0	0	14.6
3 to 3.99	0	0	0	2.53	1.9	0.09	0.05	0	0	0	0	4.57
4 to 4.99	0	0	0	0.05	1.29	0.03	0.02	0	0	0	0	1.39
5 to 5.99	0	0	0	0	0.37	0.06	0	0	0	0	0	0.44
6 to 6.99	0	0	0	0	0.02	0.07	0	0	0	0	0	0.08
7 to 7.99	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0.63**	**8.21**	**40.6**	**31.1**	**13.3**	**3.89**	**2.09**	**0.14**	**0.04**	**0.02**	**0.01**	**100**

Table 4.5 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 13511: June, July and August

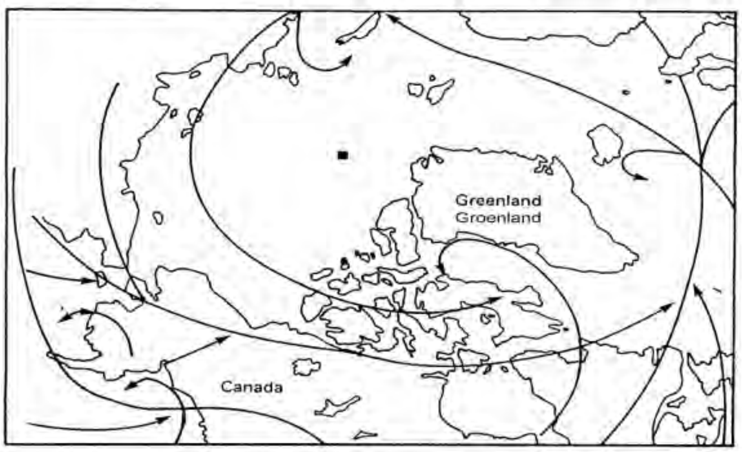
Period	Significant Wave Height (m)										Total
	1	3	5	7	9	11	13	15	17	19	
0 to 0.99	0	7.74	24.5	11.3	4.26	1	0.89	0.34	0.19	0.02	50.3
1 to 1.99	0	0.43	27.8	9.87	1.31	0.53	0.05	0.07	0.03	0.01	40.1
2 to 2.99	0	0	0.26	7.73	0.25	0.07	0	0.01	0	0	8.32
3 to 3.99	0	0	0	0.54	0.58	0.02	0	0	0	0	1.14
4 to 4.99	0	0	0	0	0.17	0	0	0	0	0	0.17
5 to 5.99	0	0	0	0	0.01	0	0	0	0	0	0.02
6 to 6.99	0	0	0	0	0	0	0	0	0	0	0
7 to 7.99	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**11.2**	**52.6**	**29.5**	**6.59**	**1.63**	**0.94**	**0.41**	**0.23**	**0.03**	**100**

The majority of the significant wave heights during the fall and winter occurred at 7 m and at 5 m during the spring and summer. Generally, the winter months experienced the highest wave heights. During the fall, winter and spring the typical peak period is approximately 2 seconds and 1 second during summer months.

Surface water current fields developed by the Ocean Sciences Division, Maritimes Region of DFO (Tang et al. 2008) were used in the spill trajectory modelling. Seasonal mean surface water velocities were provided by DFO. These water currents were combined with wind data to determine the initial slick characteristics and their subsequent movement (See Section 2.12.2).

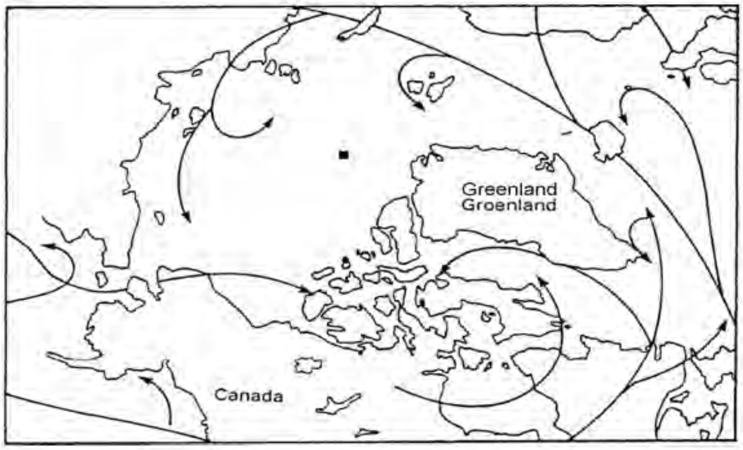
4.1.10 Storm Tracks in the Gulf of St. Lawrence

Weather systems tend to move along preferred paths over Canadian waters. Major tracks pass through the St. Lawrence Lowlands, with storms developing and moving out to sea in a northeasterly direction over the Grand Banks of Newfoundland and the Labrador Sea. Major polar storm tracks during the summer months are shown in Figure 4.21. The important weather features affecting the North Atlantic during winter are a low pressure area, the Icelandic Low, centred southeast of Greenland; and a continental high pressure system which develops west of Hudson Bay. While the most common polar storm tracks are illustrated in Figures 4.21 and 4.22, individual storms may behave quite differently. It is common to encounter severe weather conditions resulting from low pressure systems that move northward along the United States Eastern Seaboard into the Gulf and onto the Grand Banks. These variations in normal weather patterns can result in large departures from typical seasonal weather conditions, affecting wind speed and direction, air temperature, precipitation and visibility, and can produce unseasonal ice conditions for a given region (DFO 1999a). The frequency of extratropical storm tracks during 1998 are illustrated in Figure 4.23.



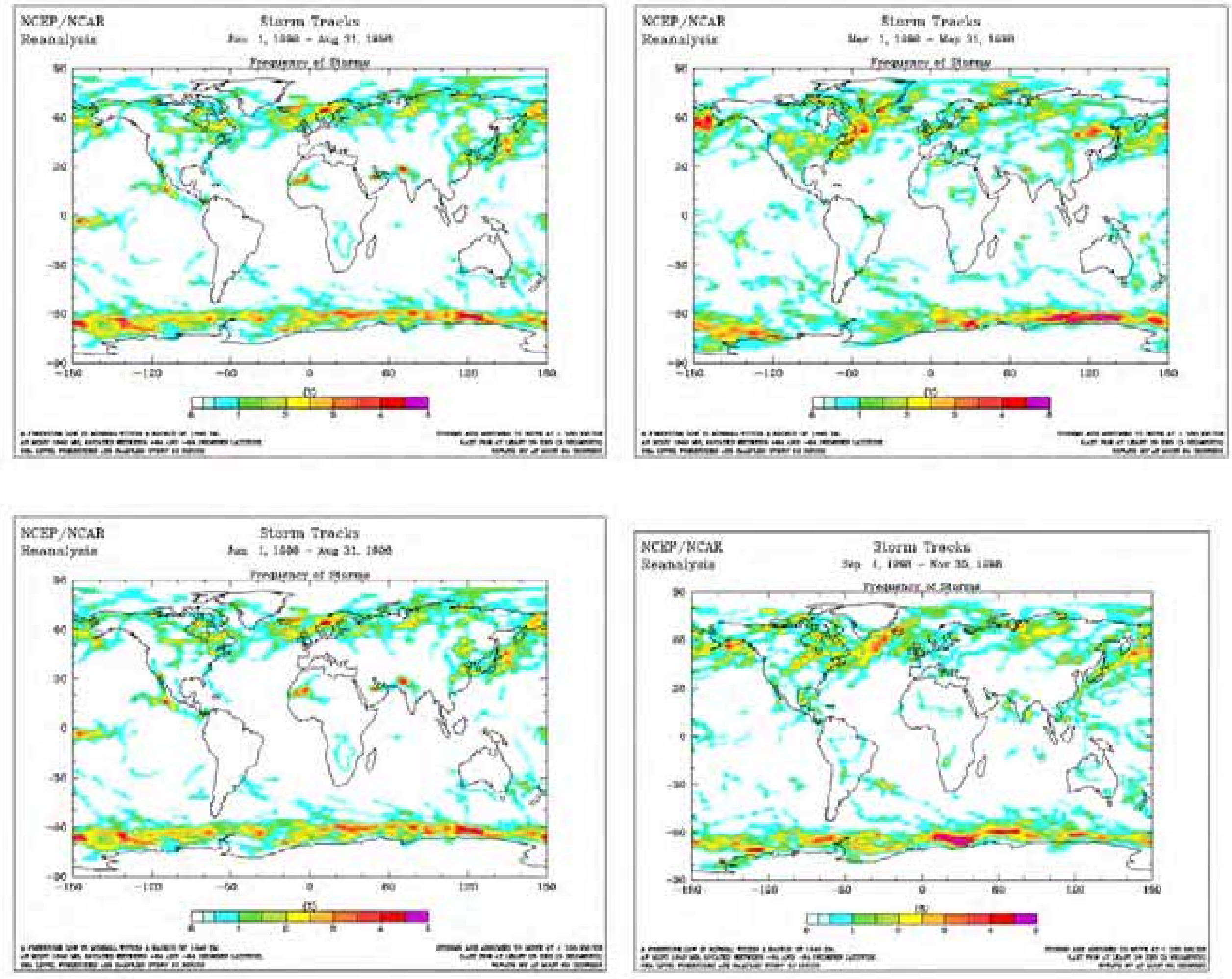
Source: DFO 1999a.

Figure 4.21 Principal Summer Storm Tracks



Source: DFO 1999a.

Figure 4.22 Principal Winter Storm Tracks

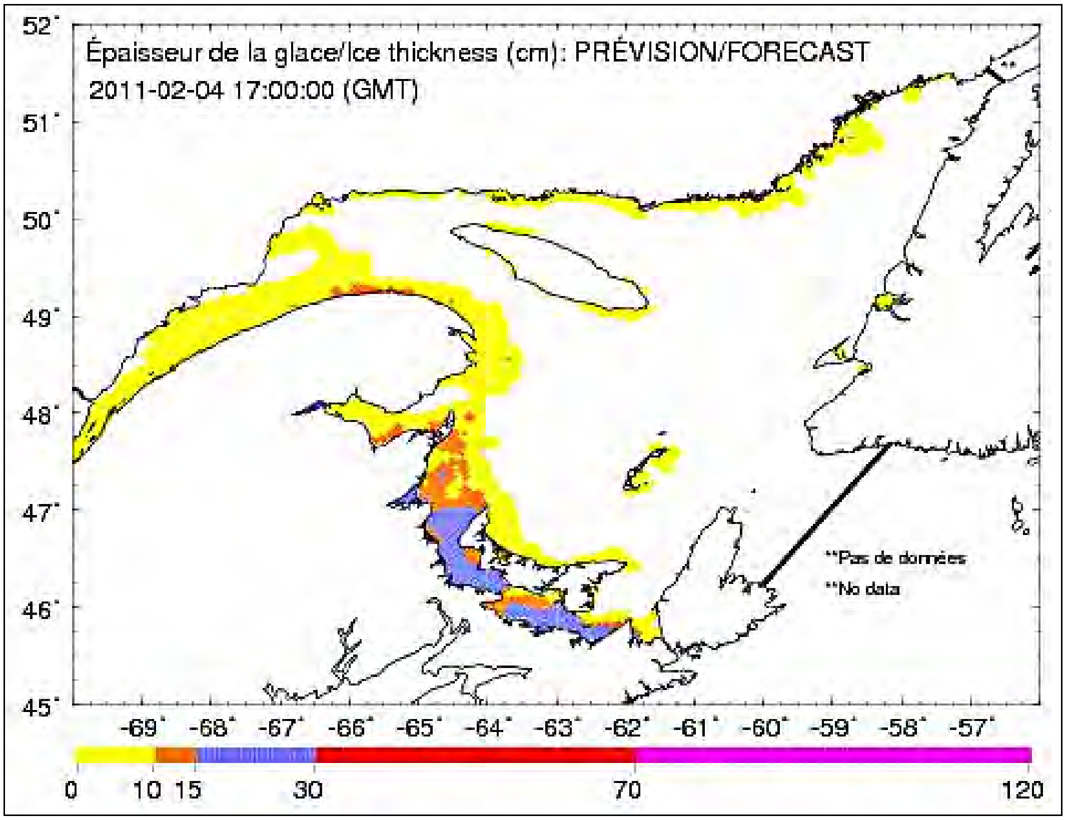


Source: NOAA No Date.

Figure 4.23 Frequency of Extratropical Storms, 1998

4.1.11 Ice

An important feature of the Gulf is that ices forms in the Gulf every winter. However, there tends to be a lot of variation in ice cover, thickness and break-up times from year to year. Floating ice is present in two forms in the marine environment - sea ice and icebergs. Both types pose a potential hazard to marine vessels and drilling rigs. Ice found in EL 1105 is a result of ice that has primarily formed in the Gulf. All sea ice in EL 1105 is first-year ice, ranging in its un-deformed thickness from 30 to 120 cm (SLGO 2011; Figure 4.20). Daily graphs such as depicted in Figure 4.24 are available as a seasonal service from http://slgo.ca/en/ocean/data/ice-concentration.html, starting in December / January through May / June.

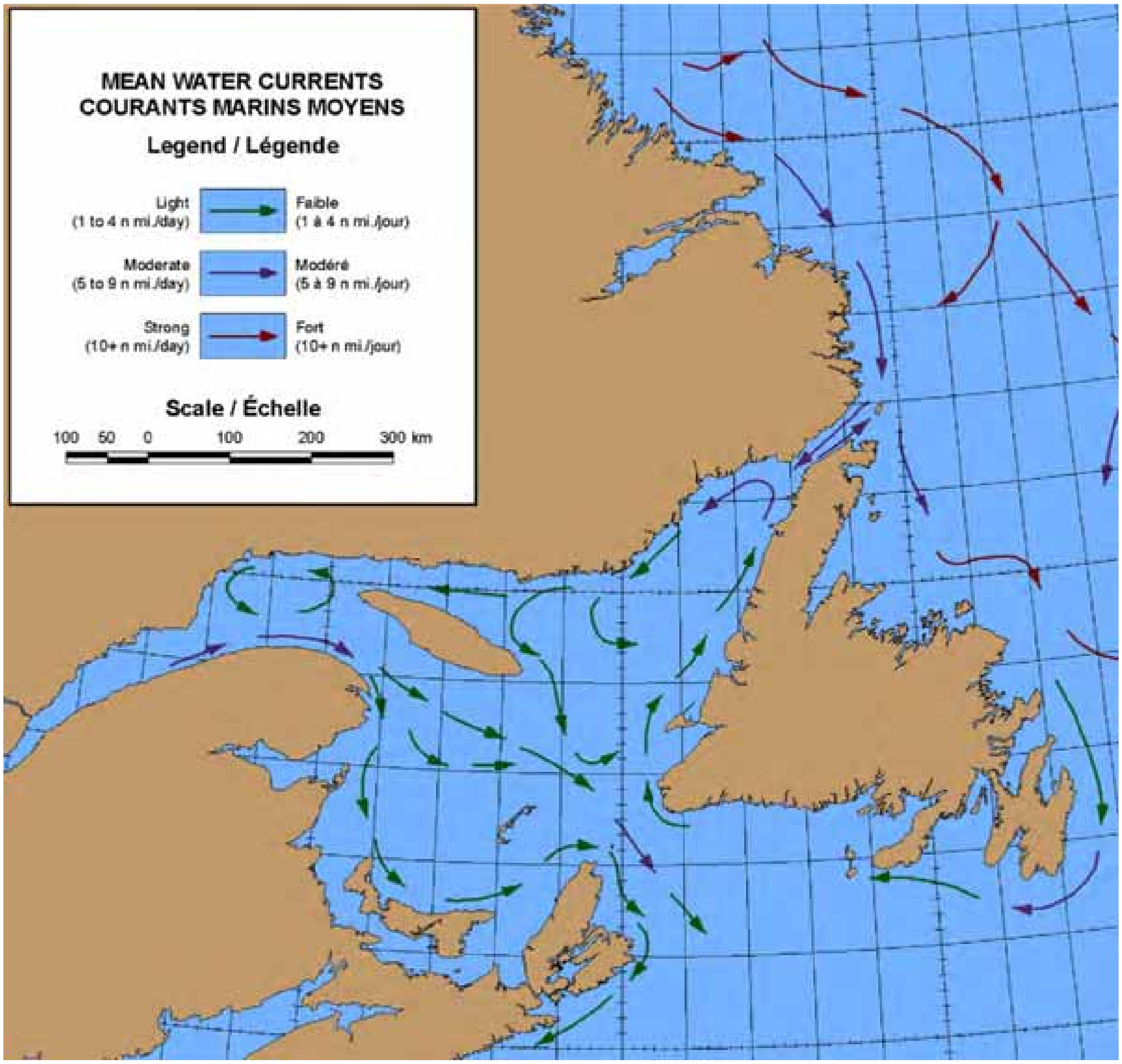


Source: SLGO 2011.

Figure 4.24 Ice Thickness for Ice in Gulf of St. Lawrence (February 4, 2011 @ 1700 hours)

The main oceanographic factors influencing the ice regime are bathymetry, currents, and tides. The bathymetry of the Gulf is well known, having a deep trench, known as the Laurentian Channel, running from Cabot Strait to the Saguenay River with depths of 500 m decreasing to 200 m above Rivière du Loup. There is an extension of this deep trench into Jacques Cartier Passage and the Northeast Arm of the Gulf with water depths of 175 to 275 m. The southwestern part of the Gulf averages less than 75 m in depth and the limiting water depth in the Strait of Belle Isle is 50 m. Northumberland Strait also has shallow water depths running between 17 and 65 m with the deepest waters located at each end of the strait (Environment Canada 2011).

The current is strongest at 2 to 12 nm offshore of the Gaspé Peninsula and has a mean speed of 6 to 10 nm per day. Once into the main portion of the Gulf, the water spreads over the Madeleine Shallows and drifts generally towards Cabot Strait with some that also follow the deep Laurentian Channel directly across the Gulf. Typical rates of motion over the Madeleine of 3 to 5 nm per day. There is a northeastward-flowing current, having a mean speed of 2 to 4 nm per day, flowing along the west coast of Newfoundland past Bay of Islands and Daniel’s Harbour (Environment Canada 2011). The mean water currents for the Gulf are illustrated in Figure 4.25 and are one of the oceanographic factors that play an important part in influencing the ice regime of the Gulf.



Source: Environment Canada 2011

Figure 4.25 Mean Water Currents

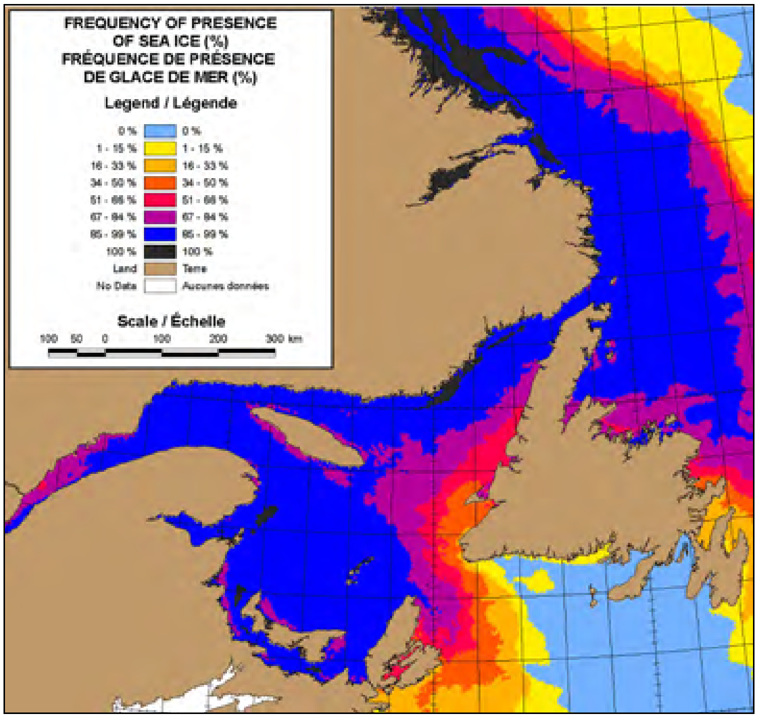
In the Gulf, the tides are complicated because the tidal surge enters from both Cabot Strait and the Strait of Belle Isle. The main tidal surge progresses in a counter-clockwise manner around the Gulf after entering at Cabot Strait and mean ranges vary from 0.8 to 1.1 m at Cape North and Cape Ray to 1.2 to 1.5 m on the west coast of Newfoundland and along the north shore of the Gulf. The tides in the Iles de la Madeleine are approximately 0.7 m. The Northumberland Strait has a complicated tidal pattern with tides in the west having one tide per day, while in the eastern section there are the normal two tides with ranges of 1.2 to 1.8 m. The Strait of Belle Isle has tides in the 0.8 to 0.9 m range (Environment Canada 2011).

The major effect on the ice from the tidal forces is that the ice moves back and forth as the tides rise and fall. This effect is most apparent in the upper Estuary as well as Chaleur Bay and its approaches. As a result of the tidal influences, fast ice in these areas tends to be limited due to the constant motion (Environment Canada 2011).

In considering the ice regime of the Gulf, there are two major climatic factors that affect the ice coverage. The mean temperatures during the winter do not fall substantially below the freezing point and, as a result, cold or mild winters have a very substantive effect on the extent and severity of the ice cover (Environment Canada 2011). The second climatic factor is the winter winds from west through north will nearly always be cold and dry, whereas those from the west through south to northeast will be mild and moist. This also has an effect on the location of areas of ice dispersal and congestion once ice has formed (Environment Canada 2011).

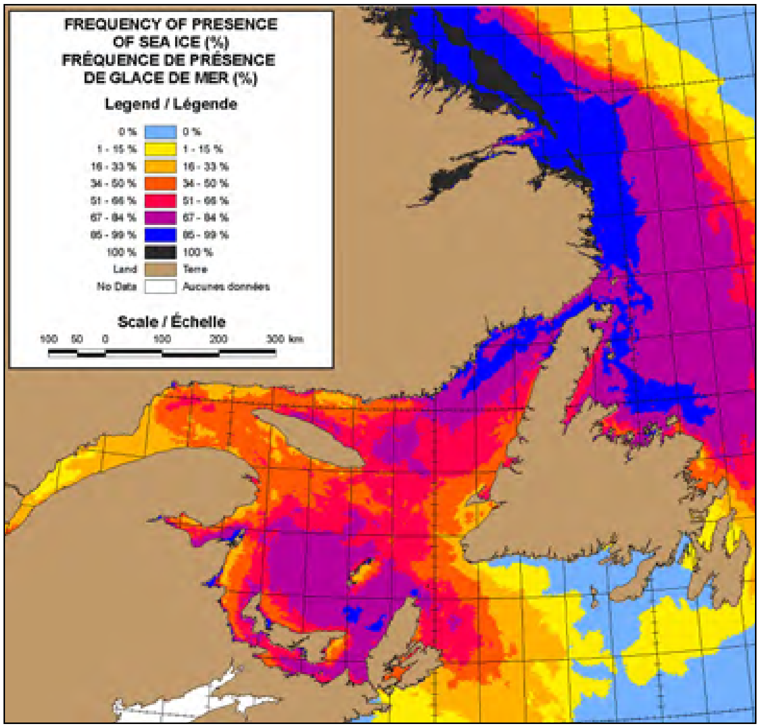
Ice forms in the Gulf commencing in the near-shore areas of the St. Lawrence River. By the first week of February, the ice drifting southward through Cabot Strait will reach the approaches to Sydney and affect shipping until mid-April. The ice cover continues to grow and thicken as it spreads to cover most of the remaining areas of the Gulf by the third week of February (Environment Canada 2011). The exception is a 10 to 30 Km coastal lead along the Newfoundland coast south of Cape Saint George.

At the beginning of February grey-white and grey ice predominates with thin first year ice gradually developing over the course of the month. By the end of the third week of February thin first year is found in Northumberland Strait, along the northwest coast of Cape Breton, along the north coast of les Îles de la Madeleine, along the west coast of Newfoundland as well as along the south shores of Chaleur Bay and the Estuary (Environment Canada 2011). Over the northern portions of the St. Lawrence Estuary and Gulf, the predominant ice type remains new and grey because offshore winds push the ice southward. From the later part of February until the middle of March, the ice in the Gulf will have reached its maximum extent and much of the ice continues to grow to the first-year stage of development. As a result of the continuous southward drift of the pack in the Gulf, the ice remains at the grey-white stage over the northwestern portions of the Gulf. The lead along the west Newfoundland coast, particularly north of the Port-au-Port Peninsula, is closed and there can be ice drifting into Cabot Strait. For the period 1981 to 2010, the most ice encountered in a single season in the Gulf occurred in 1989/1990 with the least amount of ice occurred in 2009/2010. The ice coverage varies considerably from year to year but in general, there were above normal conditions from 1980/1981 to 1994/1995 and then below normal conditions from 1995/1996 to 2009/2010. The maximum pack ice extent in the Gulf in February, March and April, based on a 30-year median of ice concentration, is displayed in Figures 4.26, 4.27 and 4.28, respectively (Environment Canada 2011).



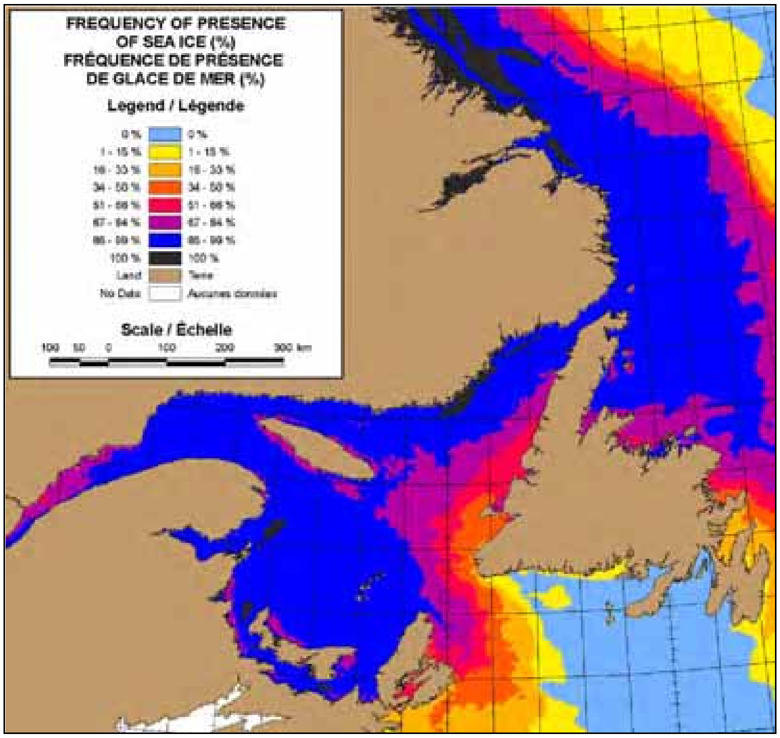
Source: Environment Canada 2011.

Figure 4.26 Maximum Pack Ice Extent in February (1981 to 2010)



Source: Environment Canada 2011.

Figure 4.27 Maximum Pack Ice Extent in March (1981 to 2010)

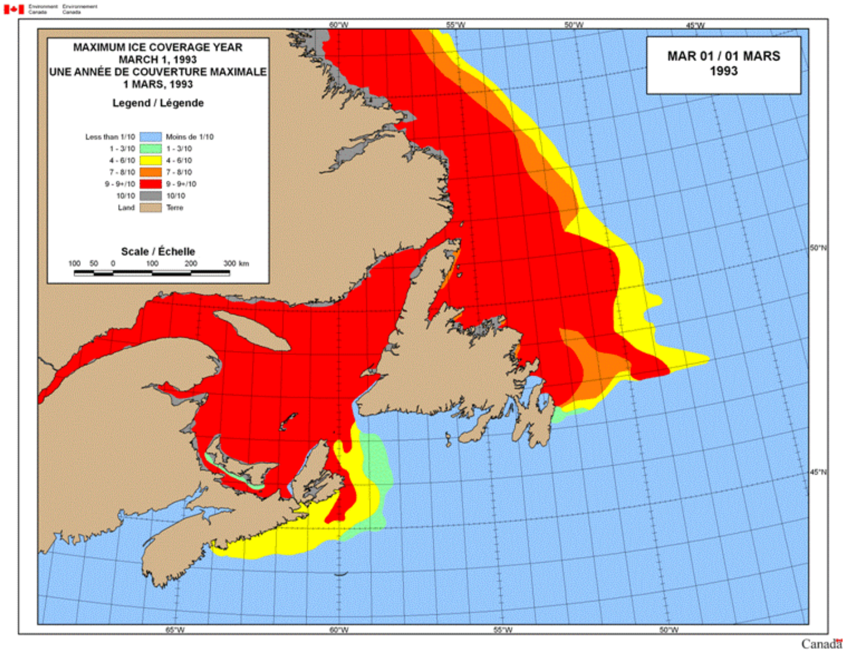


Source: Environment Canada 2011.

Figure 4.28 Maximum Pack Ice Extent in April (1981 to 2010)

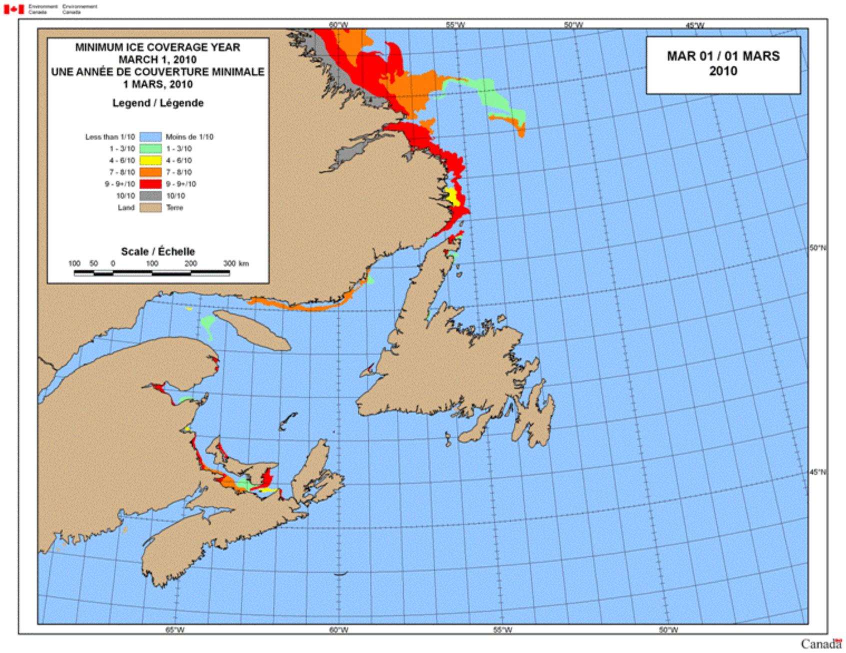
The Project Area is located in an area that ranges from 51 to 84 percent 30-Year frequency for the presence of sea ice (green and purple color bands) depending upon the month. Ice formation for the 2010/2011 year (Environment Canada 2011) is presented in Figure 4.29. Based on the average and median data for percentage ice coverage, the 2010/2011 season would be considered a “below average” ice coverage year. The maximum ice coverage year was March 1, 1993 (Figure 4.30) and the minimum ice coverage year was March 1, 2010 (Figure 4.31). EL 1105 is located in the area that has an average ice freeze up date of January 29 (Figure 4.31). The normal ice free period for EL 1105 extends from April 9th to February 12th of the following winter, and in extreme cold winters the ice free period is shorter and extends only from May 7th to January 15th. For mild winters, the ice may not reach the EL 1105. This has happened six times in the past 30 years, with most incidents experienced since the late 1990s for which an overall warming trend has been observed (Environment Canada, pers. comm.).

When the pack ice reaches EL 1105, the ice thicknesses are typically in the range of 10 to 30 cm. As the winter progresses, the ice thickens to the 30 to 70 cm range. Ice ridges could occasionally form in the area; these ridges can result in ice thicknesses that could be substantially higher than the 30 to 70 cm range. The ice concentration could vary a lot but is often close to the 80 to 100 percent range with lower concentration at the beginning of the ice season. Strong ice pressure could occasionally develop because of high winds associated with winter storms which are quite frequent in the Gulf area. Such ice pressure can have significant impacts on shipping activities (Environment Canada, pers. comm.).



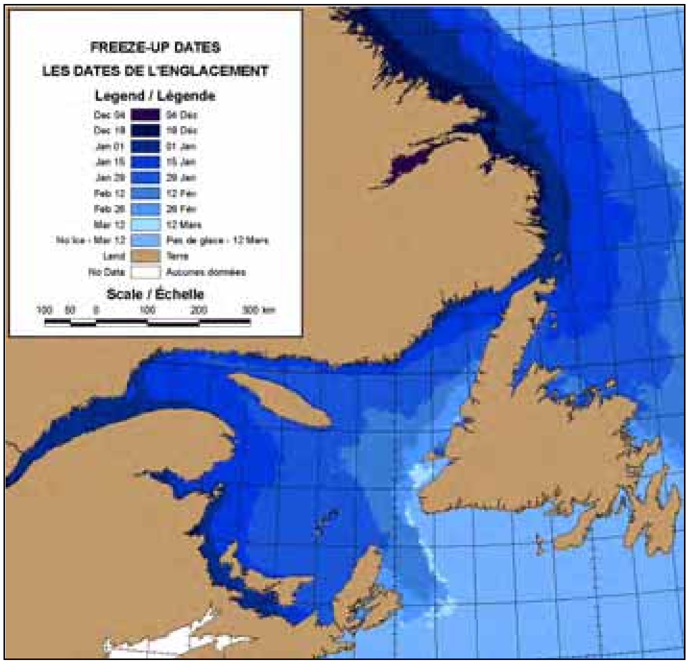
Source: http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=9453F6C9-1.

Figure 4.29 Maximum Ice Coverage Year



Source: http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=4B65BC3E-1.

Figure 4.30 Minimum Ice Coverage Year



Source: Environment Canada 2011.

Figure 4.31 Dates of Freeze-up (1981 to 2001)

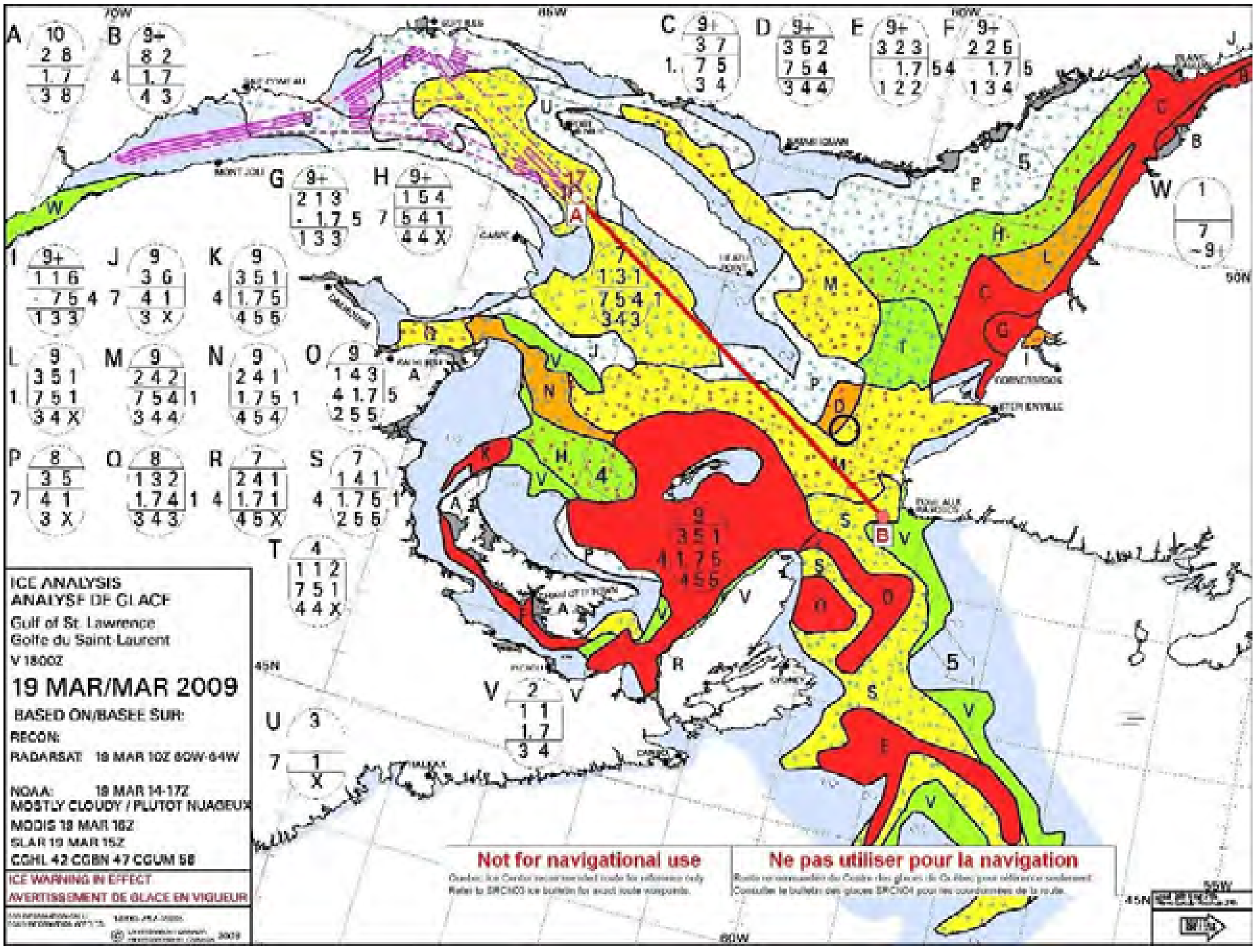
Dispersal of the ice begins in late February and is first evident in the Estuary near the mouth of the Saguenay River where ice concentrations fall to very open range, as a result of tidal upwelling of warmer water at the western limit of the deep channel through the Estuary combined with the general rise of spring air temperatures. By the middle of March, extensive open water areas exist along the north side of the St. Lawrence Estuary and the north shore to Natashquan, and south of Anticosti Island. The ice concentrations along the main shipping route through the central Gulf are decreasing rapidly and for the last half of March decreasing median ice concentrations are evident through the centre of the Gulf. As the thinner ice forms melt and decay faster, the predominant remaining ice types at this time are the thicker forms of ice (Environment Canada 2011).

By the first of April, the Estuary is usually free of ice and the inner ice edge has passed Anticosti Island. During the early days of April, the main shipping route through the Gulf clears, separating into two ice areas: the southwestern Gulf, including the waters surrounding Cape Breton; and the area from the Port-au-Port Peninsula to the Strait of Belle Isle. Once this separation has occurred, navigation into the Estuary is unhindered and re-formation of an ice barrier across the shipping route does not occur (Environment Canada 2011).

Ice in the central part of the Gulf produces an ice cover of large floes of thick ice, combined with new ice formation, from Gaspé Passage to Cape Breton Island. Leads and areas of dispersed ice are created along the New Brunswick and Prince Edward Island shores in response to the wind. The southwestern section of the Gulf generally becomes congested with thick ice in large floes that can exert considerable pressure against Cape Breton Island and the northwestern shores of the Îles de la Madeleine. In the northeastern Gulf the ice motion is much more restricted by the wind-induced drift from west to east resulting in occasional congestion in the

Bay of Islands area. Area of thick and deformed ice is prevalent from the Port-au-Port Peninsula northward. Coastal leads can develop in this area when easterly winds prevail but lateral motion of the ice along the coast does not often result. Old ice is not normally a concern in the Gulf; however, old ice can drift into the Northeast Arm through the Strait of Belle Isle. Also, Ocean swells from storms in the Atlantic Ocean can enter through Cabot Strait and cause extreme fracturing of the floes in the Iles de la Madeleine-Cabot Strait areas (Environment Canada 2011).

During the time of maximum ice coverage, a recommended shipping route is maintained by the Canadian Coast Guard and is published on a daily basis by Ice Quebec during the ice season in the Gulf (Figure 4.32 is an example of the recommended shipping route) and the commercial ships are expected to follow that route when transiting in the Gulf. It is normal for the shipping route to enter the Gulf near the Newfoundland coast off Cape Ray, head northwestward towards Anticosti Island, then follow the lighter ice conditions along the south side to West Point and then the north side of the Estuary. When strong south winds cause ice congestion along the south side of Anticosti Island, the winter shipping route can be shifted to the north side of the Island (Environment Canada 2011).

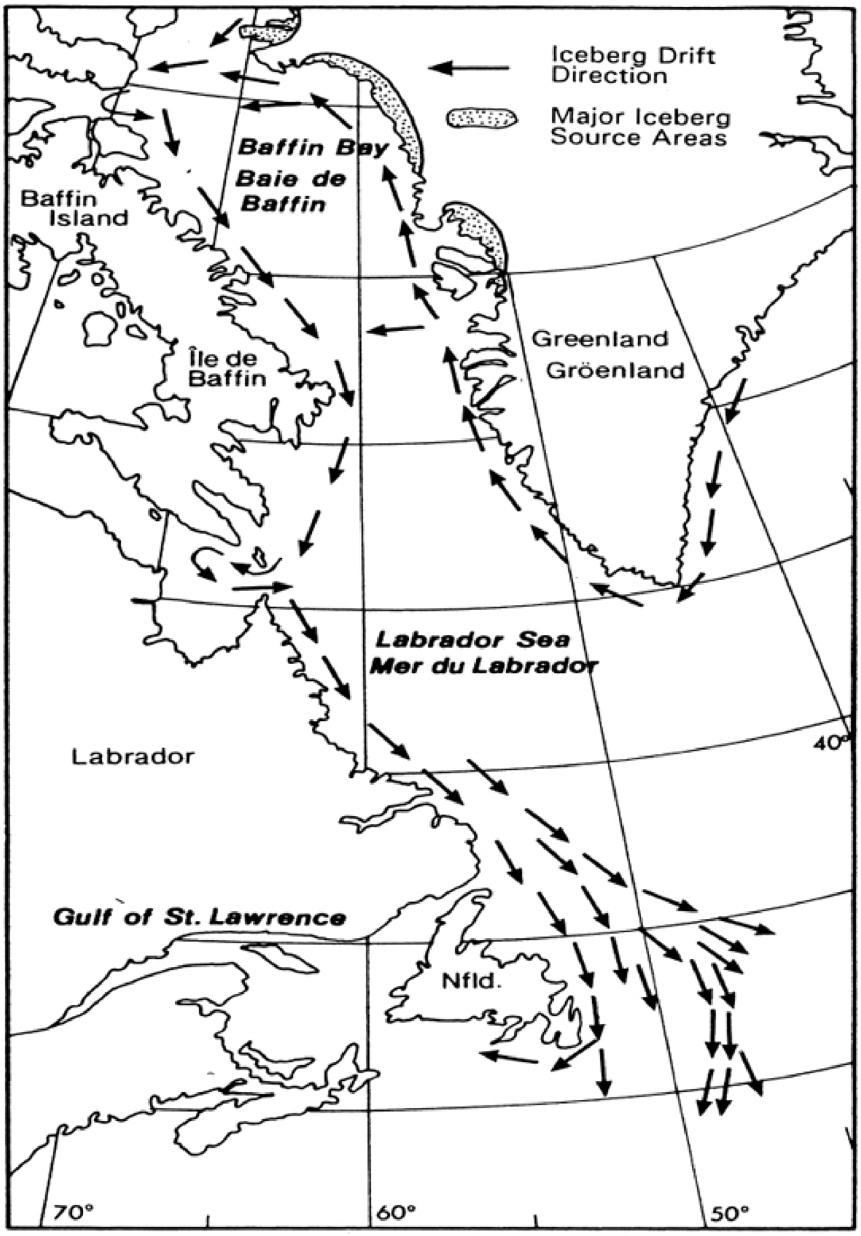


Source : Environment Canada

Figure 4.32 Ice Analysis Daily Report

4.1.12 Icebergs

Occasionally icebergs enter the Gulf, passing through the Strait of Belle Isle. These icebergs are generally small, as the water depths in the Strait (55 m) limit iceberg draught. Most icebergs entering the Gulf tend to go aground along the Quebec shore, east of Harrington Harbour, although a few have been observed as far west as Anticosti Island and in the Bay of Islands area along the west Newfoundland coast. A considerable number of icebergs can remain grounded in the Strait of Belle Isle (Canadian Coast Guard 1999). The sources and main tracks of icebergs in Eastern Canadian waters is presented in Figure 4.33.



Source: Canadian Coast Guard 1999

Figure 4.33 Sources and Tracks of Icebergs in Eastern Canadian Waters

4.2 Meteorology

Meteorology is discussed below in terms of climate, wind and visibility.

4.2.1 Climate

The climate of EL 1105 is dominated by the effects of the Gulf water that surrounds it and also by the eastward movement of continental air masses and their associated pressure systems. The climate is categorized as maritime temperate. Due to the severe winters experienced in the Gulf, the presence of buoys is limited. To assess the historical climate conditions in EL 1105, data were obtained from the Port Aux Basques weather station, located on the southwestern coast of Newfoundland approximately 100 km from the Project Area. The data are summarized in Table 4.6.

Table 4.6 Temperature and Precipitation Climate Data, 1971 to 2000, Port Aux Basques, NL

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)												
Daily Average	-5.2	-6.4	-3.5	1	5.2	9.5	13.7	15	11.6	7	2.6	-2.2
Daily Maximum	-1.9	-3	-0.4	3.7	8.3	12.8	16.7	18.3	15	10	5.2	0.8
Daily Minimum	-8.4	-9.8	-6.6	-1.7	2.1	6.2	10.6	11.7	8.2	3.9	-0.1	-5.1
Precipitation (mm)												
Rainfall	52.8	39.2	61	101.8	124.2	114.1	115.3	114.1	123.1	147	126.2	97
Snowfall (cm)	93.5	75	51.7	21.5	3.4	0	0	0	0	3.4	19.6	75.3
Precipitation	146.4	115.1	113.9	126.5	128.2	114.1	115.3	114.2	123.1	150.5	147.6	174.7
Days with Precipitation												
>= 0.2 mm	24.9	20.8	18.9	16.1	15.4	15	15.8	14.7	16.2	17.7	19.5	8.6
>= 5 mm	8.9	6.5	6.6	6.7	6.7	6.3	6.2	6	7.1	8.3	8.6	4.7
>= 10 mm	4.6	3.7	3.7	4	4.4	4	3.6	3.7	4	4.8	4.9	3.3
>= 25 mm	0.96	0.74	0.78	1.1	1.2	1.1	1.1	1.1	1.2	1.6	1.4	0.92
Source: Environment Canada 2010a.												

Average daily temperatures in the vicinity of EL 1105 ranged from -6.4°C in February to 15°C in August. Above-zero temperatures were recorded for all months except December, January, February and March. The highest amount of precipitation was recorded for the month of December and the least amount for the month of March. October was the month that recorded the highest amount of days (1.6) with rainfall greater than 25 mm.

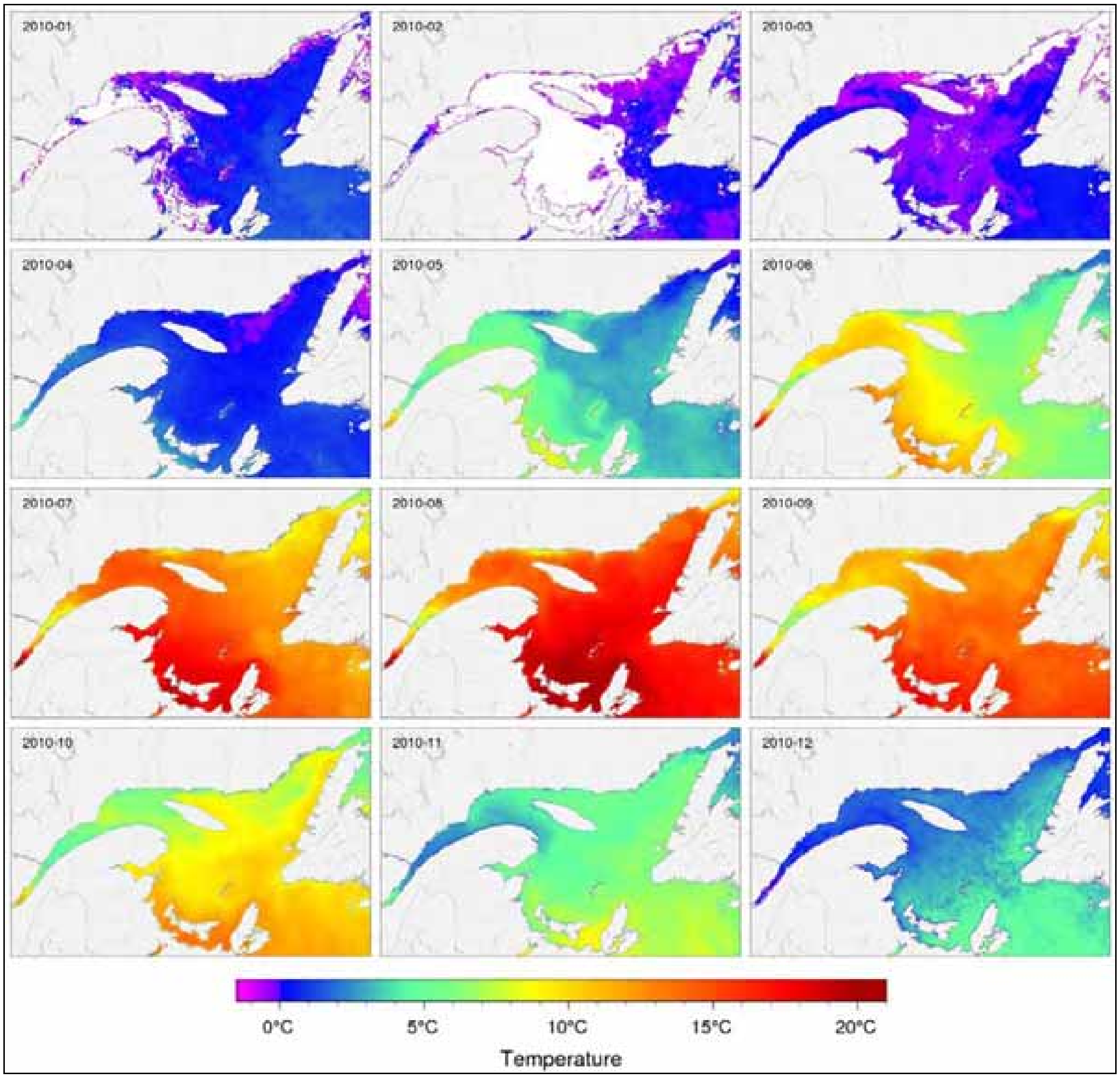
In 2008, the average monthly air temperatures for several land-based weather stations surrounding the Gulf (including Sept-Iles, Natashquan, Blanc-Sablon, Daniel's Harbour, Port Aux Basques, Charlottetown, Îles-de-la-Madeleine, Mont-Joli and Gaspè) were generally normal or slightly higher than temperatures recorded in 2007 (DFO 2009a). However, the southern and eastern portions of the Gulf did exhibit greater abnormalities than the other areas, and March was an exceptionally cold month for all weather stations. The temperatures recorded for September, October and November in 2008 at the Port Aux Basques and Iles-de-la-Madeleine weather stations were all above 0°C. The months that recorded temperatures below 0°C included December, January, February and March for both stations (DFO 2009a). Air temperatures in the Gulf have been above the 1971 to 2000 normal between November 2009 and December 2010 except for the near normal month of June (Galbraith et al. 2011). Gulf-wide monthly above-average air temperatures were record highs (since 1945) in February, April, and December 2010. The average of the several land-based weather stations provides an overall temperature index for the entire Gulf, which was above normal in 2010 by 2.4°C (+2.5 SD) - a record-high since 1945, breaking the previous 2006 record of 1.6°C (+1.6 SD). The last negative annual anomaly occurred in 2002 (Galbraith et al. 2011). The 2010 annual and winter conditions was a record high with the third-warmest spring conditions and above-normal summer conditions. The 2010 fall conditions were also a record high since 1945, characterized by very warm air temperatures in December 2010 that did not even fall below 0°C averaged over nine land-based weather stations (Galbraith et al. 2011).

In terms of sea surface temperatures, the minimum mean temperatures for February and March are approximately -0.8 °C and the maximums occur in August and September and are approximately 15°C (LGL 2005b). Sea-surface temperature averages for the first 28 days of each month of 2009 as observed with NOAA AVHRR remote sensing are provided in Figure 4.34. The white areas have no data for the period due to ice cover (Galbraith et al. 2011).

4.2.2 Wind Climate

Wind is an important aspect related to planning due to its role in current and wave generation, which in turn could produce forces on vessels, the drilling platform and other related equipment. Knowledge of the frequency of occurrence of wind speed is necessary to the planning of operations. From autumn through the winter and spring, many extra-tropical storm disturbances pass through or near the Gulf. These storms can produce gale-force winds that may persist for many hours and in some cases, for several days (as described in Section 4.2.5). During the summer months when the tracks of cyclonic activity are displaced farther north, the persistent strong wind becomes less frequent over the Gulf.

The parameters used to describe the wind characteristics most commonly are wind speed and wind direction. Data on percent wind speed by wind direction from 1954 to 2008 were acquired from the MSC50 data set for grid point 13511 (UTM – Northing, 5,331,208 m; Easting, 708,455 m) and are presented in Tables 4.7 to 4.10 for each season. Corresponding wind roses over the same time period and seasons are presented in Figures 4.35 to 4.38.



Source: Galbraith et al. 2011

Figure 4.34 Sea-surface temperature averages (2009)

Table 4.7 Percent Wind Speed by Direction for Grid Point 13511: September, October and November

Wind Speed (m/s)	Wind Direction												Total
	15	45	75	105	135	165	195	225	255	285	315	345	
0 to 4.99	1	0.89	0.95	0.87	0.97	1.26	1.6	1.93	2.14	1.91	1.62	1.24	16.4
5 to 9.99	2.49	2.03	1.85	1.61	2.16	3.44	5.41	6.81	6.42	6.59	5.63	3.74	48.2
10 to 14.99	1.34	1.2	0.87	0.86	1.31	2.12	2.95	3.63	3.73	4.91	3.79	24	29.1
15 to 19.99	0.37	0.22	0.21	0.27	0.4	0.5	0.39	0.34	0.62	1.2	0.96	0.53	6.01
20 to 24.99	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0	0.03	0.07	0.09	0.03	0.33
25 to 29.99	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**5.23**	**4.37**	**3.89**	**3.62**	**4.85**	**7.34**	**1.04**	**12.71**	**12.9**	**14.7**	**12.1**	**7.94**	**100**

Table 4.8 Percent Wind Speed by Direction for Grid Point 13511: December, January and February

Wind Speed (m/s)	Wind Direction												Total
	15	45	75	105	135	165	195	225	255	285	315	345	
0 to 4.99	1.03	0.84	0.79	0.65	0.59	0.76	0.9	1.2	1.31	1.51	1.48	1.35	12.4
5 to 9.99	2.91	2.28	1.82	1.59	1.74	2.14	2.65	4.03	5.12	6.86	5.78	4.24	41.2
10 to 14.99	2.06	1.34	1.3	1.18	1.07	1.39	2	2.82	4.49	7.17	5.71	3.07	33.6
15 to 19.99	0.62	0.49	0.52	0.54	0.5	0.55	0.38	0.59	1.38	2.78	1.92	0.94	11.2
20 to 24.99	0.03	0.09	0.03	0.09	0.1	0.08	0.03	0.06	0.24	0.37	0.28	0.16	1.56
25 to 29.99	0	0	0	0	0	0	0	0	0.01	0	0.01	0	0.02
Total	**6.65**	**5.04**	**4.46**	**4.05**	**4**	**4.92**	**5.96**	**8.71**	**12.6**	**18.7**	**15.2**	**9.77**	**100**

Table 4.9 Percent Wind Speed by Wind Direction for Grid Point 13511: March, April and May

Wind Speed (m/s)	Wind Direction												Total
	15	45	75	105	135	165	195	225	255	285	315	345	
0 to 4.99	2.42	2.39	2.3	2.09	2.06	2.41	2.97	3.22	2.97	2.97	2.74	2.55	31.1
5 to 9.99	4	3.25	2.7	2.57	2.7	3.95	4.87	4.73	3.95	4.15	4.56	4.37	45.8
10 to 14.99	1.96	1.92	1.29	1.24	1.21	1.42	1.72	1.41	1.42	2.1	1.93	1.78	19.4
15 to 19.99	0.42	0.6	0.24	0.26	0.21	0.16	0.12	0.09	0.24	0.5	0.36	0.32	3.52
20 to 24.99	0.04	0.03	0.01	0.02	0	0	0	0	0.01	0.02	0.02	0.02	0.18
Total	**8.84**	**8.19**	**6.55**	**6.18**	**6.19**	**7.95**	**9.68**	**9.44**	**8.59**	**9.74**	**9.61**	**9.03**	**100**

Table 4.10 Percent Wind Speed by Wind Direction for Grid Point 13511: June, July and August

Wind Speed (m/s)	Wind Direction												Total
	15	45	75	105	135	165	195	225	255	285	315	345	
0 to 4.99	1.84	1.66	0.18	1.96	2.38	3.89	5.94	7.19	5.58	3.68	2.48	2.13	40.5
5 to 9.99	1.51	1.32	1.51	0.15	2.49	5.95	11	10.5	5.83	3.82	2.61	1.91	50
10 to 14.99	0.39	0.32	0.28	0.37	0.44	1.36	2.49	1.38	0.69	0.7	0.52	0.42	9.23
15 to 19.99	0.04	0.01	0	0	0.02	0.04	0.02	0	0.02	0.03	0.02	0.04	0.26
20 to 24.99	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**3.78**	**3.21**	**3.58**	**3.84**	**5.34**	**11.2**	**19.5**	**19.1**	**12.1**	**8.22**	**5.63**	**4.51**	**100**

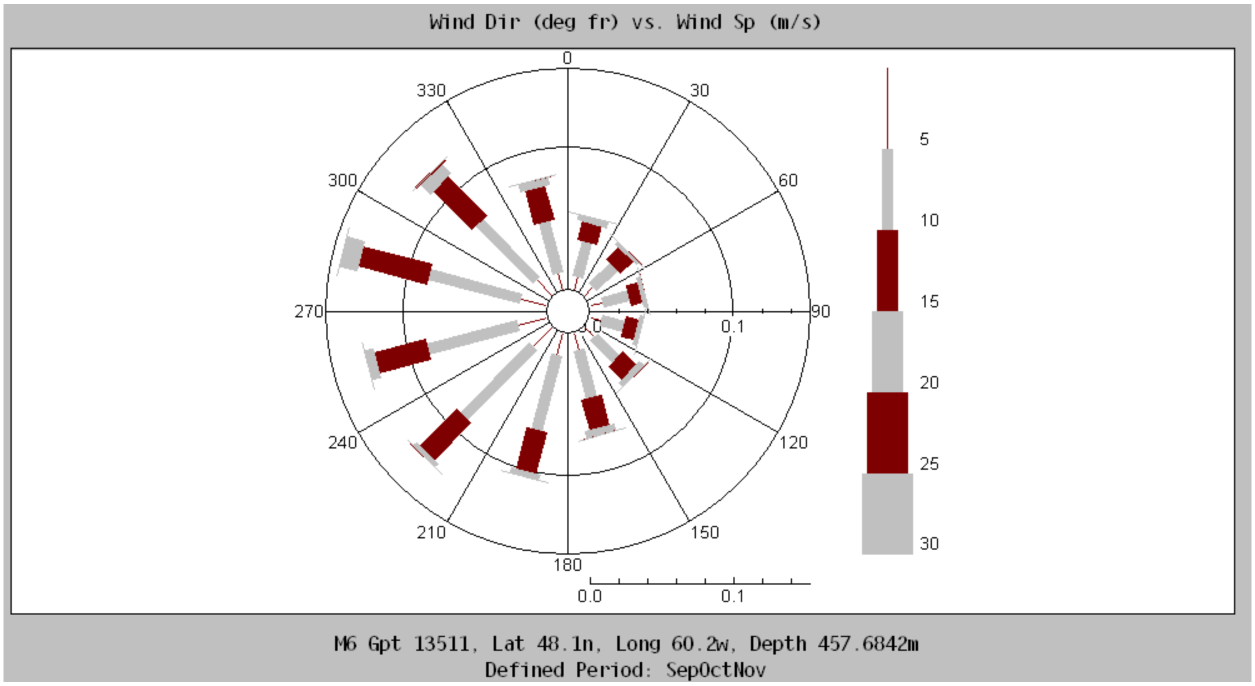


Figure 4.35 Wind Rose for September, October and November

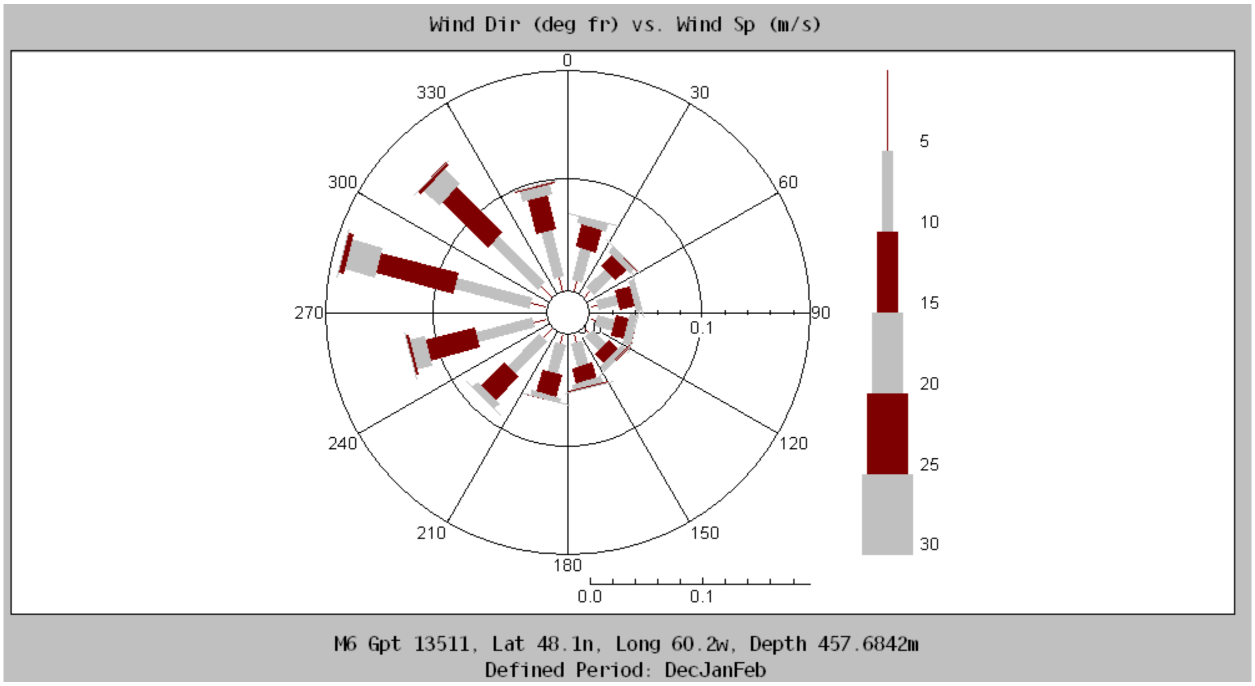


Figure 4.36 Wind Rose for December, January and February

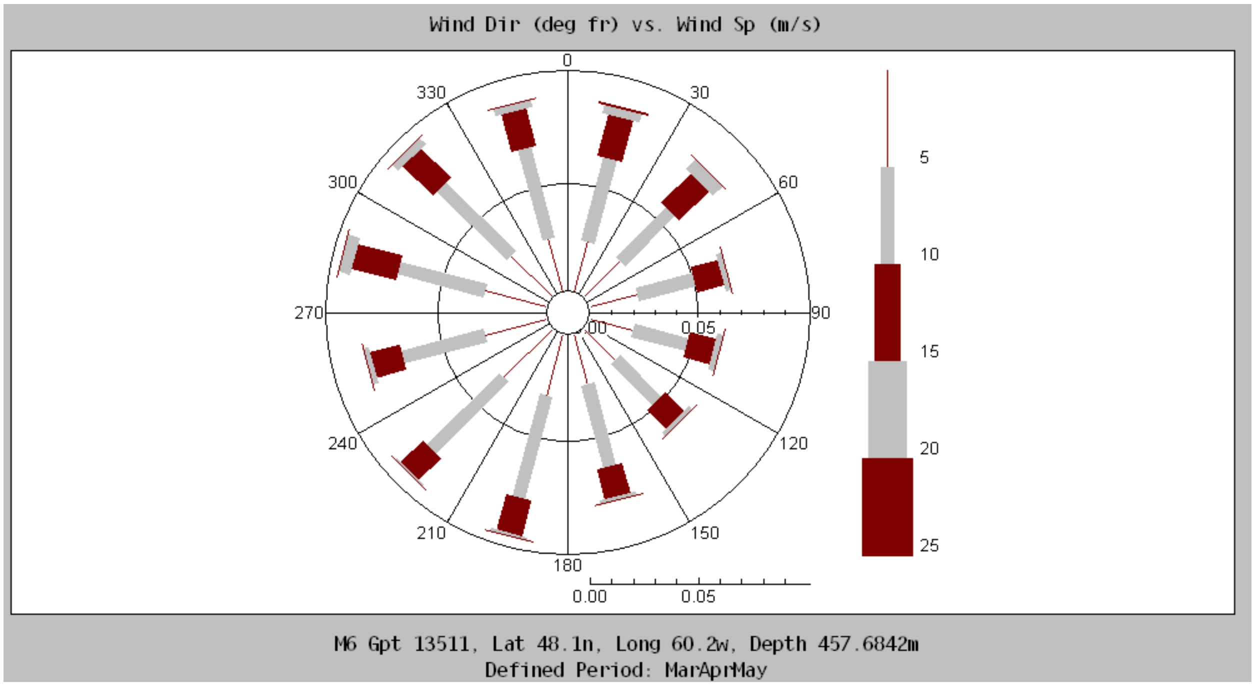


Figure 4.37 Wind Rose for March, April and May

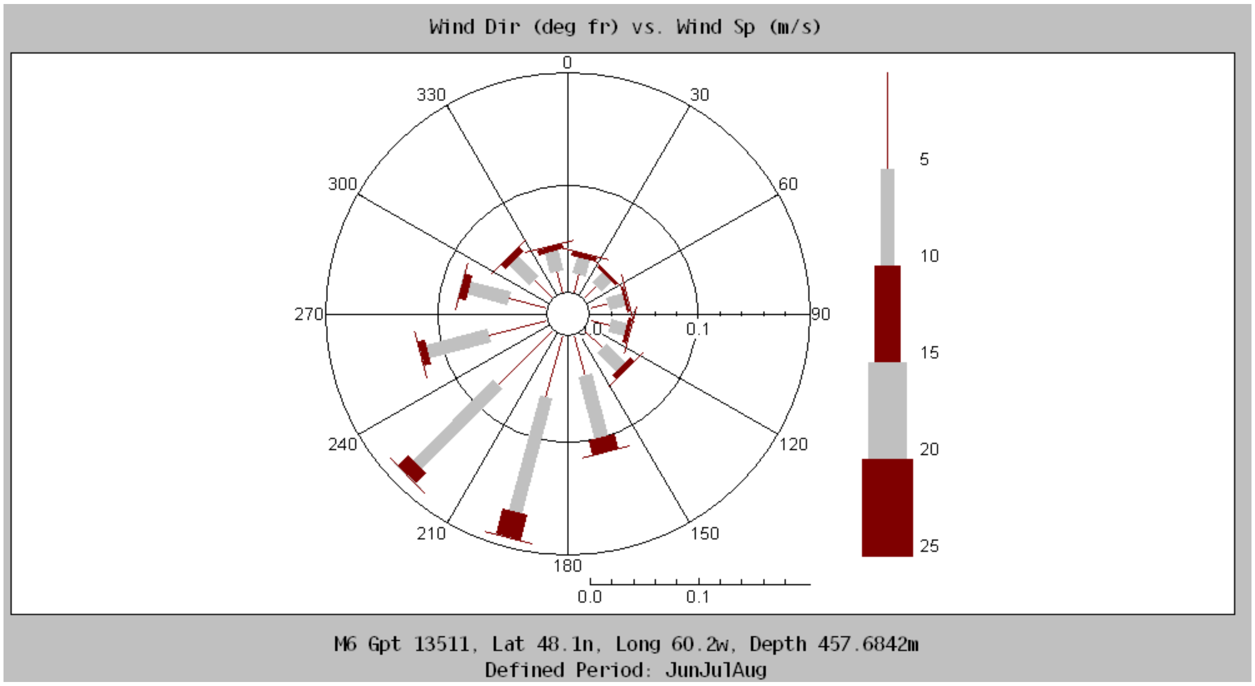


Figure 4.38 Wind Rose for June, July and August

Most wind speeds at grid point 13511 during the fall (September to November), winter (December to February) and spring (March to May) are between 5 and 9.9 m/s and are from the west-northwest direction. Approximately 50 percent of the wind speeds during the summer (June to August) are also between 5 and 9.9 m/s; however, the winds are most commonly from the southwest direction. There was no wind speed reported during the summer greater than 20 m/s. Wind speeds between 20 and 24.9 m/s were experienced during the fall, winter and spring months and the highest percentage was reported during the winter, at less than 2 percent.

4.2.3 Visibility and Fog

Fog is an important weather condition that results in poor visibility for the ships, helicopters and aircraft operating offshore. Sea fog can be dense and may often cover large areas.

Historical data for visibilities were acquired from the Port Aux Basques weather station and are presented in Table 4.11.

Table 4.11 Visibility Data Recorded at the Port Aux Basques Weather Station, 1971 to 2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Oct	Sep	Oct	Nov	Dec
<1 km	51.9	45.7	47.4	54.4	84.8	106.6	138.6	78.2	33.3	32	27.7	37.4
1 to 9 km	208.6	160.8	139.8	140.3	134.3	132.5	154.1	114.7	76.9	83.4	104.4	182
>9 km	483.6	471	556.9	525.3	525	480.9	451.3	551.1	609.8	628.7	588	524.7

During the averaging period from 1971 to 2000, the number of hours with visibility less than 1 km was greatest during June and July. The number of hours with visibility greater than 9 km was highest during September, October and November.

Existing visibility conditions in the Gulf were assessed in the 2005 SEA report (LGL 2005b) using information available from AES-40 data set at grid point 5817, which is located offshore Newfoundland and Labrador slightly north of Cape St. George. There was a relatively high occurrence (8 to 10 percent) of reduced visibilities (less than 1 km) in January, February and March, due to snow. By April to July, as the sea surface air temperature increases and warm, moist air from southern North America (with high relative humidity (high dew points)) floods the area, and the temperature of the ocean remains cooler, the air becomes cooled by the ocean and saturated, resulting in fog. An 11 percent reduced visibility (less than 1 km) was recorded for the month of July. As fall approaches, the temperature difference between the air and the ocean lessens and cool, dry air (low dew points) from the north floods the region , as does the amount of fog, with October reporting the lowest occurrences of reduced visibility, approximately 2 percent (LGL 2005b).

4.3 Climate Change

It is generally accepted that a warming world will result in a rise in the global sea level and that sea surface temperatures will increase by 1°C to 2°C over the next several decades if global warming continues. Meteorological drivers of the long-term trends in global sea level rise were examined (Kolker and Hameed 2007) and a major fraction of the variability and trend since 1900 at five Atlantic Ocean tide gauges can be explained by atmospheric indices like the North Atlantic Oscillation. Kolker and Hameed (2007) state that "debate has centred on the relative contribution of fresh water fluxes, thermal expansion and anomalies in Earth's rotation". When factors such as the North Atlantic Oscillation were subtracted out from their analysis of the long-term rise, the "residual" sea level rise was between 0.49±0.25 and 0.93±0.39 mm per year, which could be due to rising global temperatures (Kolker and Hameed 2007).

Between 1961 and 2003, the global average sea level rose at an average rate of 1.8 (1.3 to 2.3) mm per year (Intergovernmental Panel on Climate Control (IPCC) 2007); a worldwide increase of 18 to 58 cm is predicted by 2100 (IPCC 2007). Based on emission scenarios from the 2007 IPCC assessment, Vermeer and Rahmstorf (2009) estimated sea-level rise projections over the next century using a semi-empirical model to a relationship between historical global temperature and sea-level rise. This semi-empirical method implicitly accounts for the effects of the recent rapid glacial melt.

Sea levels off the northeast coast of North America could rise by 30 to 51 cm more than other coastal areas due to moderate to high rates of ice melt from Greenland (Hu et al. 2009). Since ocean dynamics would push water in different directions, oceans will not rise uniformly as the Earth warms (Hu et al. 2009).

Estimates of the global sea level rise over the next 100 years due to global warming alone are from 5 cm to as much as 190 cm. Based on a rate of 1.7 cm per year (as per Vermeer and Rahmstorf (2009)), the expected total rise has a central estimate of 45 cm and an upper limit of approximately 70 cm over the time period of 2010 to 2050.

5.0 BIOLOGICAL ENVIRONMENT

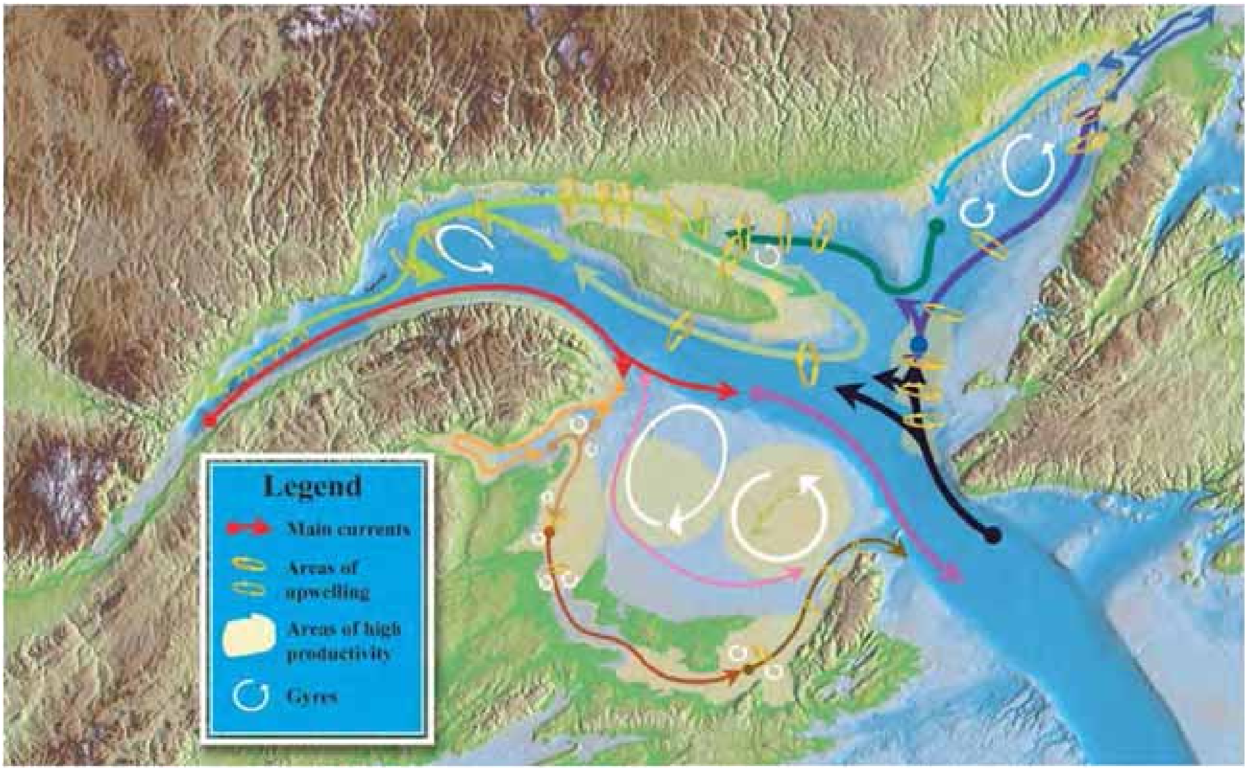
The biological environment in which the Project will occur is described below at several different scales. Most information is presented for the Gulf in general or in relation to the offshore waters of western Newfoundland. Where area-specific information is available, further details have been provided for EL 1105, recognizing that this is where the majority of Project activities will be focused.

5.1 Regional Overview

The Estuary and Gulf of St. Lawrence are described as a semi-enclosed sea with a unique marine ecosystem. This is a result of the Gulf being partially separated from the North Atlantic, receiving freshwater discharge from major rivers, a deep trough running along its length, seasonal ice, several water masses including a cold intermediate layer, regions of shallow water depths and plateaus and high biological productivity and diversity (DFO 2005a). There are only two openings in the Gulf that permit water exchange with the North Atlantic: the Strait of Belle Isle to the northeast of the Gulf through which cold, dense water flows in from the Arctic via the Labrador Current; and the Cabot Strait in the Laurentian Channel to the southeast of the Gulf, where Atlantic waters of the Gulf Stream flow in. EL 1105 is located approximately 70 km northwest of the Cabot Strait in the Laurentian Channel.

The unique features of the Gulf give rise to enhanced areas of plankton production and biomass that establishes diverse benthic communities and also attracts feeding populations of fish, marine birds and marine mammals to the Gulf. These enhanced biological areas are a result of physical factors related to the unique topography of the seafloor, oceanographic currents and winds that, combined with chemical factors such as nutrient-rich waters, give rise to physical processes such as upwelling of bottom water, horizontal or vertical fronts between two distinct circulation patterns and water masses, and zones of convergence and gyres. These physical processes in the Gulf can either result in increased growth and production in the biological environment, or act as a mechanism to steer, concentrate and retain marine populations into a smaller area, thereby yielding higher abundance and reproductive, rearing and feeding successes. An overview of these physical processes is illustrated in Figure 5.1.

The enhanced productivity of marine populations in the Gulf and protection from high energy waves and storms in the Atlantic Ocean have given rise to important commercial fisheries, vessel navigation routes, ports, marine mammal tourism, aquaculture, human settlements in coastal communities and other anthropogenic environmental effects such that some populations of marine life have declined substantially. This has resulted in certain marine species being listed as at risk by SARA for the Estuary and Gulf populations, or for marine populations that migrate to the Gulf during a stage of their life cycle. The species at risk include commercial fisheries species, marine birds and marine mammals, which are described in more detail in Section 5.2.



Source: http://www.glf.dfo-mpo.gc.ca/e0006095

Figure 5.1 Physical Processes and Major Areas of High Productivity for the Biological Environment in the Estuary and Gulf of St. Lawrence

5.2 Species at Risk

Schedule 1 of SARA is the official list of wildlife species at risk. Where a species is both listed under Schedule 1 of SARA and designated as ‘at risk’ by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), it is the SARA designation that legally applies. A summary of all species found within Gulf that are considered at risk under SARA and/or COSEWIC are presented in Tables 5.1 and 5.2, respectively. Individual species descriptions of those species listed under SARA or designated under COSEWIC are provided in the following series of sub-sections.

Table 5.1 Species at Risk Occurring in the Gulf

Common Name	Species Name	SARA Schedule 1 Status	Occurrence in Relation to EL 1105
Marine Fish			
Northern Wolffish	*Anarhichas denticulatus*	Threatened	Low potential for occurrence – May occur along the slope of the Laurentian Channel. Most commonly found inhabiting the seafloor in water depths of 500 to 1,000 m. Non-migratory spawning occurs in the Fall. Larvae may be present on the seafloor in fall to early winter

Common Name	Species Name	SARA Schedule 1 Status	Occurrence in Relation to EL 1105
Spotted Wolffish	*Anarhichas minor*	Threatened	Low potential for occurrence – May occur along the slope of the Laurentian Channel though populations are declining. Most commonly found inhabiting the seafloor in water depths of 200 to 750 m. Non-migratory spawning occurs in the Summer. Eggs / larvae may be present on the seafloor in summer to fall
Marine Fish			
Atlantic (striped)	*Anarhichas lupus*	Special Concern	Low potential for occurrence – May occur along the slope of the Laurentian Channel and the coast of western Newfoundland. Most commonly found inhabiting the seafloor in water depths of 150 to 350 m. Short migrations to spawning in shallow waters during the Fall. Eggs / larvae may be present on seafloor in fall to early winter
Marine Birds			
Ivory Gull	*Pagophila eburnea*	Endangered	May occur in the Gulf during winter months, on pack ice, both offshore and in coastal areas
Eskimo Curlew	*Numenius borealis*	Endangered	Likely extinct and extremely unlikely to be encountered in the Gulf
Piping Plover *melodus* subspecies	*Charadrius melodus melodus*	Endangered	Breeds and forages on Atlantic Canada beaches during summer, including on the Magdalen Islands and in western Newfoundland
Roseate Tern	*Sterna dougallii*	Endangered	Occurs in low numbers at several remote islands in Nova Scotia, New Brunswick, and on the Magdalen Islands from April-early August, where they nest. This species exhibit high site fidelity and are unlikely to occur in western Newfoundland or elsewhere in the Gulf
Barrow's Goldeneye (Eastern population)	*Bucephala islandica*	Special Concern	Breeds on high altitude lakes and nest in trees. In the non-breeding (summer) season, these ducks occur in coastal areas of the St. Lawrence Estuary and Gulf, where they feed
Harlequin Duck (Eastern population)	*Histrionicus histrionicus*	Special Concern	Forages in nearshore marine waters during summer, fall, and winter. Prefers offshore islands, coastal headlands and exposed rocky coastlines during winter and move inland to rivers during spring for breeding. Could occur off western Newfoundland and coastal areas of the Gulf year-round
Horned Grebe (Magdalen Islands population)	*Podiceps auritus*	Endangered	Small (average approximately 15 adults), isolated population exist on the Magdalen Islands during summer months where they breed and feed. Wintering grounds are unknown but likely along the mainland Atlantic coastline
Marine Mammals			
Blue Whale	*Balaenoptera musculus*	Endangered	Forages for krill in both coastal and offshore areas of the northern Gulf of St. Lawrence and eastern Nova Scotia during spring, summer and fall. May migrate through the Gulf and western Newfoundland waters during these months
North Atlantic Right Whale	*Eubalaena glacialis*	Endangered	Occurs very occasionally in the Gulf during late summer (north shore and east of Gaspé) where it forages for copepods
Northern Bottlenose Whale (Scotian Shelf population)	*Hyperoodon ampullatus*	Endangered	Rarely sighted as it is a pelagic, deep water species (>800 m), except that it is common to 'The Gully' off southeastern Nova Scotia, and in the Labrador Sea. Could occur rarely, and in low numbers, in the Gulf where it may feed in deep waters
Beluga Whale (St. Lawrence Estuary population)	*Delphinapterus leucas*	Threatened	St. Lawrence Estuary represents its southern limit, however individuals and small groups are occasionally sighted in coastal Atlantic Canada waters, including the Gulf and western Newfoundland
Fin Whale (Atlantic population)	*Balaenoptera physalus*	Special Concern	Concentrated in the Northwest Atlantic region during summer months, including coastal and offshore waters of the Gulf and western Newfoundland to feed along oceanic fronts

Common Name	Species Name	SARA Schedule 1 Status	Occurrence in Relation to EL 1105
Sea Turtles			
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	Forages along the Scotian Shelf and in the southern Gulf of St. Lawrence, from June to October, mainly feeding on jellyfish

Table 5.2 Species Designated 'At Risk' by the Committee of the Status of Endangered Wildlife in Canada that may occur in the Gulf

Common Name	Species Name	COSEWIC Designation	Occurrence in Relation to EL 1105
Marine Fish			
Atlantic Cod (Laurentian North population)	*Gadus morhua*	Endangered	High potential for occurrence – Benthopelagic species that inhabits coastal waters as juveniles. Adults prefer deeper waters up to 500 m. Resident populations are also located within the coastal waters of Newfoundland. Eggs and Larvae may be present in upper water column from May to April
Atlantic Cod (Laurentian South population)		Endangered	Moderate potential for occurrence – Benthopelagic species that migrates from the southern Gulf to the waters of Cape Breton between May to October. Eggs and Larvae may be present in upper water column from May to April
Atlantic Cod (Newfoundland and Labrador population)		Endangered	Low potential for occurrence - Atlantic Cod from this population inhabit waters from the Northern tip of Labrador to the Southern Grand Banks
Atlantic Cod (Southern population)		Endangered	Low potential for occurrence – Atlantic Cod from this population inhabit waters from the Bay of Fundy and Southern Nova Scotia to the southern extent of the Grand Banks
Winter Skate (Southern Gulf of St. Lawrence population)	*Leucoraja ocellata*	Endangered	Low potential for occurrence – Located within the Southern Gulf, Scotian Shelf and Georges Bank. Closely associated with the seafloor commonly inhabits waters ~ 100 m in depth. Could occur at any time of the year. Non-migratory spawning occurs in fall. Eggs / larvae may be present up to 22 months after spawning
Roundnose Grenadier	*Coryphaenoides rupestris*	Endangered	Low potential for occurrence - Closely associated with the seafloor commonly found inhabiting waters 800 to 1,000 m in depth. Could occur at any time of the year. Non-migratory spawning occurs in fall
Porbeagle Shark	*Lamna nasus*	Endangered	Low potential for occurrence – Migrant in Atlantic Canadian waters. May be found in EL 1105 from May to late fall and are most often caught in water depths of 35 to 100 m
White Shark (Atlantic population)	*Carcharodon carcharias*	Endangered	Low potential for occurrence – Rare in Canadian waters (32 records in 132 years). Most records are located within the Bay of Fundy, (the northern-most edge of their range. Extremely rare as far north as the drilling block
Atlantic Salmon (Anticosti island population)	*Salmo salar*	Endangered	Low potential for occurrence – Juvenile Atlantic salmon migrating from freshwaters streams to the North Atlantic may pass through EL 1105, with any presence being transient in nature
Atlantic Bluefin Tuna	*Thunnus thynnus*	Endangered	Low potential for occurrence – Atlantic bluefin tuna migrate into the Gulf following food stocks in July through December. Forms schools of <50 individuals
Deepwater Redfish (Gulf of St. Lawrence - Laurentian Channel population)	*Sebastes mentalla*	Endangered	High potential for occurrence - Closely associated with the seafloor commonly found inhabiting waters 350 to 500 m in depth in the Gulf / Laurentian Channel. Mature individuals expected in to occur in EL 1105 from May to October. Spawning occurs in fall. Larvae may be present in water column April to July

Common Name	Species Name	COSEWIC Designation	Occurrence in Relation to EL 1105
Deepwater Redfish (Northern population)		Threatened	Low potential for occurrence - Closely associated with the seafloor commonly found inhabiting waters 350 - 500 m in depth from the Grand Banks to Northern Labrador
Atlantic Salmon (South Newfoundland population)		Threatened	Low potential for occurrence – Juvenile Atlantic salmon migrating from freshwaters streams to the North Atlantic may pass through EL 1105, with any presence being transient in nature
Acadian Redfish (Atlantic population)	*Sebastes fasciatus*	Threatened	Low potential for occurrence - Closely associated with the seafloor commonly found inhabiting waters 150 to 300 m in depth. Mature individuals expected in to occur in EL 1105 from May to October. Spawning occurs in fall. Larvae may be present in water column May to August
Shortfin Mako	*Isurus oxyrinchus*	Threatened	Low potential for occurrence – A pelagic species which migrates north following food stocks (i.e., mackerel, herring, tuna) and may pass through EL 1105. Any occurrence would be transient in nature
American plaice (Maritime population)	*Hippoglossus platessoides*	Threatened	Low potential for occurrence – Closely associated with the seafloor and commonly found in water depths of 100 to 200 m where soft / sandy sediments are present. The maritime population is common to the Gulf and may be present within EL 1105. Spawning occurs in April / May. Larvae may be present in the water column between May and June
American plaice (Newfoundland and Labrador population)		Threatened	Low potential for occurrence – Closely associated with the seafloor commonly found in water depths of 100 to 200 m where soft / sandy sediments are present. The Newfoundland and Labrador population is located from the Grand Banks north and to the northern tip of Newfoundland
Striped Bass (Southern Gulf of St. Lawrence population)	*Marone saxatilis*	Threatened	Low potential for occurrence – Scientific evidence suggests that populations currently exist in only two Canadian rivers. The Shubenacadie which flows into the Bay of Fundy, and the Miramichi River in the southern Gulf of St. Lawrence. The Gulf population is considered extirpated.
Cusk	*Brosme brosme*	Threatened	Low Potential for occurrence – Commonly found between the Gulf of Maine and southern Scotian Shelf. Rare along the continental shelf off Newfoundland and Labrador. Very rare within the Gulf, with three observations
Atlantic Salmon (Gaspé-Southern Gulf of St. Lawrence population)		Special Concern	Low potential for occurrence – Juvenile Atlantic salmon migrating from freshwater streams to the North Atlantic may pass through EL 1105, with any presence being transient in nature
Atlantic Salmon (Québec Eastern North Shore population)		Special Concern	Low potential for occurrence – Juvenile Atlantic salmon migrating from freshwater streams to the North Atlantic may pass through EL 1105, with any presence being transient in nature
Roughead Grenadier	*Macrourus berglax*	Special Concern	Low potential for occurrence – Closely associated with the seafloor commonly found in water depths of 400 to 1,300 m on or near the continental slope of the Newfoundland and Labrador Shelves from the Davis Strait to the southern Grand Banks. Spawning may occur within the southern Grand Banks
Spiny Dogfish (Atlantic population)	*Squalus acanthias*	Special Concern	Low potential for occurrence – Commonly found from the intertidal zone to the continental slope in water depths up to 730 m. Most abundant between Nova Scotia and Cape Hattaras
Blue Shark (Atlantic population)	*Priomace glauca*	Special Concern	Low potential for occurrence – Commonly found in offshore waters in water depths up to 350 m. Most abundant along the coast of Nova Scotia to the Scotian Shelves
Basking Shark (Atlantic population)	*Cetorhinus maximus*	Special Concern	Low potential for occurrence –Found in offshore waters and coastal waters of Newfoundland concentrated between Port aux Basques and Hermitage. May be present within EL 1105 feeding on plankton

Common Name	Species Name	COSEWIC Designation	Occurrence in Relation to EL 1105
American Eel	*Anguilla rostrata*	Special Concern	Low potential for occurrence – Adult American eels migrating from freshwater streams to the Sargasso Sea may pass through EL 1105. Any presence would be transient in nature
Atlantic Sturgeon (Great Lakes/ Gulf of St. Lawrence Populations)	*Ancipenser oxyrinchus*	Threatened	Low potential for occurrence - Highly migratory species capable of traveling great distances and are spread out along the east coast of North America and over the continental shelf regions to at least 50 m depths, therefore may pass through EL 1105, with any presence being transient in nature
Atlantic Sturgeon (Maritimes Populations)		Threatened	Low potential for occurrence - Highly migratory species capable of traveling great distances and are spread out along the east coast of North America and over the continental shelf regions to at least 50 m depths, therefore may pass through EL 1105, with any presence being transient in nature
Marine Mammals			
Harbour Porpoise (Northwest Atlantic population)	*Phocoena phocoena*	Special Concern	Occurs in both offshore and coastal waters of the Gulf. Occurs regularly in coastal bays and inlets during summer and can move rapidly following prey or stay in areas where for food is abundant for periods of time
Killer Whale	*Orcinus orca*	Special Concern	Distribution is not well documented, but they are widespread, and sightings are reported most commonly in the offshore and coastal waters of Newfoundland, including western Newfoundland
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea Population	*Hyperoodon Ampullatus*	Special Concern	Low potential for occurrence - the northern bottlenose whale is confined to the waters of the northern Atlantic Ocean, with population centres off the Davis Strait / northern Labrador. More survey effort is needed to fully describe the distribution and abundance of northern bottlenose whales in Canada, particularly in the northern part of its distribution and around Newfoundland.
Sea Turtles			
Loggerhead Sea Turtle	*Caretta caretta*	Endangered	Widely distributed in pelagic (>200 m) waters feeding, particularly on jellyfish. Juveniles concentrate along the edge of the Gulf Stream. Occurs in the offshore parts of the Gulf and western Newfoundland, particularly in summer months

5.2.1 Marine Fish Species at Risk

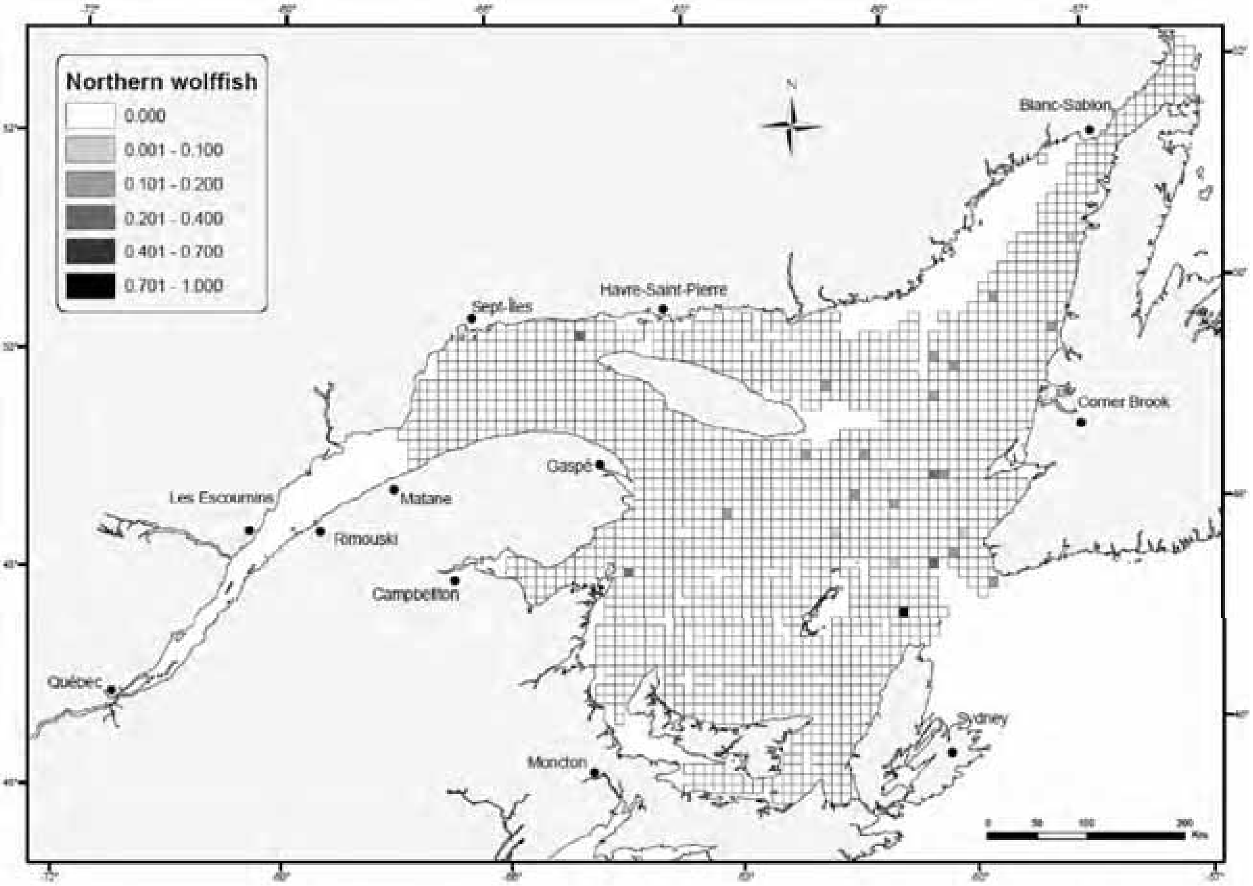
There are 19 species (and 23 populations) of marine fish that could potentially be found within or near the Gulf that are considered at risk. The status of these species is presented in Tables 5.1 and 5.2.

5.2.1.1 Wolffish

Three species of wolffish, each of which has been designated a status under SARA Schedule 1, can be found in the Gulf and in or near EL 1105. The northern and spotted wolffish have been listed as threatened under SARA Schedule 1; the Atlantic wolffish is considered of special concern.

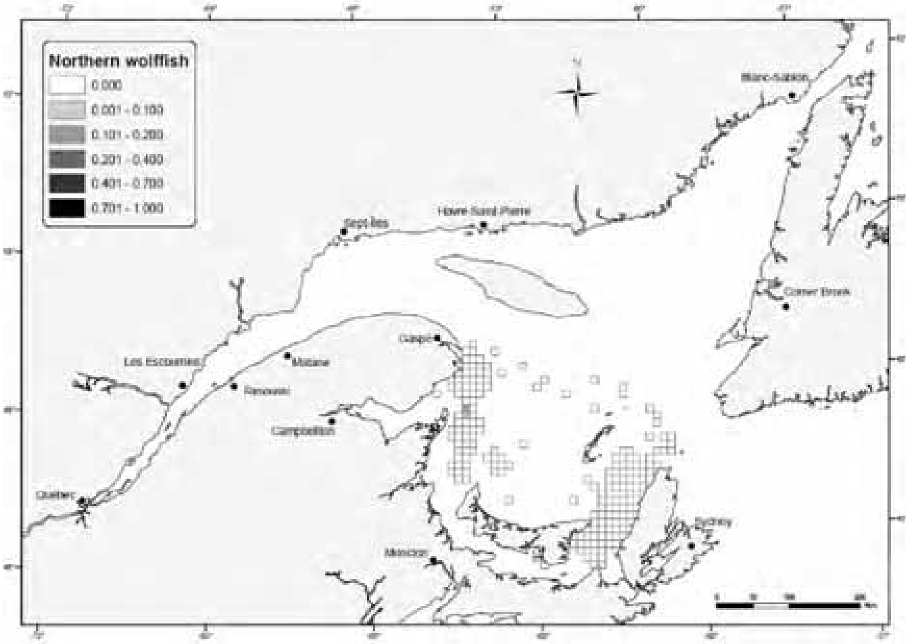
The northern wolffish can be found in cold Continental Shelf waters at depths up to 900 m but prefer depths of approximately 100 m. Spawning occurs in fall and females can lay up to 27,000 extremely large eggs. This species is non-migratory and usually make nests to guard their eggs. They feed upon benthic invertebrates (Kulka et al. 2007). Spatial distribution of the relative occurrence of northern wolffish in the Sentinel Fisheries Program from 1995 to 2002 from stratified random stations and fixed stations are provided in Figures 5.2 and 5.3, respectively.

Northern wolffish in the Northwest Atlantic is treated as a single population and is listed as Threatened on Schedule 1 of SARA due to the rapid decline along the Northeast Newfoundland / Labrador Shelf and the Grand Banks. Northern wolffish occur along the slope of the Laurentian channel, along the edges and slopes of the Labrador shelf, northeast Newfoundland shelf and in low numbers on the Grand Banks (Kulka et al. 2004a). Abundance off northeast Newfoundland is thought to have declined by 98 percent from 1978 to 1994. The number of locations where the species occurs has also declined (SARA 2010).



Source: Dutil et al. 2010.
Note: The data are aggregated by 100 km^2 cells. No trawling took place in areas where the grid is not shown.

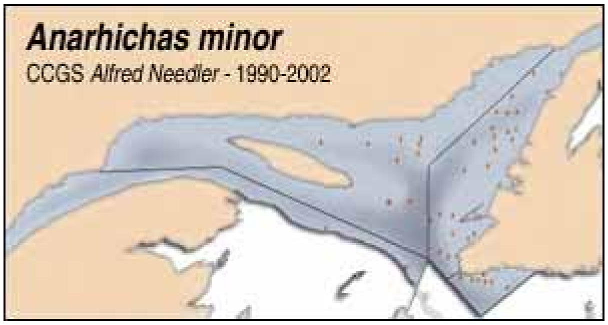
Figure 5.2 Spatial Distribution of the Relative Occurrence of Northern Wolffish in the Sentinel Fisheries Program from 1995 to 2002 from Stratified Random Stations



Source: Dutil et al. 2010.
Note: The data are aggregated by 100 km^2 cells. No trawling took place in areas where the grid is not shown.

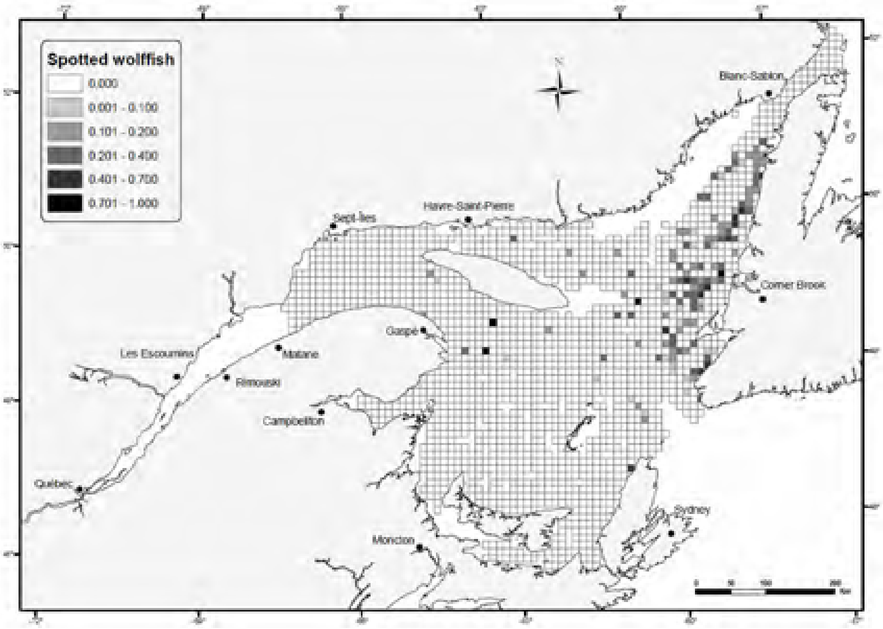
Figure 5.3 Spatial Distribution of the Relative Occurrence of Northern Wolffish in the Sentinel Fisheries Program from 1995 to 2002 from Fixed Stations

The spotted wolffish is a bottom-dwelling predatory fish that can be found in cold Continental Shelf waters, at depths ranging from 50 to 600 m. Spawning occurs in summer (Kulka et al. 2007). Spotted wolffish are treated as a single population in the Northwest Atlantic and are listed as Threatened on Schedule 1 of SARA, due to the rapid decline along the northeast Newfoundland / Labrador Shelf and the Grand Banks. In the western North Atlantic, they occur primarily off northeast Newfoundland. Scientific surveys indicate a 96 percent decline in the Canadian population over 21 years. Distribution of spotted wolffish in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.4. The spatial distribution of the relative occurrence of spotted wolffish in the Sentinel Fisheries Program from 1995 to 2002 from stratified random stations is provided in Figures 5.5.



Source: http://slgo.ca/app-guidesp/en/poiss/sp/a-minor.html

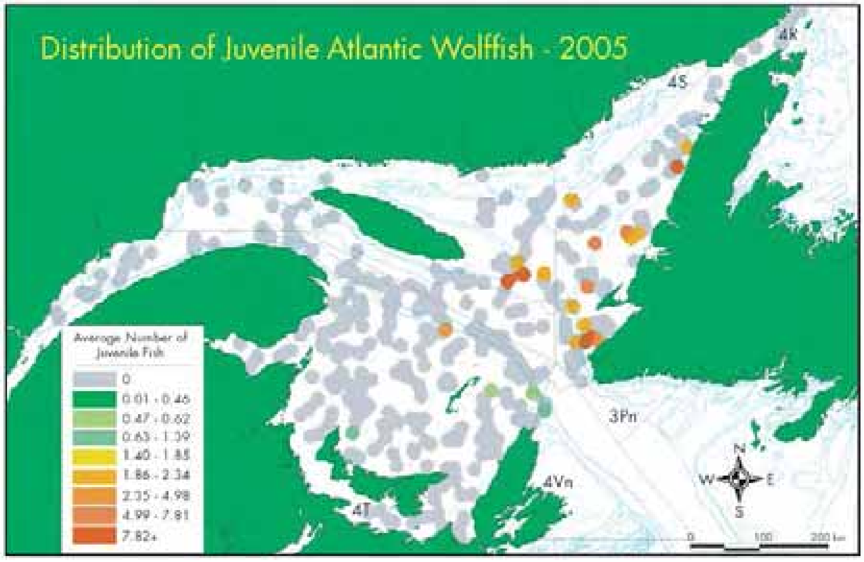
Figure 5.4 Spotted Wolffish Distribution in the Gulf of St. Lawrence, 1990 to 2002



Source: Dutil et al. 2010.
Note: The data are aggregated by 100 km^2 cells. No trawling took place in areas where the grid is not shown.

Figure 5.5 Spatial Distribution of the Relative Occurrence of Spotted Wolffish in the Sentinel Fisheries Program from 1995 to 2002 from Stratified Random Stations

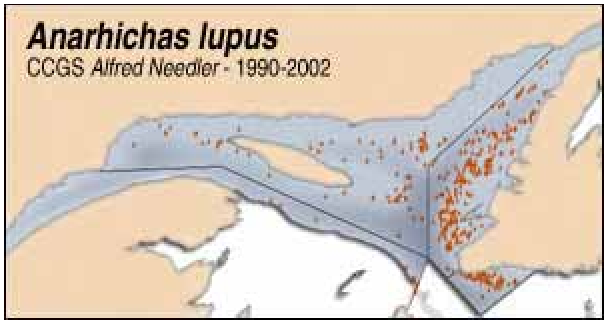
The Atlantic (or striped) wolffish inhabits cold deep waters with rocky or hard clay bottoms along the continental shelf. Within the western Atlantic Ocean, this species can be found in the Strait of Belle Isle and in the Gulf. Spawning typically occurs in September in shallow waters. Juvenile fish however remain in deeper waters. Their diet is composed of hard shelled benthic invertebrates and smaller fish (Kulka et al. 2007). Modelled juvenile Atlantic wolffish densities (from DFO RV data) for 2005 are illustrated in Figure 5.6.



Source: Ollerhead and Lawrence 2007.

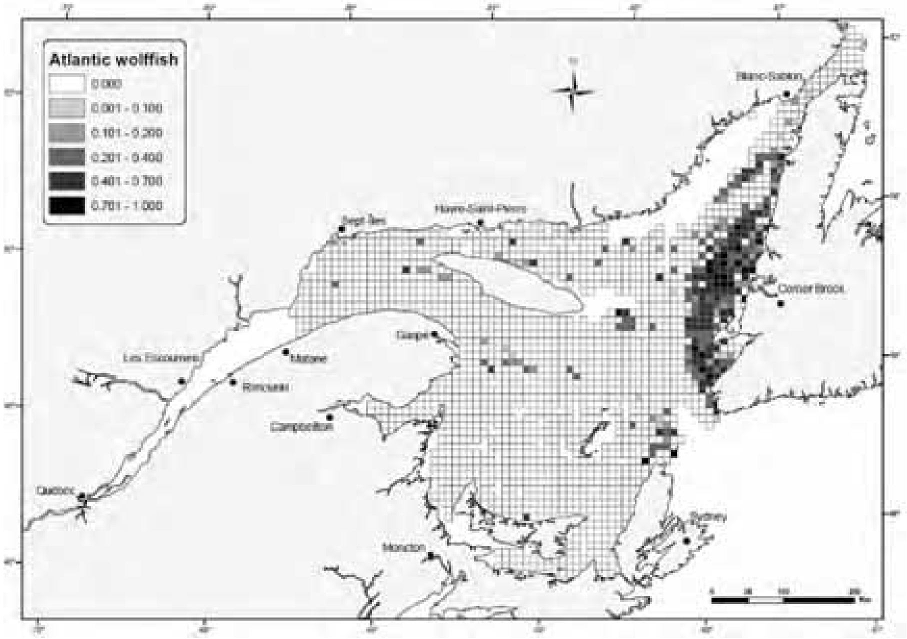
Figure 5.6 Distribution of Juvenile Atlantic Wolffish, 2005

Distribution of Atlantic wolffish in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.7. The spatial distribution of the relative occurrence of Atlantic wolffish in the Sentinel Fisheries Program from 1995 to 2002 from stratified random stations is provided in Figure 5.8.



Source: http://slgo.ca/app-guidesp/en/poiss/sp/a-lupus.html

Figure 5.7 Atlantic Wolffish Distribution in the Gulf of St. Lawrence, 1990 to 2002



Source: Dutil et al. 2010.
Note: The data are aggregated by 100 km^2 cells. No trawling took place in areas where the grid is not shown.

Figure 5.8 Spatial Distribution of the Relative Occurrence of Atlantic Wolffish in the Sentinel Fisheries Program from 1995 to 2002 from Stratified Random Stations

Atlantic wolffish is listed as a species of Special Concern on Schedule 1 of SARA. They occur further south and in greater abundance than the northern and spotted wolffish. They occur along the south coast and St. Pierre Bank, along the Labrador and northeast Newfoundland shelves and on the Grand Banks (Kulka et al. 2004a). Available data indicate populations in Canadian waters have declined by 87 percent from the late 1970s to the mid-1990s. As well, locations where the species occur have declined and the range where the species is abundant may be shrinking. Even though it has measurably declined, it is thought to be very widespread and to still exist in relatively large numbers (SARA website 2010).

A Recovery Strategy for northern and spotted wolffish, and Management Plan for Atlantic wolffish, has been developed to increase the population levels and distribution of the northern, spotted and Atlantic wolffish in eastern Canadian waters such that the long-term viability of these species is achieved (Kulka et al. 2007). Five primary objectives have been identified to achieve the long term viability of the three wolffish species and include . The primary objectives relate to activities that may be mitigated through human intervention and each objective is designed to achieve the goal of increasing population levels and distribution of the wolffish species, such that long-term viability is ensured. The five primary objectives are to enhance knowledge of the biology and life history of wolffish species; identify, conserve and/or protect wolffish habitat required for viable population sizes and densities; reduce the potential of wolffish population declines by mitigating human impacts; promote wolffish population growth and recovery; and develop communication and education programs to promote the conservation and recovery of wolffish populations.

Impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality. However, the live release of spotted and northern wolffish mitigates the affect of incidental capture to some degree. Other potential sources of harm (habitat alteration, oil exploration and production, pollution, shipping, cables and lines, military activities, ecotourism and scientific research) are considered to have negligible impacts on the ability of both spotted and northern wolffish to survive and recover (Kulka et al. 2004a).

Details of this recovery plan can be found in the Northern and Spotted wolffish Recovery Strategy and Atlantic wolffish Management Plan Report (Kulka et al. 2007).

5.2.1.2 Atlantic Cod

Generally the Atlantic cod can be found in waters of continental shelves and slopes, inshore or offshore, with spawning typically occurring in shallow waters (Scott and Scott 1988). There are four different populations of Atlantic cod that could be present in the Gulf and in the vicinity of EL 1105. These include the Laurentian North population, the Laurentian South population, the Newfoundland and Labrador population and the Southern population (COSEWIC 2010a). Each of these populations of Atlantic cod has been designated as endangered under COSEWIC. Due to their designated status and the fact that, as stated in Section 6.2, there is uncertainty regarding the specific timing and route of the Northern Gulf cod migration (which is an extensive annual migration between southwestern and southern Newfoundland (winter) and Port au Port Peninsula (April and May, the onset of spawning) and along the west coast of Newfoundland and middle and lower North Shore of Québec (summer) (DFO 2009b), all four populations are assessed for this Project.

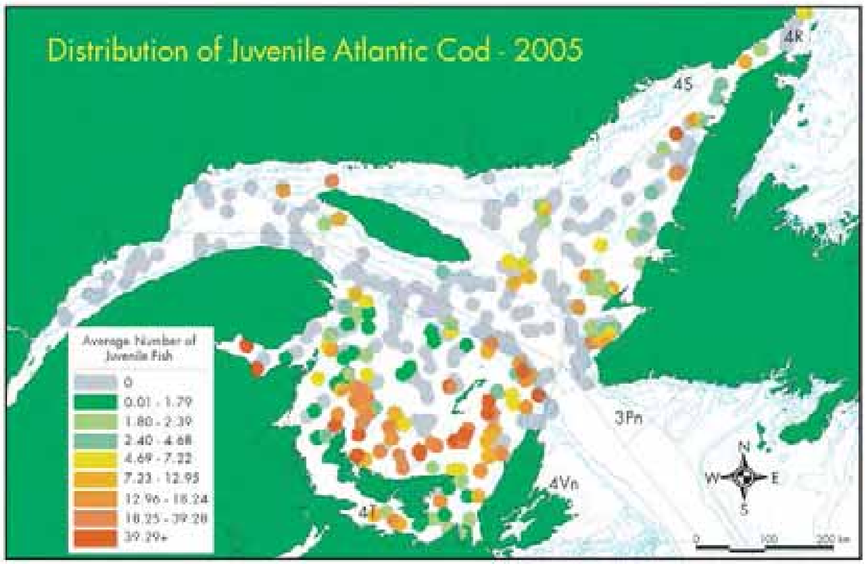
The Newfoundland and Labrador population of the Atlantic cod includes those species that inhabit waters ranging from the northern tip of Labrador, southeast to the Grand Banks of Newfoundland. Three stocks of cod are typical for this region and include, the Northern Labrador cod (Northwest Atlantic Fisheries Organization (NAFO) Divisions 2GH), Northern cod (NAFO Divisions 2J3KL) and Southern Grand Bank cod (NAFO Divisions 3NO) (COSEWIC

2003a). The cod in this area have declined by more than 99 percent since the 1960s (COSEWIC 2010a), with the major cause of the decline being overfishing. Even though fishing efforts have been reduced since the early 1990s this population has shown very little sign of recovery (COSEWIC 2010a).

The Maritimes population, which included five different DFO stocks (the Southern Gulf (NAFO Division 4T), the Cabot Strait (NAFO Division 4Vn), the Eastern Scotian Shelf (NAFO Divisions 4VsW), the Bay of Fundy / Western Scotian Shelf (NAFO Division 4X) and cod found in the Canadian waters of Georges Bank (NAFO Division 5Zjm) (COSEWIC 2003a)) was split in April 2010 into the Laurentian South population and the Southern population (COSEWIC 2010a). Both populations were designated as endangered. The Laurentian South population includes the management units 4T, 4Vn and 4VsW and the Southern population includes the management units 4X and 5Zjm. The main cause of decline of these populations of cod was also a result of overfishing. Commercial fishing efforts were reduced in the early 1990s; however, increased natural mortality of older cod and continual small catch efforts have caused the population to continue to decline (COSEWIC 2010a).

The Laurentian North population of the Atlantic cod includes two DFO identified stocks, St. Pierre Bank (NAFO Division 3Ps) and the Northern Gulf (NAFO Divisions 3Pn4RS) (COSEWIC 2003a); EL 1105 (including the proposed wellsite) is in NAFO Unit Area 4Ss, with the likely supply vessel routes extending into Unit Area 4Tf. The status of this population was re-examined in April 2010 and designated as endangered by COSEWIC. The population has declined by 89 percent over three generations as a result of overfishing and there is no indication of recovery (COSEWIC 2010a). Between 2000 to 2009, exploitation rates were too high compared to current productivity to permit any substantive rebuilding of the Northern Gulf stock (DFO 2010a).

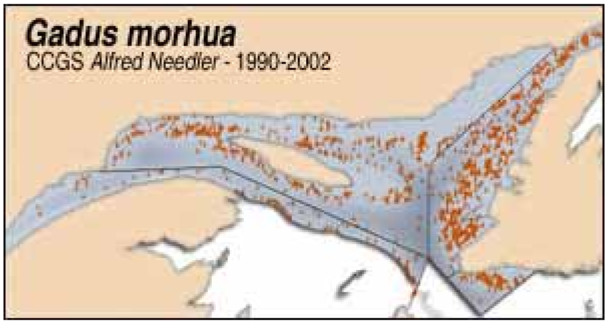
Atlantic cod eggs and larvae are planktonic during and are primarily zooplankton feeders; once they settle, their primary food source are benthic and epibenthic invertebrates (Scott and Scott 1988). Pelagic juveniles can occupy eelgrass beds, macroalgal habitat, sandy bottoms, cobble and rock reefs (Keats et al. 1985; Tupper and Boutilier 1995a, 1995b). The primary diet of juvenile cod includes pelagic crustaceans, especially zooplankton (but benthic species are also included in their diet (e.g., gammarids and harpacticoids) (Grant and Brown 1998), while inshore adult cod feed primarily on capelin (Lilly 1987), depending on the season (O'Driscoll et al. 2000). Modelled juvenile Atlantic cod densities (from DFO RV data) for 2005 are illustrated in Figure 5.9.



Source: Ollerhead and Lawrence 2007.

Figure 5.9 Distribution of Juvenile Atlantic Cod, 2005

Distribution of Atlantic cod in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.10.



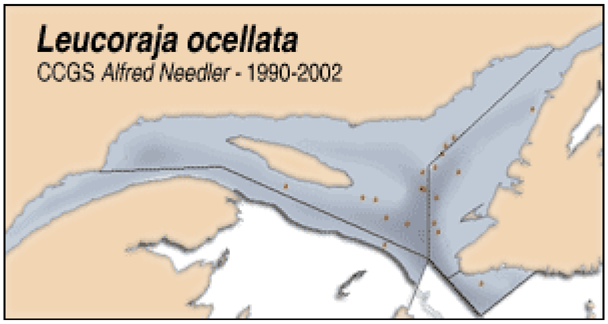
Source: http://slgo.ca/app-guidesp/en/poiss/sp/g-morhua.html

Figure 5.10 Atlantic Cod Distribution in the Gulf of St. Lawrence, 1990 to 2002

5.2.1.3 Winter Skate

The southern Gulf population of the winter skate has been designated as endangered under COSEWIC. As indicated in Table 5.2, this species has a low potential to occur within EL 1105. The winter skate is endemic to the Northwest Atlantic and in Canadian waters this species tends to be concentrated in three areas, the southern Gulf, the eastern Scotian Shelf, and the Canadian portion of Georges Bank. It is a bottom-dwelling species that prefers sand and gravel bottoms and occurs at depths up to 371 m. However, there are more commonly found at a depth of approximately 100 m. Spawning occurs during late summer to early fall and their diets consist mainly of various shellfish, amphipods and small fish (COSEWIC 2005a).

Distribution of winter skate in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.11.

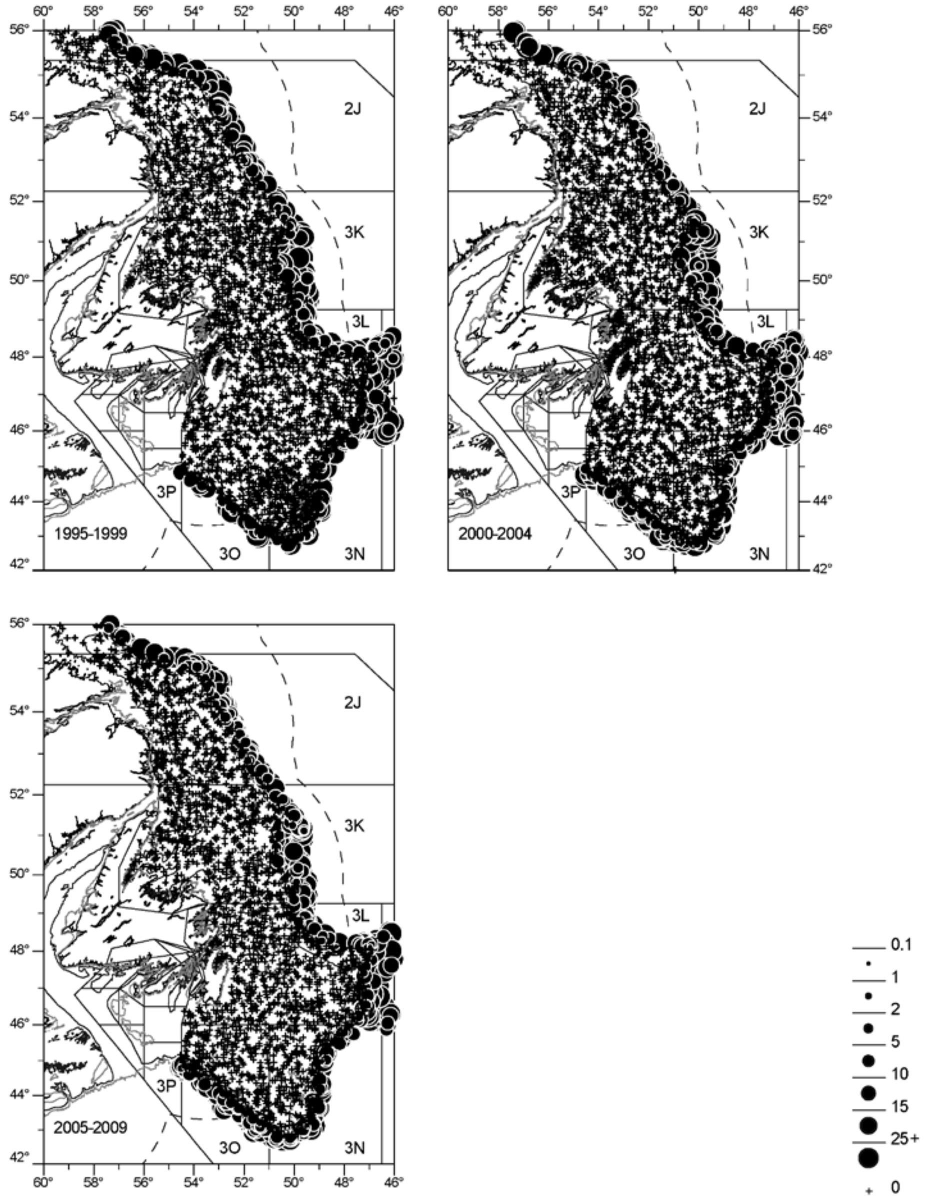


Source: http://slgo.ca/app-guidesp/en/poiss/sp/l-ocellata.html

Figure 5.11 Winter Skate Distribution in the Gulf of St. Lawrence, 1990 to 2002

5.2.1.4 Roundnose Grenadier

In November 2008, the roundnose grenadier was designated as endangered under COSEWIC. The population of the roundnose grenadier showed declines of 98 percent from 1978 to 1994 and additional declines from 1995 to 2003. Roundnose grenadier inhabit the Northwest Atlantic's continental slopes (see Figure 5.12), from Baffin Island and Greenland south to Cape Hatteras (DFO 2010b). Roundnose grenadier is under moratorium in NAFO Subareas 0, 2 and 3 within the Canadian Economic Exclusion Zone; however, it is part of the bycatch of other fisheries within and outside the Canadian Economic Exclusion Zone (DFO 2010b). This species is typically found at depths between 180 and 2,600 m, primarily between 400 to 1,200 m (COSEWIC 2008a) and migrate vertically to feed on squid and small fish and crustaceans (DFO 2010b). They live for a long time and are slow to grow; they are late to mature and females have relatively low fecundity (DFO 2010b). As indicated in Table 5.2, they are considered to have low potential to occur in EL 1105.



Source DFO 2010b.

Figure 5.12 Distribution of Roundnose Grenadier from DFO-NL Fall Research Vessel Surveys, 1995 to 2005

5.2.1.5 Porbeagle Shark

The porbeagle shark has been designated as endangered by COSEWIC. In Canadian waters, the porbeagle shark can be found from northern Newfoundland into the Gulf and around Newfoundland to the Scotian Shelf and Bay of Fundy. This shark is a pelagic species but is more commonly found on continental shelves in waters between 5°C and 10°C. Mating occurs off southern Newfoundland and at the entrance to the Gulf, between late September and November. Pregnant females are present in this area from late September through to December and are seldom seen from January through to June (COSEWIC 2004a). As indicated in Table 5.2, they are considered to have a low potential for occurrence within EL 1105.

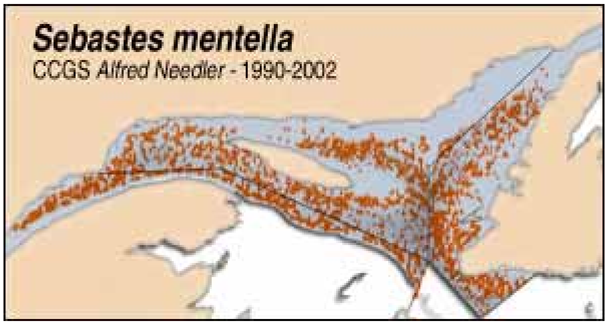
5.2.1.6 White Shark

White sharks are designated as Endangered under COSEWIC; they have no status under SARA. They are rare (only 32 records in over 132 years for Atlantic Canada) in Canadian waters (which represent the northern-most edge of their range) and are recorded mostly in the Bay of Fundy area (COSEWIC 2006a). They are extremely rare as far north as the Gulf and would be an unlikely occurrence in EL 1105.

5.2.1.7 Redfish

Two species of redfish occur in the Gulf, Acadian and deepwater redfish, and both are expected to be found in EL 1105. These species are very similar in appearance and are managed together and not separated in the fishery (DFO 2004a). EL 1105 falls within the redfish management Unit 1 (which includes NAFO Divisions 4RST). Redfish are typically found at depths ranging from 100 to 700 m. Mating takes place in the fall and larvae hatch within the female and are released during April to July (LGL 2005c). In the early 1990s, the landings of redfish in Unit 1 dropped from about 60,000 t in 1993 to approximately 19,500 t in 1994 (DFO 2001). The directed redfish fishery was closed in 1995 as a result of low stock levels (DFO 2001; LGL 2007). In April 2010, the status of both species of redfish potentially found near the Project was re-examined and the deepwater redfish was designated as endangered and the Acadian redfish was designated as threatened by COSEWIC. The deepwater redfish has declined by 98 percent since 1984 and the Acadian redfish has declined by 99 percent, in areas of historical abundance over two generations. The major treats to both species are directed fishing and incidental harvest (COSEWIC 2010b).

Distribution of deepwater redfish in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.13.



Source: http://slgo.ca/app-guidesp/en/poiss/sp/s-mentella.html

Figure 5.13 Deepwater Redfish Distribution in the Gulf of St. Lawrence, 1990 to 2002

For the remainder of this report, any discussions regarding redfish will collectively include both the deepwater redfish and the Acadian redfish, as their species profiles are similar, with the major difference being that the deepwater redfish are generally distributed at greater depths than that of the Acadian redfish (LGL 2005b).

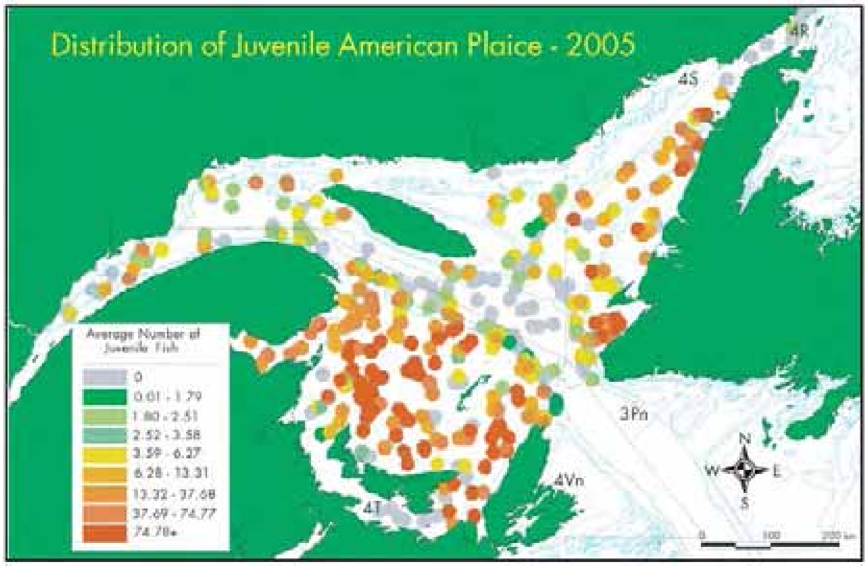
5.2.1.8 Shortfin Mako

The Atlantic population of the shortfin mako has been designated as threatened under COSEWIC. This species is highly migratory and its distribution pattern is dependent on water temperature, but it can withstand significant changes in temperature as well as food availability. Migration to the Atlantic coast of Canada and to the warm waters of the Gulf, typically occurs in later summer and fall. They feed primarily on tuna, mackerel, bluefish, swordfish and marine mammals and are considered one of the fastest swimming sharks in the world (SARA 2010). As indicated in Table 5.2, this species is considered to have a low potential of occurring in EL 1105.

5.2.1.9 American Plaice

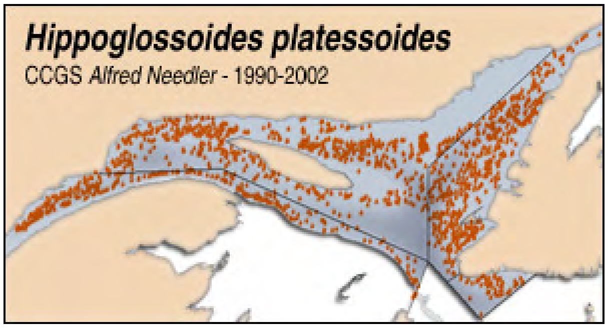
Both the Maritime and Newfoundland and Labrador populations of the American plaice occur in the Gulf and could be found in EL 1105. In 2009, both populations were designated as threatened under COSEWIC. This species prefers depths of 100 to 200 m and sediment suitable for burrowing. The Maritime population is more common to the Gulf. The abundance of mature individuals has declined by 86 percent in the Gulf due mainly to overfishing, but also natural mortality (COSEWIC 2009a). Modelled juvenile American plaice densities (from DFO RV data) for 2005 are illustrated in Figure 5.14.

Distribution of American plaice in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.15.



Source: Ollerhead and Lawrence 2007.

Figure 5.14 Distribution of Juvenile American Plaice, 2005



Source: http://slgo.ca/app-guidesp/en/poiss/sp/h-platessoides.html

Figure 5.15 American Plaice Distribution in the Gulf of St. Lawrence, 1990 to 2002

5.2.1.10 Striped Bass

Striped bass occur from the St. Lawrence Estuary along the Atlantic coast to Florida, with historical breeding in five eastern Canadian rivers, including the St. Lawrence Estuary. Two genetically-distinct (and isolated) extant populations occur in the southern Gulf (Miramichi River) and Bay of Fundy (Shubenacadie River). Females usually spawn at age five (although they can mature at age four) and males mature at year three or four. Spawning occurs in late May or early June, primarily in freshwater, and development from egg to young-of-the-year corresponds to a gradual movement to salt water. Once yolk sacs are depleted, the larvae feed on zooplankton for approximately one month. Immature and adult bass feed on invertebrates or fish in estuaries and coastal waters in summer and can overwinter in rivers. Striped bass school to fish and cover tens of kilometres in one day (COSEWIC 2004b).

There has been no evidence of spawning in the St. Lawrence Estuary for over two decades, nor has there been any authenticated catches of local bass in the same time period. Limiting factors include commercial and recreational overfishing and alteration of habitat (e.g., flow modifications and changes in water quality due to pollution from anthropogenic activities) (COSEWIC 2004b). Strict harvesting regulations, followed by a complete closure in 2000 of any striped bass fishery, seem to have a allowed a population recovery. The St. Lawrence Estuary population is considered extirpated and the southern Gulf population has been designated as Threatened by COSEWIC; it is not listed under SARA Schedule 1 (COSEWIC 2004b). As indicated in Table 5.2, this species is considered to have a low potential for occurrence in the vicinity of EL 1105.

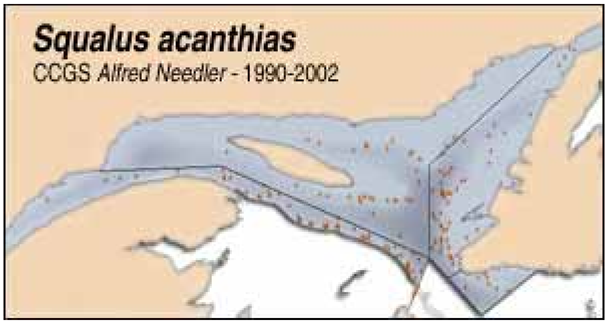
5.2.1.11 Roughead Grenadier

Roughead grenadier is abundant throughout the North Atlantic and can be located on both the shelf and continental slope (González-Costas and Murua 2007). In the Northwest Atlantic, it shows a continuous distribution along the slope of the Continental Shelf from the Davis Strait to the southern Grand Bank (COSEWIC 2007). As indicated in Table 5.2, this species is considered to have a low potential for occurrence in the vicinity of EL 1105.

5.2.1.12 Spiny Dogfish

The spiny dogfish, Atlantic population, was designated as of special concern by COSEWIC in April 2010. This small shark is abundant in Canadian waters and widely distributed in temperate regions, being most abundant in southwest Nova Scotia. Reasons for concern in Canadian waters include low fecundity, long generation time, and uncertainty regarding abundance of mature females and demonstrated vulnerability to overfishing in US waters (COSEWIC 2010c). As indicated in Table 5.2, this species is considered to have the potential to occur in low numbers in the vicinity of EL 1105.

Distribution of spiny dogfish in the Estuary and Northern Gulf (based on survey data from missions on the *CCGS Alfred Needler* from 1990 to 2002) are depicted in Figure 5.16.



Source: http://slgo.ca/app-guidesp/en/poiss/sp/s-acanthias.html

Figure 5.16 Spiny Dogfish Distribution in the Gulf of St. Lawrence, 1990 to 2002

5.2.1.13 Blue Shark

The blue shark is widespread and highly migratory. It has been designated as a species of Special Concern by COSWEIC. In Atlantic Canada, they can be found in almost all offshore surface waters to a depth of 350 m, and peak occurrence occurs in the late summer and fall. The blue shark has a 9 to 12 month gestation period and females produce litters approximately every two years. They are opportunistic feeders and tend to eat a variety of prey including squids, birds and marine mammal carrion (COSEWIC 2006b). This species is considered to have a low potential for occurrence in the vicinity of the Project (see Table 5.2).

5.2.1.14 Basking Shark

The Atlantic population of basking shark has recently been assessed as a species of Special Concern by COSEWIC; it has no status under SARA (SARA 2010). The basking shark is found in the western North Atlantic from northern Newfoundland south to Florida and occurs in Canadian waters from May to September (Scott and Scott 1988). The Canadian population ranges from approximately 5,000 to 10,000 individuals (COSEWIC 2009b). This species is considered to have a low potential for occurrence in the vicinity of the Project (see Table 5.2).

5.2.1.15 American Eel

American eel are found from northern South America to Greenland and Iceland. They breed at sea and return to fresh water to feed and grow; all spawners are part of a single breeding unit. Spawning and hatching takes place in the Sargasso Sea and spawning occurs only once per adult. The larval stages are completely physiologically dissimilar to the adult eel. The life stages are: egg; leptocephalus (larval form); glass eel (upon reaching the Continental Shelf; unpigmented); elver (progressively pigmented as they approach shore), yellow eel (the growth stage of the life cycle); and silver eel (the spawning stage of the life cycle) (COSEWIC 2006c). Female silver eels exit Newfoundland freshwater systems between August to October (Gray and Andrews, in COSEWIC 2006c). The population abundance in the southern Gulf has had a generally increasing trend between 1997 to 2008, while population abundance in Newfoundland is deemed to be variable, but stable in recent years (DFO 2010c). As indicated in Table 5.2, any occurrence of this species in the vicinity of EL 1105 would be transient in nature.

5.2.1.16 Atlantic Salmon

Atlantic salmon (*salmo salar*) is an anadromous species, living in freshwater rivers for the first two years of life before migrating to sea. Atlantic salmon return annually to their natal river or tributary for spawning. Both post-smolt (juvenile) and adult salmon migrate from northeastern North America in the spring and summer to over-winter in waters off Labrador. While at sea, adult salmon were found spending a considerable amount of time in the upper portion of the water column (Reddin 2006). Tagging studies of post-smolts also indicated they spend most of their time near the surface, but undergo deep dives, likely in search of prey (Reddin et al. 2006). While at sea, they consume euphausiids, amphipods and fishes such as herring, capelin, small mackerel, sand lance and small cod. Salmon are prey for seals, sharks, pollock (Pollachius spp.) and tuna (Scott and Scott 1988).

The commercial fishing of Atlantic salmon in Newfoundland waters was placed under moratoria since 1992. There are four at risk populations that may occur in the Gulf and have the potential to interact with the Project: the Anticosti Island population, assessed by COSEWIC as Endangered; the South Newfoundland population, assessed by COSEWIC as Threatened, the Gaspé-Southern Gulf of St. Lawrence population assessed by COSEWIC as Special Concern; and the Québec Eastern North Shore population, also assessed by COSEWIC as Special Concern. All of these populations are considered to have a low potential for occurrence within EL 1105, with any presence being transient in nature (Table 5.2).

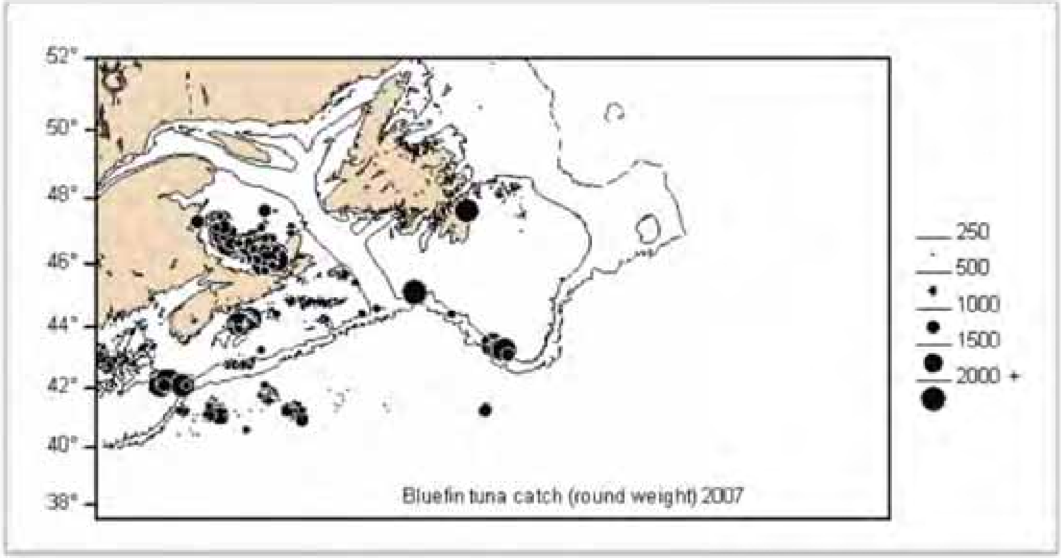
The primary cause of population decline for Atlantic salmon are not well understood, although it is thought that poor marine survival rates is a major factor, contributed to both fishing and overall changes in the marine ecosystem brought about by climate change (COSEWIC 2010d).

5.2.1.17 Atlantic Bluefin Tuna

Bluefin tuna are a warm-blooded pelagic species that is distributed from the Gulf of Mexico (GOM) to the Gulf. The large, endothermic bluefin tuna are adapted for migration to colder waters while maintaining a high metabolic rate, which is evident in their migration into the Gulf in search of food stocks (National Oceanic and Atmospheric Administration (NOAA) 2005).

The bluefin tuna generally follow food stocks that aggregate in the Gulf from July through November. There are two populations of bluefin tuna based on their distinct spawning areas, the Eastern Mediterranean population and the Western GOM population; either population can be found within the Gulf (Walli et al. 2009). The western Atlantic bluefin tuna spawn between mid-January and late March, with the eastern population spawning in late May. Eggs incubate for two days before emerging in a larval state (DFO 2009c). Maturity is expected to occur around age eight (DFO 2009c) with habitat range expanding with age. Adults follow Atlantic herring and Atlantic mackerel fishing grounds and are known to forage on Atlantic herring in late summer and switch to Atlantic mackerel in the fall (Walli et al. 2009).

The distribution of the catch of bluefin tuna in the western Atlantic including the Gulf is presented in Figure 5.17. As indicated in Table 5.2, this species has a low potential for occurrence within EL 1105.



Source: DFO 2009c.

Figure 5.17 Bluefin Tuna Catch Distribution in the in the Gulf of St. Lawrence and Western Atlantic

5.2.1.18 Atlantic Sturgeon

Atlantic sturgeon are a large-bodied, slow-growing, late-maturing anadromous fish that occurs in rivers (preferably with deep channels), estuaries (with relatively warm and partially saline water), nearshore marine environments and shelf regions to at least 50 m. The Maritimes Designated Unit has an estimated 1,000 to 2,000 adults (minimum), with spawning occurring within the lower Saint John River area only. The St. Lawrence Designated Unit has an estimated 500 to 1,000 adults. Breeding populations are known from the St. Lawrence River and possibly other rivers tributary to the St. Lawrence river. Potential spawning locations occur in the St. Lawrence River and Estuary (COSEWIC 2011).

Limiting factors and threats include changes to riverine habitat and potentially, pollution in rivers, and from offshore oil and gas developments. Atlantic sturgeon are fished commercially and that, along with pollution, may have been the most important factor in the suspected past population declines (COSEWIC 2011).

5.2.1.19 Cusk

Cusk are designated as Threatened by COSEWIC, but not listed under SARA. Cusk are a cod-like fish that can live up to 20 years and grow to a length greater than 100 cm, with at least half of the adults reaching sexual maturity when they are approximately 50 cm in length (five or six years old). They area usually located at depths of 150 to 400 m in relatively warm water (6ºC to 10ºC) (COSEWIC 2003b).

Cusk are a northern species inhabiting subarctic and boreal shelf waters of the North Atlantic, with the centre of abundance in the Gulf of Maine and southern Scotian Shelf (overlapping the international border of Canada and the United States). While rare, it also occurs in the deep waters along the edge of the continental shelf off Newfoundland and Labrador. Cusk are virtually absent from the Gulf of St. Lawrence and is rare north of the Laurentian Channel in the Newfoundland and Grand Bank region (COSEWIC 2003b).

5.2.2 Bird Species at Risk

5.2.2.1 Ivory Gull

The Ivory Gull is a medium sized, long-lived gull species that is associated with polar pack ice at all times of the year (Gilchrist and Mallory 2004), which is unusual for a gull species (Stenhouse et al. 2004).

The wintering grounds of the Ivory Gull are thought to be along the edge of pack ice in the North Atlantic Ocean, particularly in the north Gulf, Davis Strait, the Labrador Sea and the Strait of Belle Isle. Various studies conducted from 2002 to 2005 suggest that the Canadian breeding population of the Ivory Gull has decreased. They nest on flat terrain or on sheer cliffs during May and early June. Outside their breeding season, they live near the edges of pack ice, as mentioned above. The Ivory Gull is a surface feeder and primarily feeds on small fish and small mammals (SARA 2010).

Approximately 35,000 individuals were observed among the pack ice of the Labrador Sea in 1978 (Orr and Parsons 1982), representing the bulk of the world population of Ivory Gulls. A 2004 survey conducted off the coast of Newfoundland and Labrador showed a decrease in Ivory Gull numbers, with sightings of, from 0.69 individuals sighted per 10 minutes observed in 1978 to 0.02 individuals sighted per 10 minutes in 2004 (COSEWIC 2006d).

The Ivory Gull is listed as Endangered on Schedule 1 of SARA and is protected under the *Migratory Birds Convention Act* 1994 and *Migratory Bird Regulations* (COSEWIC 2006d). This species is rare during October to May and absent during June to October. As indicated in Table 5.1, it is likely to occur in the vicinity of EL 1105 only in association with pack ice.

The management plan for the Ivory Gull (Stenhouse 2004) outlines specific measures that can be taken to increase knowledge and promote the recovery of Ivory Gulls in Canada. The long-term recovery goal is to restore “the Canadian breeding population to historic levels and to expand the breeding range to historically occupied areas”. The objectives aim to maintain Ivory gull colonies currently in existence and prevent further loss; identify and understand the threats to Ivory Gulls in Canada, with a focus on anthropogenic activities; acquire further knowledge to understand the life history characteristics of the species; identify and protect critical habitat; educate stakeholders and the general public on ways to support recovery; and work collaboratively at an international level to further recovery.

Currently, the hunting of birds on migration is negatively affecting survival and possibly population viability (Stenhouse 2004). Human disturbance at breeding colonies may have a considerable effect by reducing reproductive success and possible habitat degradation. Resource extraction near Ivory Gull breeding areas requires use of planes, helicopters, snowmobiles and ATVs, which may introduce noise and pollution. The presence of semi-permanent drilling camps may also attract predators to otherwise remote areas.

There are several other factors (Stenhouse 2004) influencing the potential for recovery in Ivory Gulls, for which there is no current data, including ecological perturbation, such as changes in the extent of ice cover causing degradation of winter habitat; exposure to toxic pollutants in the marine environment; and vulnerability to oiling.

Details of this management plan can be found in the Canadian management plan for the Ivory Gull (*Pagophila eburnea*) (Stenhouse 2004).

5.2.2.2 Eskimo Curlew

The Eskimo Curlew is a migratory bird that typically migrated through the Labrador Shelf area in the fall and may have migrated through the Strait of Belle Isle area. They were once found from Newfoundland and Labrador to Alberta to the Northwest Territories (Environment Canada 2007a). It is likely that this species has become extinct as efforts to locate individuals have been unsuccessful (Environment Canada 2007a).

The Eskimo Curlew is listed as endangered on SARA Schedule 1. They are under management jurisdiction from the federal government and are covered under the *Migratory Birds Convention Act* (Environment Canada 2007a). The Recovery Strategy for Eskimo Curlew (Environment Canada 2007a) currently notes that it is not aware of the existence or location of any Eskimo Curlew and as such, recovery is not technically or biologically feasible for this species at this time. The primary causes of the rapid decline for the Eskimo curlew are believed to be overhunting and habitat change, the bird’s failure to recover was likely a combination of low population numbers, continued loss of habitat, and conservative life history traits.

Details of this recovery plan can be found in the Recovery Strategy for the Eskimo Curlew (*Numenius borealis*) in Canada. (Environment Canada 2007a).

5.2.2.3 Piping Plover

The Piping Plover *melodus* subspecies is a migratory shorebird that nests in coastal areas on the southwest coast of Newfoundland (Amirault 2005) in sand, gravel, or cobble, in open, elevated areas of the beach (Haig and Elliot-Smith 2004), on barrier island sandspits, or peninsulas in marine coastal areas. It breeds in eastern and central Canada and adjoining regions in the United States. Piping Plover nest on the Island of Newfoundland, the Magdalen Islands and St. Pierre et Miquelon, as well Nova Scotia (including Cape Breton Island), Prince Edward Island and New Brunswick (Goosen et al. 2002; Newfoundland and Labrador Department of Environment and Conservation 2010).

The North American breeding population consists of approximately 5,900 birds, 2,100 breeding in Canada (Goosen et al. 2002). The eastern Canadian population was estimated at 481 adults in 2001. A census in Newfoundland in 2006 identified 48 nesting adult Piping Plovers, an increase from 39 birds in 2001. Piping Plovers have not been found on the northeast coast since 1987. In 2009, a pair of nesting Piping Plovers was identified in Gros Morne National Park for the first time since 1975 (Newfoundland and Labrador Department of Environment and Conservation 2010).

Nesting sites for this species on the Island of Newfoundland include Big Barasway, Sandbanks Provincial Park, Little Barasway, Seal Cove and areas around J.T. Cheeseman Provincial Park, Grand Bay West and Little Codroy. Piping Plovers that nest in Newfoundland generally overwinter along the southern Atlantic Coast of the United States. One of its largest breeding areas in Newfoundland and Labrador is the beach at Big Barasway Piping Plover Wildlife Reserve near Burgeo (Protected Areas Association of Newfoundland and Labrador 2000), in addition to the adjoining Sandbanks Provincial Park in Burgeo.

The Piping Plover melodus species is listed as Endangered on Schedule 1 of SARA, Endangered under the Newfoundland and Labrador *Endangered Species Act* and is protected under the *Migratory Bird Convention Act*. Piping Plover habitat is protected under SARA, which provides a residence description of the melodus (and circumcinctus) subspecies (SARA 2010). Noted threats to this species as human disturbance, predation (egg, chick and adult), habitat loss and degradation, live stock disturbances, as well as identifying a number of specific threats that that may directly affect the plovers including driving vehicles on beaches, pets, boats, oil spills, mosquito control, and hurricanes (Stucker and Cuthbert 2006). This species is not expected to occur in offshore areas of the Gulf, such as within the Study Area, but does occur in coastal areas of western Newfoundland with the potential to occur in the vicinity of supply vessel or helicopter transit routes, depending on the final route selected.

5.2.2.4 Roseate Tern

The Roseate Tern breeds almost exclusively on coastal islands in Nova Scotia, although small numbers of birds also breed on islands in Québec and New Brunswick. Roseate Tern nesting sites are populated with beach grass and herbaceous plants and always in association with Common or Arctic Terns (in northeastern North America) to provide protection from diurnal predators (Nisbet and Spendelow 1999, in COSEWIC 2009c). There are approximately 120 to 150 pairs in Atlantic Canada, mostly in one or two colonies (Country Island (>40 pairs) and the Brothers (>80 pairs), Nova Scotia), with small peripheral colonies of Roseate Terns nesting on Sable Island and the Magdalen Islands (COSEWIC 2009c).

The Roseate Tern is listed as Endangered on Schedule 1 of SARA and is a migratory bird covered under the *Migratory Birds Convention Act*, 1994. There is a Recovery Plan in place for the Roseate Tern (Environment Canada 2010b); however, recovery of the entire population relies heavily on the recovery of the portion of the population nesting in the US (which also has a recovery plan (United States Fish and Wildlife Service 1998), as less than 5 percent of the northeastern North American population of Roseate Terns nests in Canada.

The objectives of the recovery plan are to maintain high numbers of breeding pairs at Country Island, Nova Scotia (>40 pairs) and The Brothers, NS (>80 pairs), enhance productivity at managed colonies to high levels, restore a broader distribution by establishing at least one more managed colony, remove or reduce threats to Roseate Terns and their habitat, and maintain small peripheral colonies of Roseate Terns nesting on Sable Island, NS and the Magdalen Islands, QC. These objectives will be achieved primarily by monitoring population size, distribution, movement, and productivity; enhancing nesting habitat; managing additional colonies; identifying critical habitat; protecting habitat; identifying limiting factors at managed colonies; monitoring threats and improving decision making and planning (Environment Canada 2010b). Threats to this species that were identified include predation from gulls and animals such as foxes, high post-fledging mortality and a shortage of males.

Details of this recovery plan can be found in the Recovery Strategy for the Roseate Tern (*Sterna dougallii*) in Canada. (Environment Canada 2010b). Because this species exhibit high site fidelity, it is unlikely to occur in western Newfoundland or in the vicinity of EL 1105 (Table 5.1).

5.2.2.5 Horned Grebe

The Horned Grebe is a small duck-like waterbird, found across Eurasia and in northwestern North America, primarily in Canada. A small, isolated breeding population has persisted for at least a century in the Magdalen Islands and includes birds breeding in this archipelago and other sporadic breeders that occur in Québec. While it is unknown where the Magdalen Islands population overwinters, it is assumed that birds winter along the Atlantic coast of North America (SARA 2010).

Between 1993 and 2007, the population on the Magdalen Islands declined by 2 percent per year, with only five adults observed in 2005 (the average has been 15 adults, with no more than 25 adults seen during the same breeding season); this suggests a 22 percent population decline over the last three generations. From 2000 to 2007, most of the birds and nests found during the breeding season were concentrated on East Pond and on Brion Island; other nesting areas of the archipelago seem to be deserted (SARA 2010).

Almost half of the ponds preferred by the Horned Grebe on the Magdalen Islands are located on protected lands including: the Pointe de l'Est National Wildlife Area, managed by Canadian Wildlife Service (CWS); an additional 1,049 ha protected by conservation organizations; an additional 1,290 ha adjacent to this reserve, forming part of the Pointe-de-l'Est Wildlife Preserve; and all the ponds on Brion Island located within the limits of the Brion Island Ecological Reserve, under the jurisdiction of the Québec government (COSEWIC 2009d). On the Magdalen Islands, adults gather on East Pond before migrating to the wintering areas in late September or early October. At sea, these birds are particularly vulnerable, since they spend most of their time on the water.

The Horned Grebe, Magdalen Islands population, is listed as Endangered on Schedule 1 of SARA (added February 3, 2011). It is also protected under the *Québec Act Respecting Threatened or Vulnerable Species* (*Loi sur les espèces menacées et vulnérables du gouvernement du Québec*) (which protects the species but does not offer any protection to the their breeding habitat) and the *Migratory Birds Convention Act*, 1994, which prohibits harming migratory birds, their nests or their eggs (SARA 2010). Pursuant to the listing of the Horned Grebe, Magdalen Islands population as endangered on Schedule 1 of SARA, a recovery strategy will be required to be developed.

This species is not expected to occur offshore in the vicinity of EL 1105 or elsewhere off the west coast of Newfoundland.

5.2.2.6 Harlequin Duck

The eastern population of Harlequin Duck breeds on the Island of Newfoundland, Labrador, northern Québec, the Gaspé Peninsula and northern New Brunswick (CWS website). Harlequin Duck migrate north in the Gulf until May and then again in later summer, when the birds return to the ocean from inland rivers where they breed. During most of the year, Harlequin Duck are found in such coastal marine environments, but in spring they ascend to high-elevation rivers and streams to breed. Harlequin Duck breed in central Newfoundland and it is expected that they breed in low densities on south coast rivers as well. Harlequin Duck are known to overwinter on the coast of the Island of Newfoundland, near Ramea, Burgeo, Connoire Bay and near the Penguin Islands. Harlequins are known to winter along the St. Pierre et Miquelon coast and have site fidelity to wintering sites (Jacques Whitford 2007; Thomas 2008).

The eastern population of Harlequin Duck is listed on SARA Schedule 1 as a Species of Special Concern and listed as Vulnerable under the Newfoundland and Labrador *Endangered Species Act* (2002). There is a Management Plan for Harlequin Duck conservation for Atlantic Canada and Québec (Environment Canada 2007b).

The goal for the Management Plan is to maintain a wintering population of 3000 Harlequin Ducks in eastern North America for three of five consecutive years. To meet this goal, the Management Plan has established a series of objectives and actions meant to address maintaining population levels and protecting important habitat (Environment Canada 2007b). The objectives identified to meet the management goal is to clarify possible threats to the species and outline a regime(s) to address these issues; assess population status; identify, protect and manage important areas for breeding, moulting, wintering, and staging habitat; work with governments, industry, aboriginal groups, and private citizens to identify the threats to the Harlequin Duck, and work toward eliminating or reducing these threats; identify targeted groups for education and stewardship initiatives on Harlequin Duck issues, and develop appropriate campaigns and programs; conduct gap analysis to determine shortcomings in knowledge of the Harlequin Duck; and engage Greenland in further collaboration with Canada regarding Harlequin Duck conservation.

Threats identified for the Harlequin Duck include pollution (oil/bilge contamination, shipping, oil spills), Insect control programs, habitat loss or degradation (hydro developments, forestry, and mining), accidental mortality as a result of fishery bycatch and aquaculture, disturbances due to aircraft and human activities and illegal hunting (Environment Canada 2007b).

Details of this management plan can be found in the Management Plan for the Harlequin Duck (*Histrionicus histrionicus*) Eastern Population, in Atlantic Canada and Québec. (Environment Canada 2007b). This species could occur off western Newfoundland and coastal area of the Gulf year-round, but are unlikely to be encountered as far offshore as EL 1105.

5.2.2.7 Barrow's Goldeneye

The Barrow's Goldeneye is a medium-sized diving duck that primarily breeds and winters in Canada (SARA 2010), with the majority of wintering occurring in the inner Gulf and the North Shore of Québec. Small numbers (approximately 400 birds) of this population winter in the Atlantic Provinces and along the northern Atlantic coastline in the United States (approximately 100 birds in Maine) (Robert and Savard 2006, in CWS Waterfowl Committee 2008; Schmelzer 2006). Only a small number of birds have been documented at six sites in Newfoundland, including Traytown Bay, Port Blandford, Spaniard's Bay, St. Mary's Bay, Stephenville Crossing and at the mouth of the Humber River near Corner Brook (Schmelzer 2006).

Wintering mostly in marine habitats (bays, inlets, harbours and rocky shores), their winter diet consists of marine molluscs and crustaceans (SARA 2010). The world distribution of Barrow's Goldeneye consists of three separate populations, with approximately 4,500 Barrow's Goldeneye (or 1,400 pairs (based on an estimate of 30 percent of birds are adult females)) in the eastern North America population (Savard and Dupuis 1999; Robert et al. 2003; Robert and Savard 2006). The range of the eastern population is unknown, but data indicate that breeding is exclusive to Canada, with the only confirmed breeding records being from Québec. Barrow's Goldeneye prefer to breed at high elevations on alkaline wetlands around freshwater lakes. Wintering populations in Québec are found on small fishless lakes above 500 m elevation, nesting in tree holes or cavities within 2 to 3 km of a water body (Todd 1963; Robert et al. 1999a, 1999b). Specific population trends are unknown, but it is believed that the eastern population may be declining.

The eastern population of Barrow's Goldeneye is listed as a Species of Special Concern under Schedule 1 of SARA. It is also protected by the *Migratory Birds Convention Act* and is listed as Vulnerable on the Newfoundland and Labrador *Endangered Species Act*. The Newfoundland and Labrador Department of Environment and Conservation has a management plan for Barrow's Goldeneye in Newfoundland and Labrador (Schmelzer 2006).

This species is unlikely to occur in offshore areas of the Gulf, including EL 1105, but as indicated above, will be found in coastal waters of western Newfoundland.

5.2.3 Marine Mammal Species at Risk

There are seven species of marine mammals that could potentially be found in the Gulf and within or near EL 1105 that are considered at risk. The status of these species is presented in Tables 5.1 and 5.2.

5.2.3.1 Blue Whale

The Atlantic population of the blue whale has been listed as endangered under SARA. During spring, summer and fall, the blue whale can be found along the north shore of the Gulf and off eastern Nova Scotia. In the summer, they can also be found off the south coast of Newfoundland and in the Davis Strait. They typically migrate south for the winter, and could migrate through EL 1105. However, they have a tendency to remain in the Gulf during milder winters with light ice cover. A 2007 survey resulted in an estimated abundance of 16 blue whales in the entire Canadian survey (Lawson and Gosselin 2009), with one whale being sighted in the survey portion of the Gulf hat covers the location of EL 1105. They inhabit both coastal and open ocean waters and are frequently observed in highly productive coastal waters where there is an abundance of krill, their primarily food source. Blue whales can dive on average for 5 to 15 minutes after breathing at the water's surface. They mate and give birth during fall and winter in warmer southern waters. The blue whale is one of the largest and loudest (calls of 186 dB) animals in the world (SARA 2010).

The major factor responsible for the reduction in abundance of the blue whale was a result of historical whaling activities. It has been estimated that whaling reduced the blue whale population by approximately 70 percent, and that there are likely only 250 mature blue whales present in the Northwest Atlantic population (Beauchamp et al. 2009). Twelve threats to the north Atlantic blue whale were identified in the 2009 Blue Whale Recovery Strategy and include anthropogenic noise (acoustic degradation and changes in behaviour), food availability, contaminants, collisions with vessels, whale watching, anthropogenic noise (physical damage), accidental entanglement in fishing gear, toxic algal blooms, toxic spills, whaling, ice and predation. Those of highest concern include anthropogenic noise (acoustic degradation and changes in behaviour) and food availability. A number of recovery actions have already been undertaken, including blue whale protection programs and habitat protection measures and awareness, one of which includes the development of the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* (which is an appendix of the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011b)). The goal of this recovery plan is to reach a population of 1,000 mature blue whales and the objectives that were established for the next five years to help meet this goal include, undertaking a long term assessment of the number of northwest Atlantic blue whales and population trends, implementing control and follow-up measures for those activities that could disrupt the recovery of the blue whale and increasing awareness of the potential treats. Details of this recovery plan can be found in the Blue Whale Recovery Strategy Report (Beauchamp et al. 2009).

5.2.3.2 North Atlantic Right Whale

The north Atlantic right whale is a migratory species that typically inhabitants coastal waters and spend their summers feeding in cooler waters and in warmer waters during winters. This species has been listed as endangered under Schedule 1 of SARA. Two stocks of the north Atlantic right whale can be found in Canadian waters, the eastern North Atlantic stock and the western North Atlantic stock. The western North Atlantic stock can be found from the coast of Florida to Newfoundland and Labrador and in the Gulf and could occasionally occur in the vicinity of EL 1105. They feed primarily on zooplankton (SARA 2010).

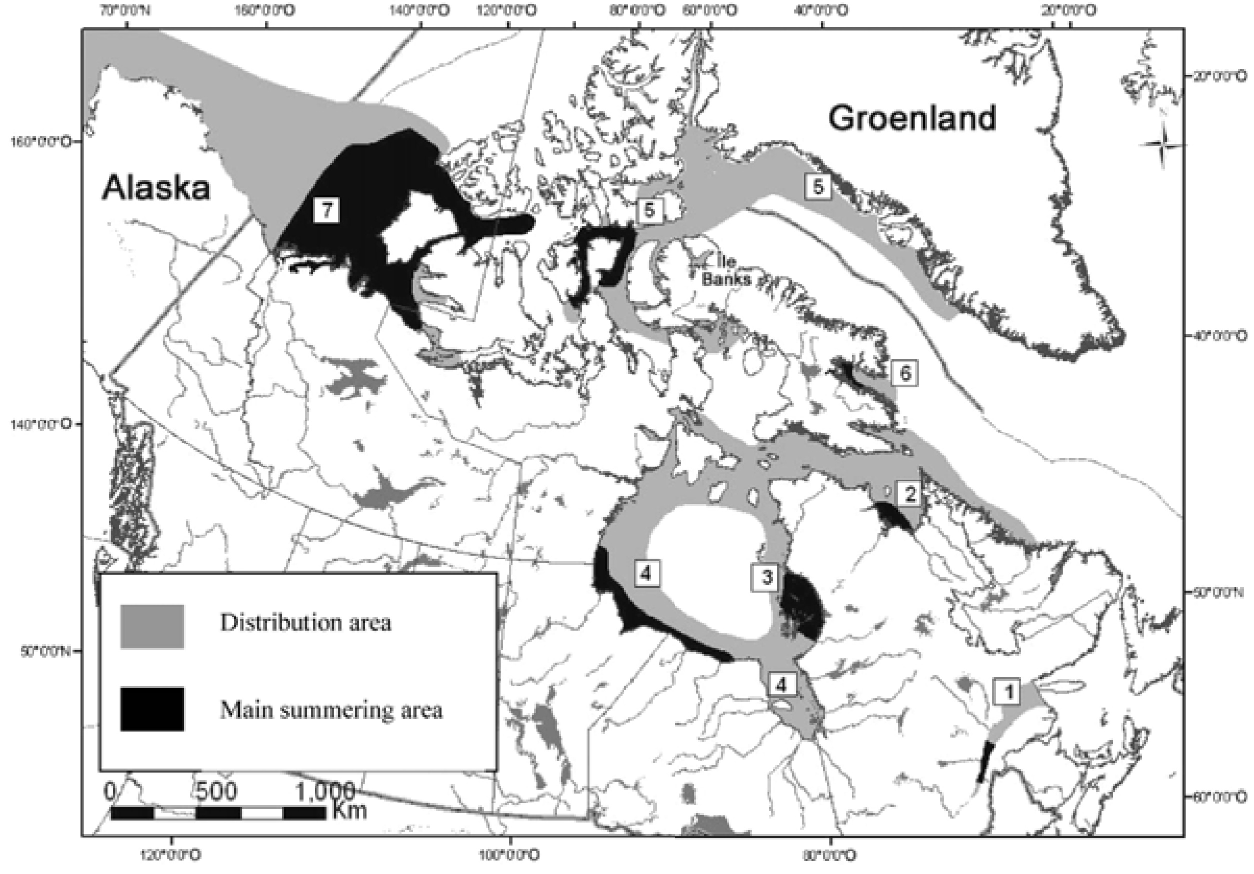
Since commercial whaling has ended, threats to the abundance of the north Atlantic right whale are a result of strikes by vessels and entanglements with fishing gear most commonly, as well as disturbance and habitat reduction (Brown et al. 2009). The 2009 North Atlantic Right Whale Recovery Strategy states that where there is limited knowledge on the actual abundance of this species, long term abundance targets cannot be determined and instead a goal to achieve an increasing tread in population abundance over three generations was identified. The objectives that were identified to meet this goal included: reducing mortality and injury as a result of vessel strikes and fishing gear interactions; reducing injury and disturbance as a result of vessel presence or exposure to contaminants and other forms of habitat degradation; monitoring population and threats; increasing the understanding of life history characteristics, low reproductive rate, habitat and threats to recovery through research; supporting and promoting collaboration for recovery between government and agencies; and developing and implementing educational programs. Details regarding the strategies that are in place to meets such objectives can be found in the North Atlantic Right Whale Recovery Strategy Report (Brown et al. 2009).

5.2.3.3 Beluga Whale

The St. Lawrence Estuary population of the beluga whale has been listed as threatened under Schedule 1 of SARA. This population of the beluga represents the southern limit of the species. Their habitat is generally ice-covered in winter and their summers are spent in warmer, shallow, turbid waters. This species feeds on various types of invertebrates and fish including squid, tube worms, capelin and Greenland and Atlantic cod (SARA 2010). A 2007 survey resulted in an estimated abundance of 893 beluga whales in the Gulf (Lawson and Gosselin 2009) down from historical levels of between 7,800 and 10,100 whales (DFO 2005b; Hammill et al. 2007). Aerial survey data between 1988 and 2005 indicate that the population increased slightly, but not statistically significantly, from 900 whales in 1988 to just over 1,200 in 2005, or approximately 12% of historical levels (Hammill et al. 2007). While the range of this species is generally considered limited geographically to the St. Lawrence River and Estuary, the 2007 survey did include two individual sightings within the main part of the Gulf and off the northwest coast of Newfoundland (Lawson and Gosselin 2009). While no sightings were reported in the area of Gulf where EL 1105 is located, these results do indicate that there is a low possibility that individuals of this species could occur occasionally in the vicinity of the Project.

Adults are distinguished by their white skin with adult beluga weighing up to 1,900 kg and growing to between 2.6 and 4.5 m in length, the female adult’s attain approximately 80% of the male’s length, or up to 3.5 m (Lesage and Kingsley 1998; COSEWIC 2004c). Calves are a greyish brown colour with occasional darker markings. Newborn calves measure 150 cm in length, nearly half the size of the mother, and weigh approximately 78 kg. At two years of age, they will have reached 60 to 65 percent of the mother's length (Lesage and Kingsley 1998). Older juveniles gradually become lighter coloured up to the age of sexual maturity, when they are completely white (Lesage and Kingsley 1998).

Based on their summer distribution, belugas in Canadian territory have been grouped into seven populations (Figure 5.18). The St. Lawrence Estuary belugas (the beluga population which may occasionally be found near EL 1105) live downstream of the densely populated, highly industrialized Great Lakes Region, along a major marine navigation corridor containing a wide range of pollutants. Mitochondrial and nuclear DNA analyses and functional genomic studies reveal that the St. Lawrence belugas are genetically isolated from other Canadian beluga populations (Brennin et al. 1997; Brown Gladden et al. 1999; Murray et al. 1999; de March and Postma 2003). Their lineage suggests their closest relatives are the belugas of the east coast of Hudson Bay (Brown Gladden and Clayton 1993; Brown Gladden et al. 1997; Brown Gladden et al. 1999; COSEWIC 2004c) with genetic analyses suggest that these two groups have been separate for approximately 8,000 years (de March et al. 2002).

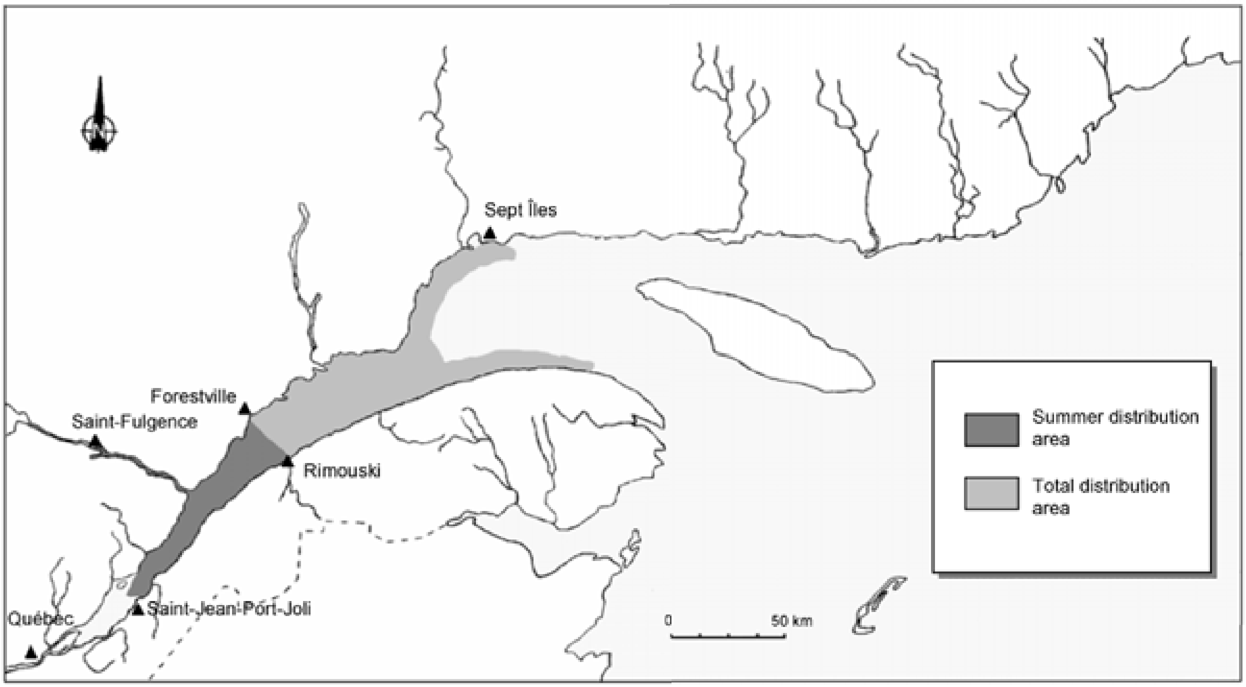


Source: DFO 2011e

Figure 5.18 Location of the Seven Canadian Beluga Populations

The beluga is a typical cold-water marine mammal with winter distribution associated with areas of fast ice where open water provides air access (Barber et al. 2001). In the summer, beluga whales concentrate in specific estuaries, with high site fidelity (Fraker et al. 1979; Finley 1982). In the St. Lawrence Estuary, belugas tend to gather in certain areas more regularly than others (DFO 2011e).

The total distribution area of the St. Lawrence Beluga population is smaller than it used to be, covering a territory of over 8,000 km² in the St. Lawrence Estuary, the Gulf of St. Lawrence, and the Saguenay River (DFO 2011e). The current summer distribution zone, which has changed very little in the last 20 years, is only a portion of what it was historically (Lesage and Kingsley 1998; Gosselin et al. 2007). The population is concentrated at the mouth of the Saguenay River, where it occupies an area of 2,000 km² extending from the Battures aux Loups Marins across from Saint-Jean-Port-Joli to Rimouski on the south shore of the St. Lawrence River and Forestville on the North Shore (Figure 5.19). Approximately 30 belugas over the last several years have been sighted in the Estuary east of Rimouski and Forestville and in the area of Sept-Îles, suggesting a wider distribution than was previously thought (Gosselin et al. 2007). The summer distribution into the Saguenay River extends from the mouth of the river to Saint-Fulgence.



Source: DFO 2011e

Figure 5.19 Present Distribution Area of the St. Lawrence Beluga (adapted from Michaud 1993)

Sightings are rare in spring and fall, and while uncertain, the distribution in these seasons is thought to be similar to that for summer (DFO 2011e). This population is partially migratory, moving to the northwest sector of the Gulf of St. Lawrence in the winter (Lesage and Kingsley 1998; DFO 2011e). Occasional sightings, along with aerial surveys conducted in 1989 and 1990, suggest that the winter distribution area extends downstream into the Gulf, all the way to

Sept-Îles on the North Shore and small groups have also been sighted in the Estuary up to Rivière-du-Loup. It is likely that the winter distribution varies from year to year, depending on ice conditions. In early spring, belugas can be found off the Gaspé Peninsula upstream as far as the Battures aux Loups Marins (DFO 2011e).

In September 2011 (DFO 2011e), a proposed recovery strategy for the St. Lawrence Estuary population was released. The following six recovery objectives have been identified, reduce contaminants in belugas, their prey, and their habitat that could prevent population recovery; reduce anthropogenic disturbances; ensure adequate and accessible food supply; mitigate the effects of other threats to population recovery; protect beluga habitat throughout the entire distribution range; and ensure regular monitoring of the St. Lawrence Estuary beluga population. Numerous critical, necessary and beneficial recovery strategies have been put identified and include the following that may pertain to offshore development in the Gulf (DFO 2011e) and include the development of new regulations or fully apply existing regulations to control the discharge of toxic pollutants into the environment, especially new contaminants; determine the short- and long-term effects of chronic and acute forms of disturbance; study the impacts of noise pollution on belugas; reduce anthropogenic disturbances in high-use areas; and develop and implement adequate protective measures for all inshore and offshore projects that could have an impact within the beluga distribution area.

The recovery strategy (DFO 2011e) identified threats as historic, current (population and individuals) and occasional or sporadic. Hunting and harassment were identified as historic threats. Current threats to the beluga population included longterm contaminant exposure, marine traffic, marine life observations (including ecotourism activities), noise (included noise associated with offshore oil and gas activities, marine traffic, fisheries and ecotourism and recreation), reduced prey abundance (due to overfishing, habitat degradation, pollution, barriers to migration and climate change), predator competition, commercial fisheries competition, habitat degradation (construction and dredging, hydroelectric projects, offshore oil and gas) and the introduction of exotic species. Current threats to individual belugas were identified as ship strikes, entanglement in fishing gear and scientific research. Occasional or sporadic threats were identified as toxic spills, harmful algal blooms, and epizootic disease. Under toxic spills it was noted that oil exploration and development can considerably increase the risk of accidents and spills in the Gulf (Kingston 2005) and that given the relatively limited habitat available in the St. Lawrence Estuary and Gulf, a large oil spill poses a serious risk for the beluga population.

Details regarding the strategies that are in place to meets such objectives can be found in the Recovery Strategy for the Beluga Whale (*Delphinapterus leucas*) St. Lawrence Estuary population in Canada (Proposed) (DFO 2011e).

5.2.3.4 Northern Bottlenose Whale

The northern bottlenose whale is confined to the waters of the northern Atlantic Ocean. COSEWIC recently (May 2011) assessed the Davis Strait-Baffin Bay-Labrador Sea population of Northern Bottlenose Whale as Special Concern. The area is within the known range of the northern bottlenose whale and there have been several sightings of this species in deep waters north and south of the Grand Banks. The whale's life history is poorly known and most records from Newfoundland are based on carcasses washed ashore. Known to submerge for long periods, feeding mainly on squid, this species is often curious about boats and attracted to engine and mechanical noises (Proctor and Lynch 2005). It is locally common in "The "Gully" area north of Sable Island, Nova Scotia, but otherwise sparse throughout the southern part of its range. It is uncertain as to which population the individuals sighted in the Gulf would belong. Any occurrence in the vicinity of EL 1105 would be rare.

The Scotian Shelf population of the northern bottlenose whale has been listed as endangered under Schedule 1 of SARA. The Scotian Shelf population is largely found in and around the Gully. These whales are non-migratory, are never seen in water less than 800 m deep and differ greatly from other northern bottlenose whales found in other populations (SARA 2010). Currently, there is no population estimate for the entire North Atlantic population of the northern bottlenose whale, and it is believed that the Scotian Shelf population represents an extremely small portion of the entire North Atlantic population. The Scotian Shelf population is also considered to be an isolated population with localized movements. Sightings data indicate that this population may have 163 individuals (DFO 2010d). The major threats to the abundance of the northern bottlenose whale include impacts from historical whaling, entanglement with fishing gear, oil and gas activities, acoustic disturbance, contaminants, changes to food supply and vessel strikes. The goal of the northern bottlenose recovery strategy is to achieve a stable or increasing population and to maintain, at a minimum, current distribution (DFO 2010d). The following objectives have been identified to help reach this goal including: improving the understanding of the northern bottlenose whale ecology; improving the understanding of this species population abundance and trends; improving the understanding of and monitoring of anthropogenic threats; and engaging the public and stakeholders through education.

Details regarding the strategies that are in place to meets such objectives can be found in the Recovery Strategy for the Northern Bottlenose Whale, Scotian Shelf population, in Atlantic Canadian Waters (DFO 2010d).

COSEWIC recently assessed the Davis Strait-Baffin Bay-Labrador Sea population of Northern Bottlenose Whale as Special Concern (DFO 2011f). The northern bottlenose whale is confined to the waters of the northern Atlantic Ocean, with population centres off the Davis Strait / northern Labrador, Nova Scotia (a distinct population), Iceland (to which the Davis Strait / northern Labrador population is genetically linked (COSEWIC 2002)) and Norway (Reeves et al. 1993). trends in population size since then are uncertain but Survey sighting rates have been low, so there are no population size trends nor abundance estimate (COSEWIC 2002). The major threats to the abundance of the northern bottlenose whale include impacts from historical whaling, entanglement with fishing gear, oil and gas activities, acoustic disturbance, contaminants, changes to food supply and vessel strikes. More survey effort is needed to fully describe the distribution and abundance of northern bottlenose whales in Canada, particularly in the northern part of its distribution and around Newfoundland (DFO 2011f).

Because of the low sighting of this species and deep water distribution (normally greater than 500 m with most caught at depths greater than 1000 m (DFO 2011f), it is unlikely to occur in western Newfoundland or in the vicinity of EL 1105 (Table 5.2).

5.2.3.5 Fin Whale

The Atlantic population of the fin whale has been listed of special concern under SARA. This species tends to make seasonal migrations from low latitude areas during the winter to high latitude summer feeding areas. Summer concentrations of the fin whale can be found in the Gulf, on the Scotian Shelf, in the Bay of Fundy, in the nearshore and offshore waters of Newfoundland and Labrador (COSEWIC 2005b) and thus could be present in EL 1105. Little is known about their overwintering or breeding areas. A 2007 survey resulted in an estimated abundance of 28 fin whales in the Gulf (Lawson and Gosselin 2009), with no individuals observed in the portion of the Gulf in which EL 1105 occurs.

5.2.3.6 Harbour Porpoise

The Northwest Atlantic population of the harbour porpoise is widely distributed over continental shelves and is made up of three sub-populations found in Canadian waters, Newfoundland-Labrador, Gulf and the Bay of Fundy / Gulf of Maine. A 2007 survey resulted in an estimated abundance of 3,629 harbour porpoise in the Gulf and Scotian Shelf combined (Lawson and Gosselin 2009); fifteen individuals were sighted in the survey portion of the Gulf that includes EL 1105. This population of the harbour porpoise has been designated as of special concern under COSEWIC. This species is well adapted to cold water and often inhabits bays and harbours during summer. They feed upon a variety of small fishes including cod, herring, hake, capelin and sand lance (SARA 2010).

5.2.3.7 Killer Whale

The Northwest Atlantic population of the killer whale is designated as special concern under COSEWIC. While these whales were historically considered common in the Gulf and St. Lawrence Estuary, they are now sighted only occasionally (Lesage et al. 2007, in COSEWIC 2008b). They are seen in nearshore waters of Newfoundland, particularly in the Strait of Belle Isle (Lawson et al. 2007, in COSEWIC 2008b). While no killer whales were sighted in the Gulf during a 2007 survey (Lawson and Gosselin 2009), EL 1105 does occur on the periphery of their documented range and therefore may be expected to occur occasionally in this area. The distribution of this species seems to be dependent on the availability and accessibility of their prey. The killer whale can withstand significant changes in salinity, temperature and turbidity.

5.2.4 Sea Turtles

There are two species of sea turtles that occur in the Gulf and could potentially be found within or near EL 1105 that are considered at risk. The status of these species is presented in Tables 5.1 and 5.2.

5.2.4.1 Leatherback Sea Turtle

The leatherback sea turtle is a migratory turtle that breeds in tropical and subtropical waters and feed in temperate waters. The leatherback turtle has been listed as endangered under Schedule 1 of SARA. These turtles spend the majority of their life at sea but do come ashore to nest and lay eggs. Leatherback turtles nest from November to April and are typically present in

Canadian waters from June to November to forage (Atlantic Leatherback Turtle Recovery Team 2006). As indicated in COSEWIC (2001), leatherbacks have been recorded off the coasts of Nova Scotia, Newfoundland and Labrador, with sightings in the Bay of Fundy, the Northumberland Strait, and the Gulf. Fishermen in Prince Edward Island have reported sightings and a small number of coastal strandings have occurred. Leatherbacks also have been reported in the Gulf off Québec. They may occur in the vicinity of EL 1105, feeding on jellyfish. While there are a number of factors leading to their decline (i.e., a long lifespan, very high rates of egg and hatchling mortality, and a late age of maturity), the major source of mortality in Canadian waters is incidental capture in fishing gear (COSEWIC 2001).

The recovery goal is to “achieve the long-term viability of the leatherback turtle populations frequenting Atlantic Canadian waters”. The objectives to reach this goal are to understand the threats to leatherbacks in Atlantic Canadian waters; acquire further information to improve the general knowledge of the species and its habitat; take further steps to identify critical habitat so that it may be protected; reduce the risk of harm to leatherback turtles from anthropogenic activities; educate stakeholders and the general public on ways to support recovery; and work collaboratively at an international level to further recovery. Identify threats to this species include fishing gear entanglement, marine vessel collisions, marine pollution, acoustical disturbances (oil and gas exploration and development, shipping, fishing, military activity, underwater detonations, and shore based activities), poaching, coastal construction, artificial light, climate change, beach erosion, nest predation, beach driving, beach cleaning, beach mining, and exotic vegetation (Atlantic Leatherback Turtle Recovery Team 2006).

Details regarding the strategies that are in place to meets such objectives can be found in the Recovery Strategy for Leatherback Turtle (*Dermochelys coriacea*) in Atlantic Canada. (Atlantic Leatherback Turtle Recovery Team 2006).

5.2.4.2 Loggerhead Sea Turtle

The loggerhead sea turtle is the largest hard-shelled turtle in the world and the most abundant in North American waters. Globally, there are an estimated 43,000 to 45,000 nesting females (Spotila 2004). Its distribution is largely constrained by water temperature and it does not generally occur where the water temperature is below 15°C (Brazner and McMillan 2008). There are limited estimates of the density of loggerhead turtles offshore western Newfoundland (LGL 2005b). Loggerheads can migrate considerable distances between near-equatorial nesting areas that are occupied from late April to early September (Spotila 2004) and temperate foraging areas, some moving with the Gulf Stream into eastern Canada waters during the summer and fall (Hawkes et al. 2007). Information to date indicates a seasonal population of juvenile loggerheads in Atlantic Canada (Witzell 1999; COSEWIC 2010e) but the number occurring in Canadian waters is unknown. While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004); there is no diet information available for Canadian waters (DFO 2010e). 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 (COSEWIC 2010e). The loggerhead sea turtle was designated as endangered under COSEWIC in April 2010. This species is threatened by commercial fishing activities, loss and degradation of nesting beaches, marine debris, chemical pollution and illegal harvesting of eggs and nesting females (COSEWIC 2010e).

5.3 Marine Ecosystem

The Gulf is divided into two zones, the northern and southern Gulf (which includes the Magdalen Islands, as well as New Brunswick, Nova Scotia and Prince Edward Island). Within each of these zones, fish habitat is divided into two areas, the shelf areas and the deep channels. The shallow waters along the shelf areas are characterized by warm, high productivity waters in the summer, and serve as feeding, nursing and spawning grounds for both demersal and pelagic fish. The shallow waters surrounding the Magdalen Islands support high densities of American plaice and Atlantic cod. These species are the most dominant demersal fish found in the southern Gulf (Doufour and Ouellet 2007). The highly productive, warm water areas also serve as important feeding areas for marine fish that migrate to the area looking for food, such as spiny dogfish and bluefin tuna.

A comprehensive review of the western Newfoundland offshore area in the Gulf was completed for a SEA in 2005 (LGL 2005b) and amended in 2007 (LGL 2007). The SEA (and subsequent amendment) study area was located immediately adjacent to the Old Harry Prospect and as such, these SEA documents provide a thorough assessment of the coastal and marine Gulf regions under consideration for the current Project. Where appropriate, specific report sections of the Western Newfoundland SEA documents are cross-referenced.

The fish and shellfish habitat supported in EL 1105 is characteristic of the Laurentian Channel. Oceanographic characteristics have been discussed in Section 4.2, and physical habitat features have been described at the beginning of the current section. As in most marine environments, the distribution of the majority of fish and shellfish species listed in Section 5.4 for the Gulf and EL 1105 varies temporally and spatially based on habitat needs at different life history stages.

5.3.1 Coastal Habitats

The rocky shores in western Newfoundland (and for that matter in the Gulf) can be classified as primary coasts, such that primary structural characteristics have been determined by natural processes, mainly erosion and tectonic forces caused by glacier activity and historic plate movements, respectively. Many organisms live within the coastal habitats, specifically within the tidal and subtidal zones. An abundance of plant life is present, various species of cyanophyta, seaweeds, lichens and to a lesser extent saline-tolerant species such as seaside plantain.

The focus of this section on coastal habitats will encompass the aquatic portion of the tidal and subtidal zones and as such, the primary producers will be phytoplankton (discussed in Section 5.4.3.1) and macrofloral algal seaweeds and aquatic vascular plants.

5.3.1.1 Algal Communities

Algal seaweed species are generally differentiated by color and fall within either the red, brown or green algal community. Typical species found within the tidal and subtidal zones based on wave action and substrate characteristics are located in Tables 5.3 and 5.4 from South (1983, in LGL 2005b).

Apart from being the primary producers in the coastal environment, algal seaweed species provide shelter and food for marine fauna. Species anticipated to inhabit coastal areas include mollusks, worms, crustaceans, echinoderms and fish. Commercially-sensitive species that may at some life stage inhabit or pass through coastal areas are described in Sections 5.4 and include whelks, northern shrimp, rock crab, lobster, Atlantic herring, Atlantic mackerel, pollock, white hake and Atlantic salmon.

Table 5.3 Algal Species Associated with Intertidal and Subtidal Areas in Western Newfoundland

Wave Exposure	Typical Algal Invertebrate Species		
	High Water Mark to 5 m	**5 to 20 m**	**>20m^A**
Low	Maritime lichens Cyanophyta *Bangia atropurpurea* *Fucus vesiculosus* *Balanus balanoides* *Ascophyllum nodosum* *Mytilus edulis* *Bonnemaisonia hamifera*	*Laminaria longicruris* *Phyllophora* sp. *Agarum cribrosum* *Laminaria solidungula*	*Phyllophora* sp. *Agarum cribrosum* *Lithothamnium tophiforme* *Phymatolithon laevigatum* *Laminaria longicruris* *Laminaria solidungula*
Moderate	Maritime lichens *Pilayella littoralis* *Bangia atropurpurea* *Chordaria flagelliformis* *Chorda filum* *Phyllophora* sp. *Alaria esculenta* *Saccorhiza dermatodea*	*Lithothamnium glaciale* *Desmarestia* sp. *Agarum cribropsum* *Laminaria longicruris* *Phyllophora* sp.	*Phylophora* sp. *Lithothamnium glaciale*
High	Cynophyta *Pophyra* sp. *Bangia atropurpurea* *Pilayella littoralis* *Chordaria flagelliformis* *Alaria esculenta* *Sacchorhiza dermatodea* *Lithothamnium glaciale*	*Clathromorphum circumscriptum* *Lithothamnium glaciale* *Laminaria longicruris* *Agarum cribrosum* *Phyllophora* sp.	*Ptilota serrata* *Phyllophora* sp.

Source: South 1983, in LGL 2005b.
^{A} 20 to 40 m for low exposure; 20 to 25 m for moderate and high exposure.

Table 5.4 Algal Species and Associated Substrate Type

Substrate Type	Typical Algal Species	
	High Water Mark to 5 m	5 to 10 m
Hard (including pebbles and boulders)	Maritime lichens Cyanophyta *Enteromorpha* sp. *Fucus vesiculosus* *Ascophyllum nodosum* *Ahnfeltia plicata* *Chorda filum* *Phymatholithon laevigatum*	*Laminaria longicruris* *Phymatolithon laevigatum* *Clathromorphum circumscriptum* *Lithothamnium glaciale*
Sand / Mud	*Spartina* sp. *Plantago* sp. Cyanophyta *Enteromorpha* sp. *Zostera marina* *Ascophyllum nodosum* *Fucus vesiculosus* *Ahnfeltia plicata* Benthic diatoms *Chaetomorpha* sp.	*Zostera marina* *Laminaria longicruris* *Ahnfeltia plicata*
Source: South 1983, in LGL 2005b.		

5.3.1.2 Eelgrass Community

A vascular species of the aquatic macrophyte, eelgrass (*Zostera marina*) is of ecological importance as beds of eelgrass support a high biodiversity of species, provide refuge for small species of fish, a food source for migrating and overwintering waterfowl and play a role in the global climate and ocean cycles. As such, eelgrass is also protected by law, under the *Fisheries Act*, based on its high value for fisheries species. Eelgrass and other seagrass populations worldwide are indicator species (i.e., loss of seagrass is indicative of anthropogenic stress) (DFO 2009d).

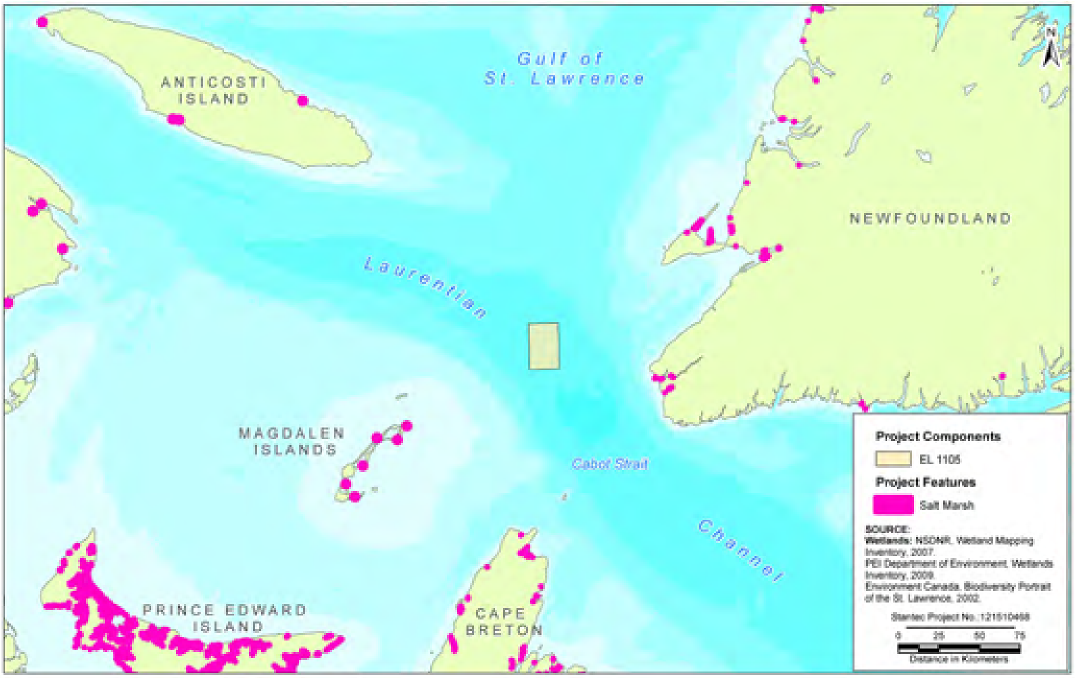
The following data are taken from DFO's distribution and description of eelgrass beds in Québec (DFO 2009e) and indicate eelgrass beds are prevalent in coastal Québec and the Magdalen Islands, representing upwards of 9,380 ha of coastal habitat. The Magdalen Islands harbour some of the eelgrass beds closest in proximity to EL 1105. In the Magdalen Islands, eelgrass beds tend to flourish within the subtidal zones of all inshore waters, with the largest beds in Lagune de la Grande Entrée, Lagune du Havre aux Maisons, Lagunes du Havre aux basques, Bassin aux Huitres and Baie du Bassin.

Other scattered eelgrass beds proximal to EL 1105 occur in Newfoundland and are greatest along the southwest coast, including large beds distributed along the western coast (DFO 2009d). Eelgrass in Prince Edward Island is also distributed commonly in the bays and estuaries. The Maritime Wetland Inventory (CWS, Environment Canada) estimates over 30,000 ha of eelgrass beds in Prince Edward Island, with 20,000 ha in each of New Brunswick and Nova Scotia (Environment Canada no date). In Prince Edward Island, large eelgrass beds are located within St. Mary's Bay, Hillsborough River, Bedeque River, Cascumpec Bay and Rustico. Eelgrass beds in New Brunswick are generally located within estuaries and lagoons along the Gulf and most notably in Kouchibouguac, Richibucto, Cocagne and Baie Verte. In Nova Scotia, the eelgrass beds are fairly evenly distributed along the Northumberland Strait and the Atlantic coast (DFO 2005e).

5.3.1.3 Salt Marsh Community

Salt marshes are salinoclines between freshwater and marine waters that support a variety of halophytic plants and organisms. They form within stable and emerging coastlines where sediment accumulates within sheltered intertidal areas. Cord grass (*Spartina* spp.) colonization plays an important role in the accumulation of sediments through the reduction in currents and stabilization of the substrate with their large root structures. Within Atlantic Canada, salt marshes are generally distributed among estuaries, protected bays and sheltered areas inland of spits, bars or islands. Salt marshes are generally divided into two types; low marshes and high marshes, each with a distinct plant community. The low marsh (as its name implies) is topographically lower than the high marsh and the plant community is mostly comprised of cord grass, rockweed, glasswort (*Salicornia* spp.), sea-blite (*Suaeda linearis*), seaside sand spurrey (*Spergularia villosa*) and orach (*Atriplex* spp.). These species tend to be more tolerant of tidal fluctuations. Within the high marsh, conditions are drier and marsh hay dominates the landscape with other halophytes, such as sea-lavender (*Limonium* spp.), arrow grass (*Triglochin* spp.), seaside plantain (*Plantago maritima*) and milkwort (*Polygala* spp.) with various grasses and sedges.

Salt marshes in closest proximity to the Study Area include those found in the Magdalen Islands, western Newfoundland and Cape Breton. In Cape Breton, marshes along the Northumberland Strait are often well developed, with 625 ha of salt marsh present in Victoria and Inverness counties, and large marshes located within Margaree Harbour and St. Annes Bay (Nova Scotia Museum of Natural History, undated). In the Magdalen Islands, the salt marshes are intertidal wet meadows dominated by sedges and bulrushes and flooded only at high tide. Nearly half of the 1,400 ha of salt marshes on the Magdalen Islands are located on the shores of East Pond. Other large marshes are located in the southern part of Havre-aux-Basques Bay and along the sand bars bordering the lagoons. These marshes developed before the closure of the bay in 1956 (Gagnon 1998). In Newfoundland, the topography limits the creation of salt marshes along the southwestern coastline and only 2,200 ha were identified. These marshes were concentrated in St. Georges Bay, Port-au-Port Bay and Cox's Cove. The distribution of identified salt marshes in the region of the Gulf (and closest to EL 1105) is illustrated in Figure 5.20.



Source: DFO 2011g

Figure 5.20 Salt Marsh Distribution in the Gulf of St. Lawrence in Relation to EL 1105

5.3.2 Marine Habitats

Fish and shellfish distribution varies seasonally in response to physical or chemical changes in the surrounding environment (e.g., depth, salinity, temperature), and as a result of seasonal habitat requirements (e.g., feeding, spawning, rearing). Long annual migrations are undertaken by most pelagic species such as herring and mackerel, and groundfish species such as Atlantic cod. The eggs of benthic spawners are found where oceanographic factors and bottom substrates are suitable, ranging from the marine sponges used by sea ravens to the hard, rocky substrate (and solid objects resting on the substrate) preferred by lumpfish. Other fish spawn in open water (e.g., pollock and wolffish), making the offshore, open ocean important habitat. Juvenile fish often require habitat that allows them to hide from predators. In this case, even scallop shells can function as protective habitat (e.g., hake).

During the winter, the waters in the shelf areas become cold and tend to freeze, resulting in the majority of the marine fish that feed in these areas during the summer migrating out of the area for the winter and into deeper waters. Spiny dogfish and mackerel migrate completely out of the Gulf to more southern areas, whereas other species including Atlantic herring, Atlantic cod, white hake, American plaice, witch flounder and thorny skate stay within the Gulf, moving into the deeper, warmer waters of the Laurentian Channel and slope. Some of these species remain in this area for the entire winter, while others (Atlantic cod and Atlantic herring) migrate to the entrance of the Laurentian Channel in the Cabot Strait (Dufour and Ouellet 2007). The warmer, deep waters of the Laurentian Channel and slope also serve as feeding, nursing and spawning grounds for certain deep-water and slope species, including redfish, Greenland halibut and witch flounder. Hence, they do not need to migrate during the winter to avoid harsh conditions (Dufour and Ouellet 2007).

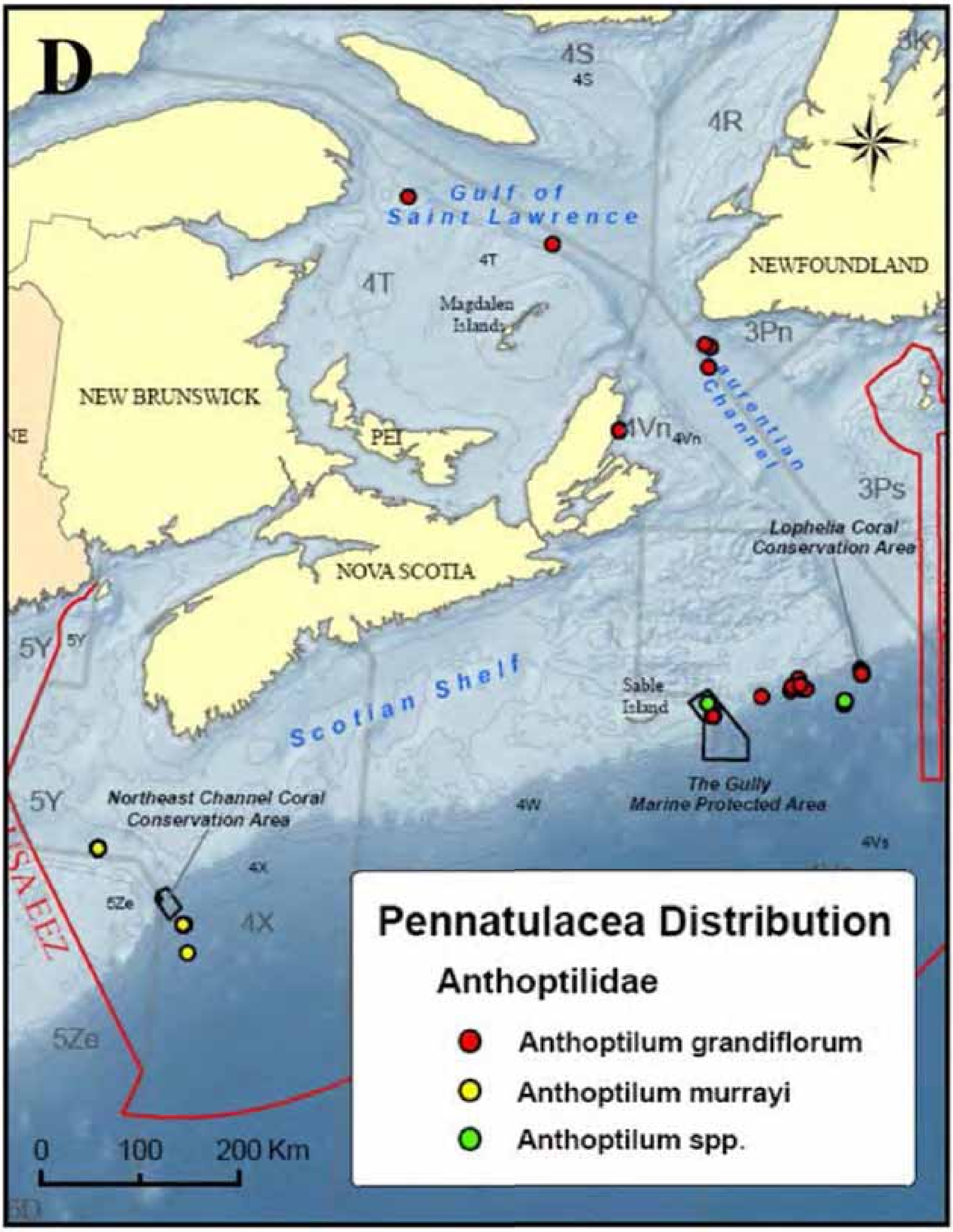
5.3.3 Deep-Water Corals and Sponges

Sea pens (*Anthoptilum grandiforum*) were present but not common in EL 1105 (as described in Section 5.3.2). Sea pens (Order Pennatulacea) are colonial animals containing many polyps, each with eight tentacles. They are not true stony or soft corals but are grouped with octocorals (polyps having eight tentacles) that include sea whips and sea fans (Order Gorgonacea), organ-pipe 'corals' (Order Stolonifera), blue 'corals' (Order Heliporacea) and the true soft corals (Order Alcyonacea). Soft corals contain soft fleshy or leathery tissue and do not possess a hard skeleton like stony corals that build reefs. *Anthoptilum grandiforum* (observed infrequently in the vicinity of the Project) is relatively common elsewhere in the Laurentian Channel and off the Scotian Shelf, as illustrated in Figure 5.21.

Wareham and Edinger (2007) noted that sea pens were generally distributed along the edge of the Continental Shelf east of Baffin Basin, off southeast Baffin Island, Tobin's Point, the Flemish Cap and the southwest Grand Bank. Eleven species of sea pens were identified, with the greatest diversity of sea pens found near the southwest Grand Bank. The sea pens were found at depths between 96 to 1,433 m and ranged in size between 10 to 80 cm, with *Anthoptilum grandiflorum* and *Pennatula phosphora* (not observed near the Project) being the most abundant.

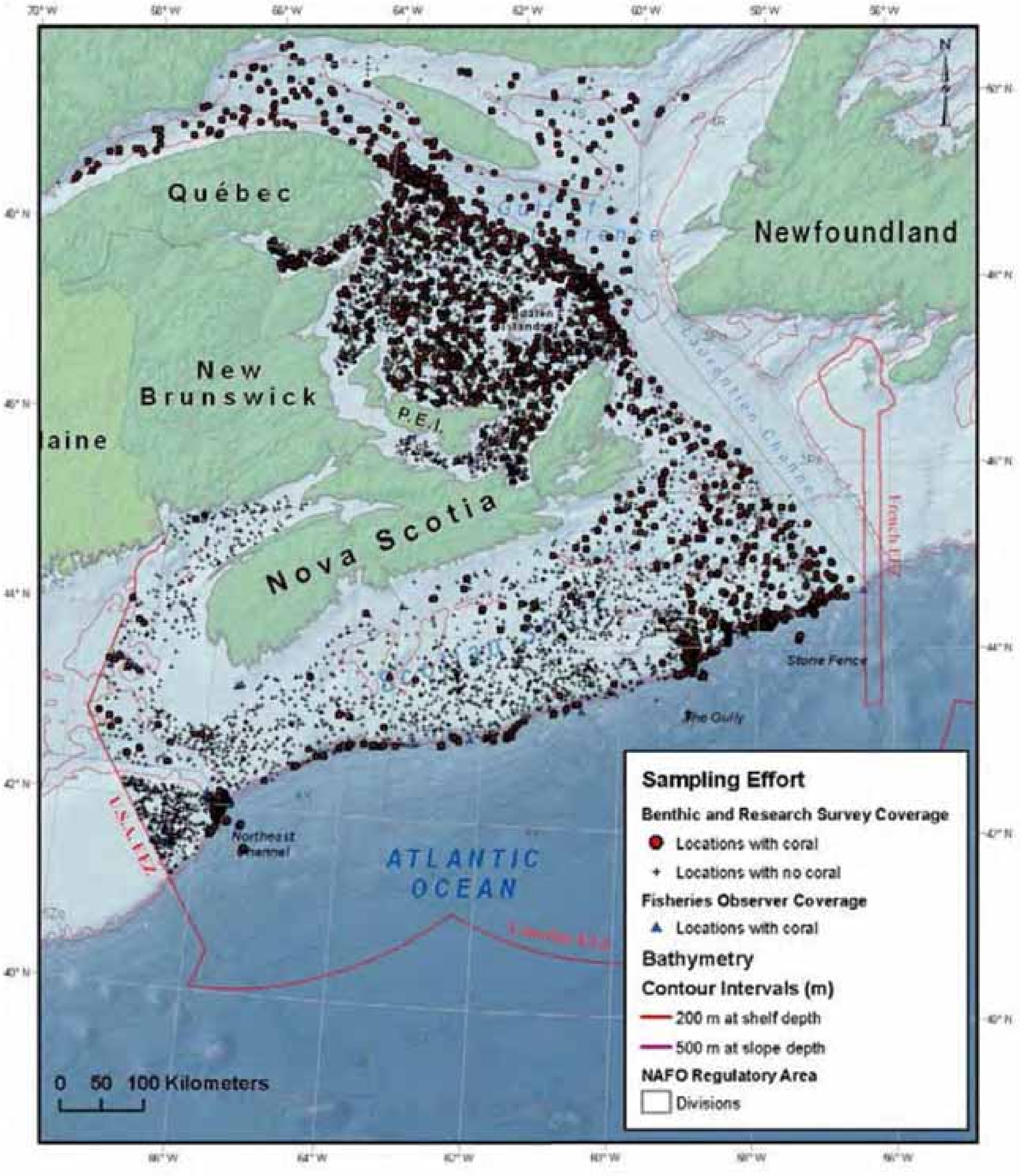
The underwater videography of benthic habitat collected during the October 2010 geohazard survey did not identify the presence of any deep-water corals or sponges, only sea pens as noted above. Most of the corals and sponges that were noted from fishery observer programs and DFO research (Campbell and Simms 2009; Gilkinson and Edinger 2009) appear not to be concentrated near EL 1105 or the Laurentian Channel within the Gulf (Figures 5.22 and 5.23) (note: there are no data on presence / absence of corals and sponges within the Laurentian Channel outside the Gulf).

Deep-water corals (also referred to as cold-water corals since water depth is not a limiting factor in their distribution) are generally found attached to hard substrate such as bedrock, boulders and rubble, and some species on gravel beds, but not on unconsolidated sediment such as sand, silts, clays and mud as present in EL 1105. The report by LGL (2007) indicates that "*In general, the low abundance of corals in the Laurentian Channel (other than the Stone Fence at the southern end of the Laurentian Channel) probably reflects the low cover of cobble and boulder in the area (Mortensen 2006).*" The Stone Fence Coral Conservation Area in the Laurentian Channel is located past Cabot Strait and closer to the Scotian Shelf and the Atlantic Ocean and is in NAFO Division 4Vs at a depth of approximately 2,500 m (refer to Figures 5.22 and 5.23). Deep-water corals also require relatively higher water current speeds to survive and where they need to feed on plankton and are therefore generally found along continental slopes and shelves (particularly on the flanks of banks). The water current data in Section 4.2 indicate that the bottom currents approximately 60 km from EL 1105 are relatively weak, and the seabed relatively flat and at a distance from the slope of the Laurentian Channel. These factors suggest that the area for which the Project is planned is not a favourable habitat for deep-water corals and likely for sponges as well, since they too depend on plankton for food.



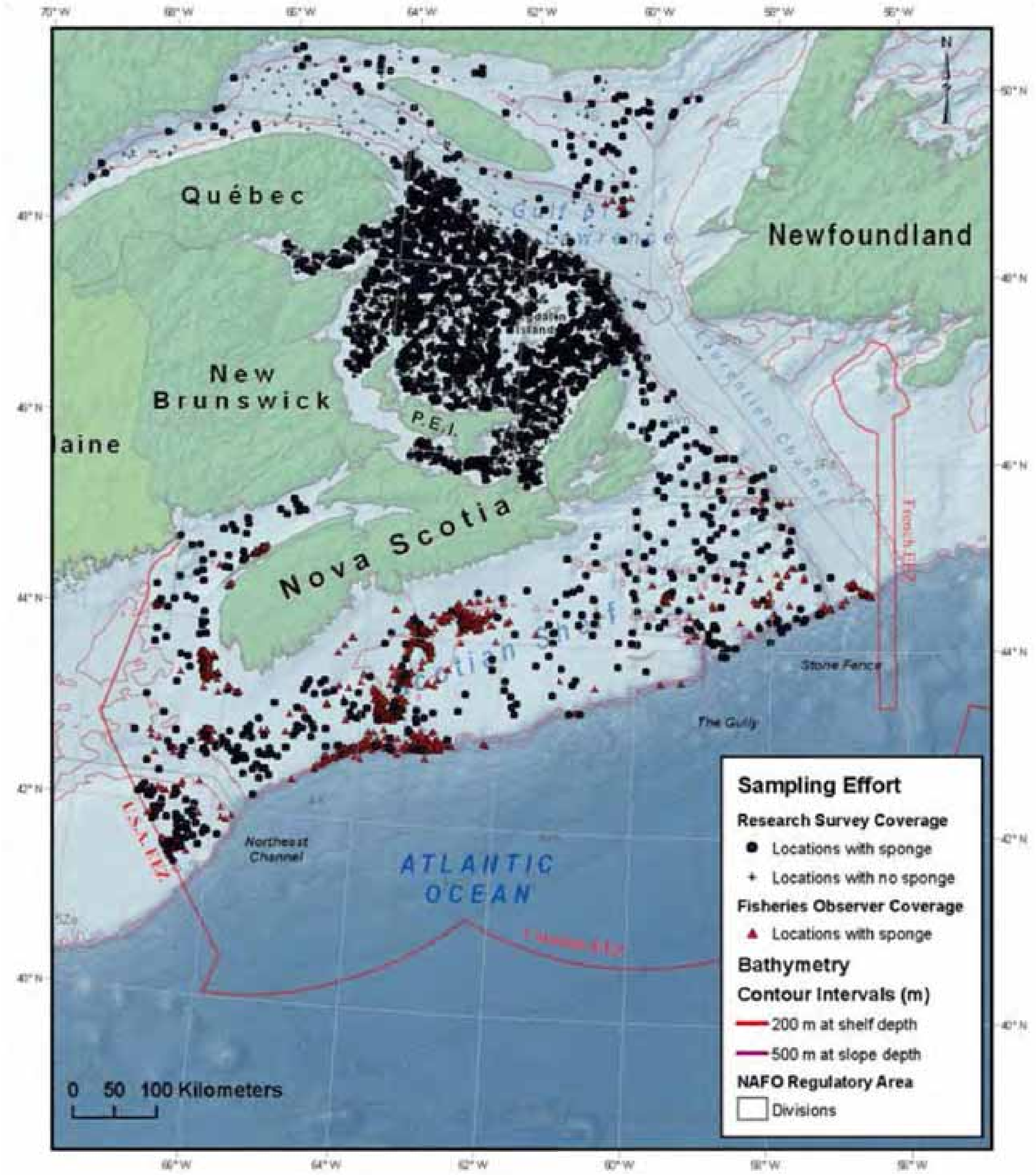
Source: from Cogswell et al. 2009.

Figure 5.21 Other Known Locations of the Sea Pen, *Anthoptilum grandiflorum*, in the Gulf of St. Lawrence, Laurentian Channel and Scotian Shelf



Source: from Cogswell et al. 2009.

Figure 5.22 Location of Cold-water Corals on the Scotian Shelf and in the Gulf of St. Lawrence



Source: from Cogswell et al. 2009.

Figure 5.23 Location of Sponges on the Scotian Shelf and in the Gulf of St. Lawrence

5.3.4 Plankton

Plankton are the very small (often microscopic), free-floating organisms that live suspended in the water column. Physical processes, such as water currents and turbulent mixing, often control the distribution of plankton. Plankton are the productive base of marine ecosystems. Phytoplankton (often unicellular algae) are the autotrophic component of plankton, whereas zooplankton are the heterotrophic component of plankton. Plankton are an integral part of the ocean food chain; phytoplankton are eaten by zooplankton, which are, in turn, eaten by larger organisms. Plankton are therefore a major factor in influencing the biodiversity and productivity of marine habitats. Recognizable areas of enhanced plankton production may therefore suggest potentially important areas for fish, marine birds, marine mammals and sea turtles.

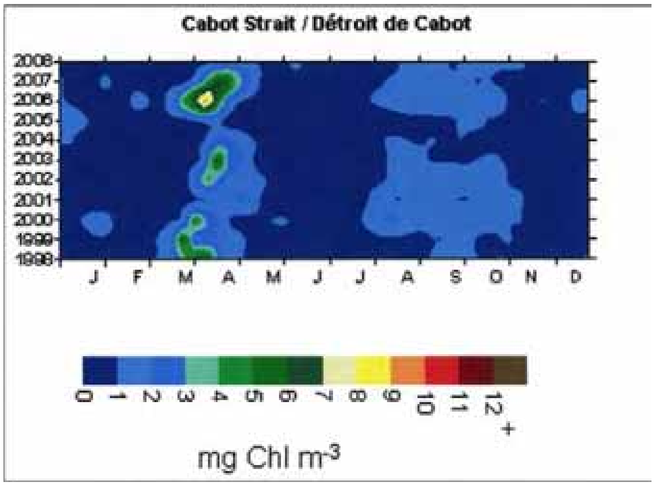
Information on plankton in the Gulf and in the vicinity of EL 1105 was compiled based on available data and scientific publications. Reports and data sources include DFO's Atlantic Zone Monitoring Program, where field studies and data collection began in 1998 and is ongoing, Sciences Advisory Reports and data from various publications in the scientific literature. The Atlantic Zone Monitoring Program (AZMP) conducts sampling at seven fixed stations and 13 transect locations (sections) in the Estuary and Gulf and generally during the spring and fall seasons (DFO 2011h). The transect line across Cabot Strait (identified as TDC in the AZMP program) is of most relevance because it spans across the Laurentian Channel between Newfoundland and Cape Breton Island and is situated approximately 70 km southeast of EL 1105. General water flow through EL 1105 and water properties would likely resemble those at Cabot Strait. Therefore, although there are no available data specifically for EL 1105 and its immediate vicinity, a comparable plankton community structure can be expected and is described in the following sections.

The AZMP also use data from satellites (primarily those with the SeaWiFS and MODIS sensors) to obtain synoptic spatial coverage for oceanographic variables such as temperature, chlorophyll as an indicator of phytoplankton biomass and ice conditions.

5.3.4.1 Phytoplankton and Primary Production

Phytoplankton consist of free-floating algae, protists and cyanobacteria. Phytoplankton form the beginning of the food chain for aquatic animals and fix large amounts of carbon through photosynthesis. Chlorophyll is the green molecule in plant cells that carries out the bulk of energy fixation in the process of photosynthesis. Besides its importance in photosynthesis, chlorophyll is probably the most commonly used estimator of algal biomass in marine systems.

In general, the annual growth cycle for primary production in the Gulf has been characterized by a most intense abundance peak in the spring and attributed to when nutrient concentrations are high and light conditions are favourable for photosynthesis (Dufour et al. 2010). In addition, inter-annual variability of phytoplankton biomass is related to freshwater runoff and wind conditions. Chlorophyll data from satellite images covering Cabot Strait are presented in Figure 5.24 (Dufour et al. 2010) and indicate the more intense spring phytoplankton growth occurs in late March to April, followed by a much smaller phytoplankton peak from August to October.



Source: Dufour et al. 2010.

Figure 5.24 Seasonal and Inter-annual Chlorophyll *a* in Surface Water for the Cabot Strait Region of the Gulf of St. Lawrence (based on satellite SeaWIFS images, 1998 to 2008)

Dufour and Ouellet (2007) summarized the seasonal pattern of phytoplankton growth in the entire Gulf. The spring bloom occurs in late April or early May and is characterized by rapid growth of large diatoms (*Thalassiora* sp. and *Chaetoceros* sp.). As nutrients are depleted, the abundance of larger diatoms decline, and several important dinoflagellates (e.g., *Peridinium* sp., *Alexandrium* sp. and *Ceratium* sp.) become numerically dominant. However, the diversity remains high during the summer but the chlorophyll concentrations and productivity remain low. A fall bloom may occur from September to November in the Gulf, where the chlorophyll concentrations are not much higher than those in the summer. The areas with relatively high phytoplankton growth were described as occurring in the Lower Estuary, the northwestern Gulf and primarily along the Gaspé Peninsula, at the southern and western end of Anticosti Island and along Québec's North Shore, with lower values on the western shore of Newfoundland and the Magdalen Shallows.

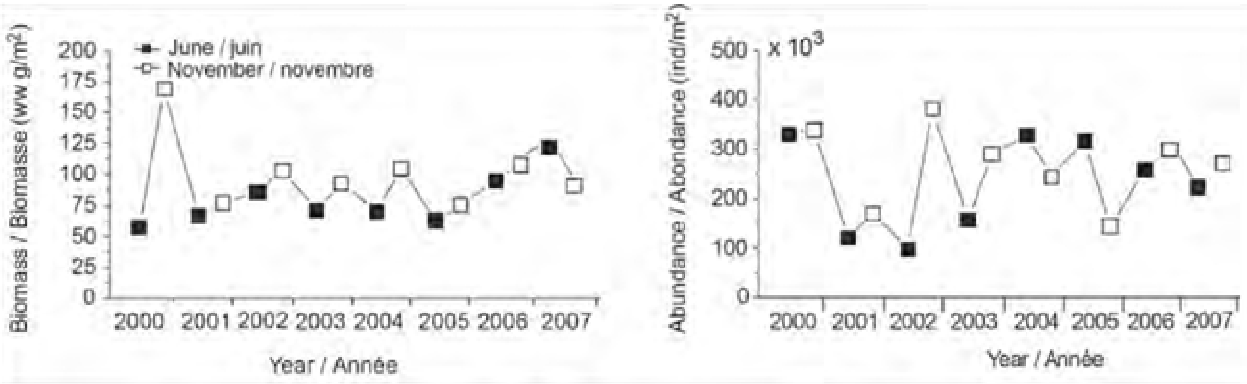
The non-native phytoplankton species *Neodenticula seminae* is a diatom from the Pacific that has been introduced and observed in the Estuary and Gulf since 2001 (Dufour et al. 2010). In 2001, this species comprised 80 percent of the phytoplankton community during the spring bloom, where the concentrations were up to $2x10^6$/L. This cold-water marine planktonic species was limited to the North Pacific and Bering Seas. It is believed to have been naturally introduced into the Gulf, where it migrated across the Arctic and down the Labrador Current, rather than from ship's ballast waters. It is hypothesized that other introductions are likely to occur from the Pacific into the Atlantic, including the Gulf, as the Arctic ice continues to melt, resulting in potentially large effects on biodiversity and fisheries in the Northwest Atlantic, including the Gulf (Dufour et al. 2010).

Other species newly introduced in the St. Lawrence region include dinoflagellates (the toxic dinoflagellate *Alexandrium pseudogonyaulax* (observed since 2001) and the non-toxic dinoflagellate *Prorocentrum rhathymum* (observed since 1999) (Dufour et al. 2010)). However, their method of introduction in the St. Lawrence is unknown. Harmful algal blooms and those responsible for paralytic shellfish poisoning by the dinoflagellate *Alexandrium tamarense* occur most notably in the Lower St. Lawrence Estuary along the north and south shores (Dufour et al. 2010). Harmful algal blooms are not known to occur in open areas of the Gulf or EL 1105.

5.3.4.2 Zooplankton

Zooplankton are animals ranging in size from <1 mm, such as copepods, to approximately 4 cm (e.g., krill). Zooplankton are consumers and depend on phytoplankton for the bulk of their food. Eggs and larvae of larger animals, such as fish and crustaceans, are also included in the diet of larger zooplankton. In turn, many organisms in higher trophic levels, such as fish and marine mammals, include zooplankton in their diet. Thus, zooplankton play a very important role in marine food webs. Physical parameters, which exert control on primary production in the Gulf, also exert an influence on the zooplankton in the system.

AZMP data collected annually in late spring and fall along different sections in the whole Gulf showed that during seven years (2000 to 2007), the average copepod abundance along the Cabot Strait section in the Gulf generally increases from late spring to late fall (Harvey and Devine 2008; Figure 5.25). This is also the general observation for other AZMP sections in the Gulf. The copepod assemblage at Cabot Strait is dominated by the mesozooplankton, comprising of small copepod species (*Oithona* sp., *Pseudocalanus* sp. and *Temora* spp.), which represented on average 64 percent of the total annual copepod abundance (Table 5.5).



Source: Harvey and Devine 2008.

Figure 5.25 Mean Zooplankton Biomass (Wet Weight) and Abundance at the AZMP Cabot Strait Section in June and November 2000 to 2007

Table 5.5 Mean Zooplankton Abundance at the AZMP Cabot Strait Section, 2000 to 2007

2002 to 2006				2007			
Ranking	**Species**	**% Total Zooplankton**	**Yearly Average (ind/m2*102)**	**Ranking**	**Species**	**% Total Zooplankton**	**Yearly Average (ind/m2*102)**
1	*Oithona* spp.	38.44	899.90	1	*Oithona* spp.	43.32	1,095.10
2	*Pseudocalanus* spp.	15.63	366.02	2	*Calanus finmarchicus*	8.70	219.94
3	*Calanus finmarchicus*	10.21	238.96	3	*Pseudocalanus* spp.	8.55	216.08
4	*Temora* spp.	9.99	233.86	4	*Calanus hyperboreus*	8.03	202.96
5	*Calanus hyperboreus*	5.70	119.92	5	Appendicularia	4.08	103.21
6	*Microcalanus* spp.	3.01	70.49	6	*Temora* spp.	4.07	102.95
7	Appendicularia	2.22	52.07	7	*Microcalanus* spp.	3.00	75.75
8	Copepod nauplii	2.01	47.11	8	Pteropods	2.77	69.91
9	Copepod eggs	1.85	43.21	9	*Metridia* spp.	2.74	69.25
10	Bivalve larvae	1.58	37.03	10	Bivalve larvae	2.33	45.15
Total			2,108.57	Total			2,200.30
Total Abundance of Zooplankton (N/m^2*10^2)			2,341.18	Total Abundance of Zooplankton (N/m^2*10^2)			2,523.51
Source: adapted from Harvey and Devine 2008.							

Mesozooplankton consist of predominantly copepods, but also includes other mesozooplankton organisms (e.g., invertebrate larvae, decapods, ostracods). Copepod nauplii were typically much more abundant in June than in November. The higher June abundance is attributed to nauplii of *Calanus finmarchicus*, which is the dominant large copepod in the Gulf marine system. The seasonal and interannual patterns in total copepod abundance are largely due to small copepods (including *Pseudocalanus* spp.), confirming that this group largely dominated the whole copepod assemblage in abundance.

For mesozooplankton other than copepods (meroplankton (marine animals with planktonic early life stages (e.g., fish larvae)), carnivorous zooplankton and krill larvae), their total abundances were usually higher in June than in November; this is the opposite of what was observed for the mesozooplankton biomass (excluding *Calanus hyperboreus*) and the total abundance of copepods, which were usually higher in November than in June.

The larger copepod species *Calanus finmarchicus* and *Calanus hyperboreus*, usually found in deeper water such as the Laurentian Channel, are generally less abundant than the small copepod species but contribute in terms of biomass and generally contribute to the high total zooplankton biomass in the region (Dufour and Ouellet 2007). Dufour and Ouellet (2007) suggest that the influence of water masses from various sources such as the Arctic and Atlantic promote the presence of these larger copepods, as well as euphausiids (krill), chaetognaths (*Sagitta elegans*), hyperiid amphipods and gelatinous organisms such as jellyfish-like hydrozoans (siphonophores). In addition, late developmental stages of *Calanus* spp., present in the deep waters of the Laurentian Channel in the autumn, are subsequently transported by the deep current towards the head of the Laurentian Channel in the Lower Estuary of the St. Lawrence. Similarly, krill are also believed to be transported by deep-water currents to the head of the Laurentian Channel where the mature individuals are concentrated. This transport mechanism is suggested to create the greatest concentration of krill (mostly *Meganyctyphanes norvegica* and *Thysanoessa rashi*) observed in the Northwest Atlantic (Simard et al. 2002, in Dufour and Ouellet 2007).

As indicated earlier, macrozooplankton are a large contributor to the plankton biomass in the St. Lawrence marine system, making up 10 to 20 percent of the total zooplankton biomass (approximately 123 g wet weight per m^2) (Harvey and Devine 2008). They play a significant role in the pelagic ecosystem as food for marine mammals, marine birds and fish, and as predators on copepods and/or fish larvae. The macrozooplankton are mainly adult and juvenile euphausids, or krill (*Meganyctiphanes norvegica*, *Thysanoessa inermis*, *Thysanoessa raschii*). This category of zooplankton also includes mysids (*Boreomysis arctica*, *Mysis mixta*, *Erythrops erythrophthalma*), which are commonly found in deep samples, hyperiid amphipods (*Themisto libellula*, *Themisto abyssorum*, *Themisto compressa*), and chaetognathes (*Sagitta elegans*, *Pseudosagitta maxima*, *Eukrohnia hamata*). Concerning the macrozooplankton species, the two more abundant overall species in the Gulf are the hyperiid amphipod *Themisto abyssorum* and the chaetognath *Sagitta elegans* at all sampling seasons and years.

Thermisto libellula is an Arctic hyperiid amphipod that has been introduced and observed in the Gulf waters since the early 1990s (Dufour et al. 2010). Analogous to introduced phytoplankton species, *Thermisto libellula* is believed to have been carried by Labrador Shelf water advected into the Gulf through the Strait of Belle Isle during winter.

5.3.4.3 Ichthyoplankton

Ichthyoplankton are part of the zooplankton population that are specific to fish larvae and eggs and at times, have been known to include the larvae and eggs of important shellfish species as well. Ichtyoplankton, along with other planktonic early life stages of marine animals, are collectively referred to as the meroplankton, which was described in Section 5.3.4.3.

The ichthyoplankton of the Gulf include up to 50 species of fish eggs and larvae (Table 5.6). Dominant in the ichthyoplankton are the larva of herring, capelin, snailfish, shanny and sculpin (White and Johns 1997), all of which are benthic spawners, whose pelagic larvae hatch from eggs deposited on the seafloor. In more inshore areas, species such as lobster, herring, scallop, cunner, radiated shanny, winter flounder and capelin dominate the ichthyoplankton. In early May, the most common fish larva in the northeast Gulf is the sandlance and by late June, redfish and capelin are prominent (de Lafontaine et al. 1991). Redfish and Greenland halibut are most prominent in waters over the Laurentian Channel and also potentially in EL 1105.

Table 5.6 Common Ichthyoplankton in the Estuary and Gulf of St. Lawrence

Pelagic Spawning Species		Benthic Spawning Species	
Atlantic Mackerel	*Scomber scombrus*	Atlantic Herring	*Clupea harengus*
Atlantic Cod	*Gadus morhua*	Rainbow Smelt	*Osmerus mordax*
American Plaice	*Hippoglossoides platessoides*	Tomcod	*Microgadus tomcod*
Fourbeard Rockling	*Enchelyopus cimbrius*	Winter Flounder	*Pseudopleuronectes americanus*
Hake	*Urophycis* sp.	Capelin	*Mallotis villosus*
Cunner	*Tautogolabrus adspersus*	Snailfish	*Liparis* sp.
Yellowtail Flounder	*Limanda ferruginea*	Shanny	*Lumpenus* sp.
Redfish[A]	*Sebastes* sp.		*Stichaeus* sp.
Crustaceans[B]			*Ulvaria* sp.
Snow Crab	*Chionoecetes opilio*	Sculpins	*Myoxocephalus* sp.
Rock Crab	*Cancer irroratus*		*Icelus* sp.
American Lobster	*Homarus americanus*		*Hemitripterus* sp.
Boreal Shrimp	*Pandalus borealis*		*Artediellus* sp.
		Sandlance	*Ammodytes* sp.

[A] Give birth to live young.
[B] Eggs attach to the underside of female abdomen until the following year; larvae drift in surface waters.
From: White and Johns 1997.
Sources: de Lafontaine 1990; de Lafontaine et al. 1991.

The most notable densities of ichthyoplankton in the Gulf have been observed on the west coast of Newfoundland, Anticosti Island and the southwestern coast of the Gulf including Chaleur Bay (DFO 2009a). Along the west coast of Newfoundland, fish larvae, particularly capelin and herring, are found in substantial quantities in the coastal region north of the Port-au-Port Peninsula and northeast to EL 1105. One of the high densities of fish eggs and larvae (particularly cod and winter flounder eggs, sand lance and Arctic shanny larvae) and decapod crustaceans occur in the northern and western regions of Anticosti Island. The southwestern coast and larger southern Gulf region has the greatest abundance in terms of species, as well as having the most abundant eggs and larvae from different marine organisms throughout the entire Gulf. This area also represents an important area for Atlantic mackerel spawning and for the southern Gulf population of Atlantic cod.

5.4 Marine Fish and Fish Habitat

The marine waters of the Gulf are home to many species of marine fish and shellfish. One of the main reasons for this diversity is the presence of warm, productive waters in the summer followed by cold waters, covered in ice, during the winters. Approximately 20 species of marine fish are currently, or have been historically, fished commercially or experimentally in the Gulf (DFO 2005a). Commercial fisheries are further discussed in Section 5.8.

5.4.1 Fish Habitat

As part of the geohazard survey conducted by Fugro GeoSurveys Inc. in October 2010, underwater videography and grab samples of the surficial sediment were taken at station locations indicated in Figure 5.26. The description of the benthic habitat provided below for this area is based on the information and data obtained from this fieldwork.

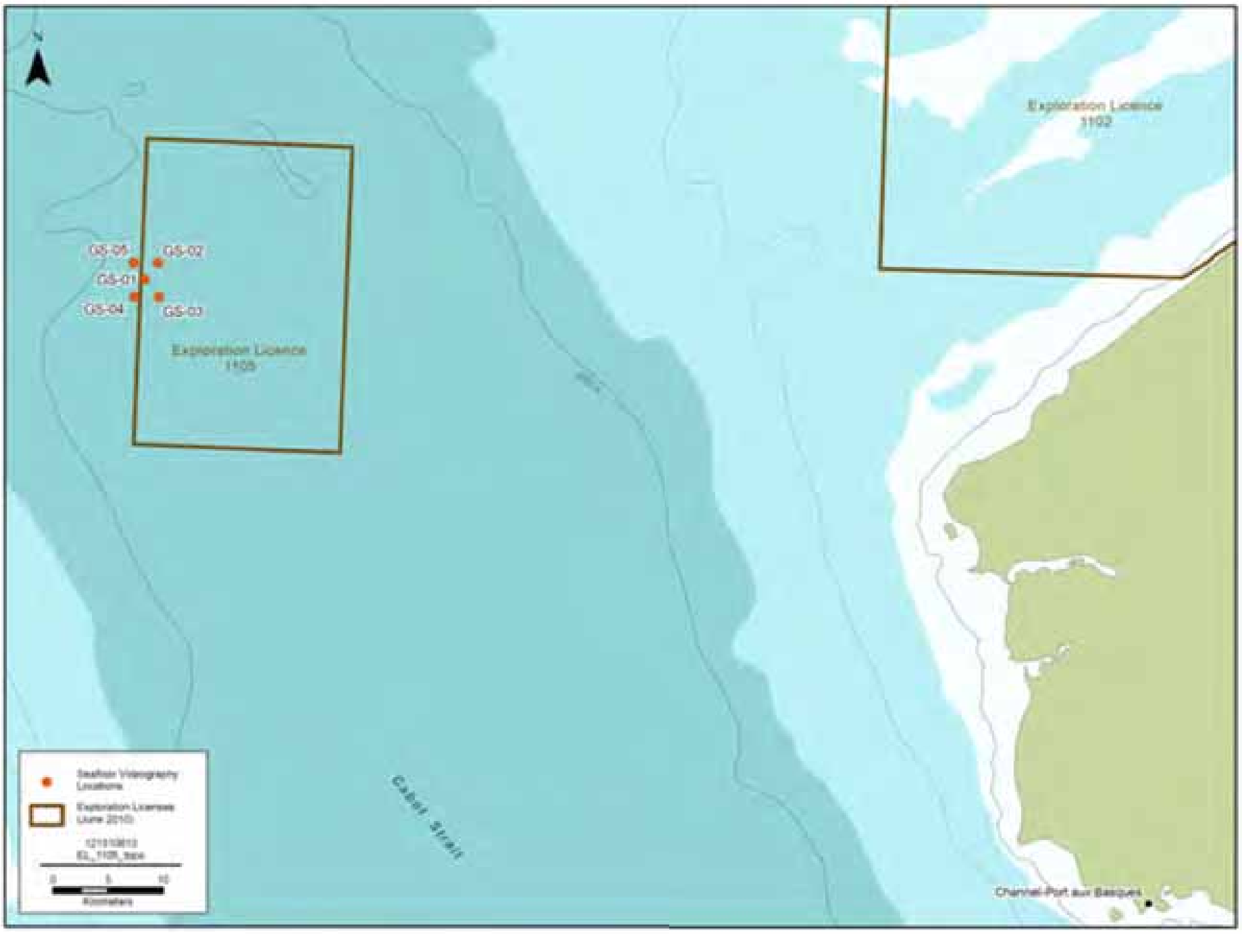
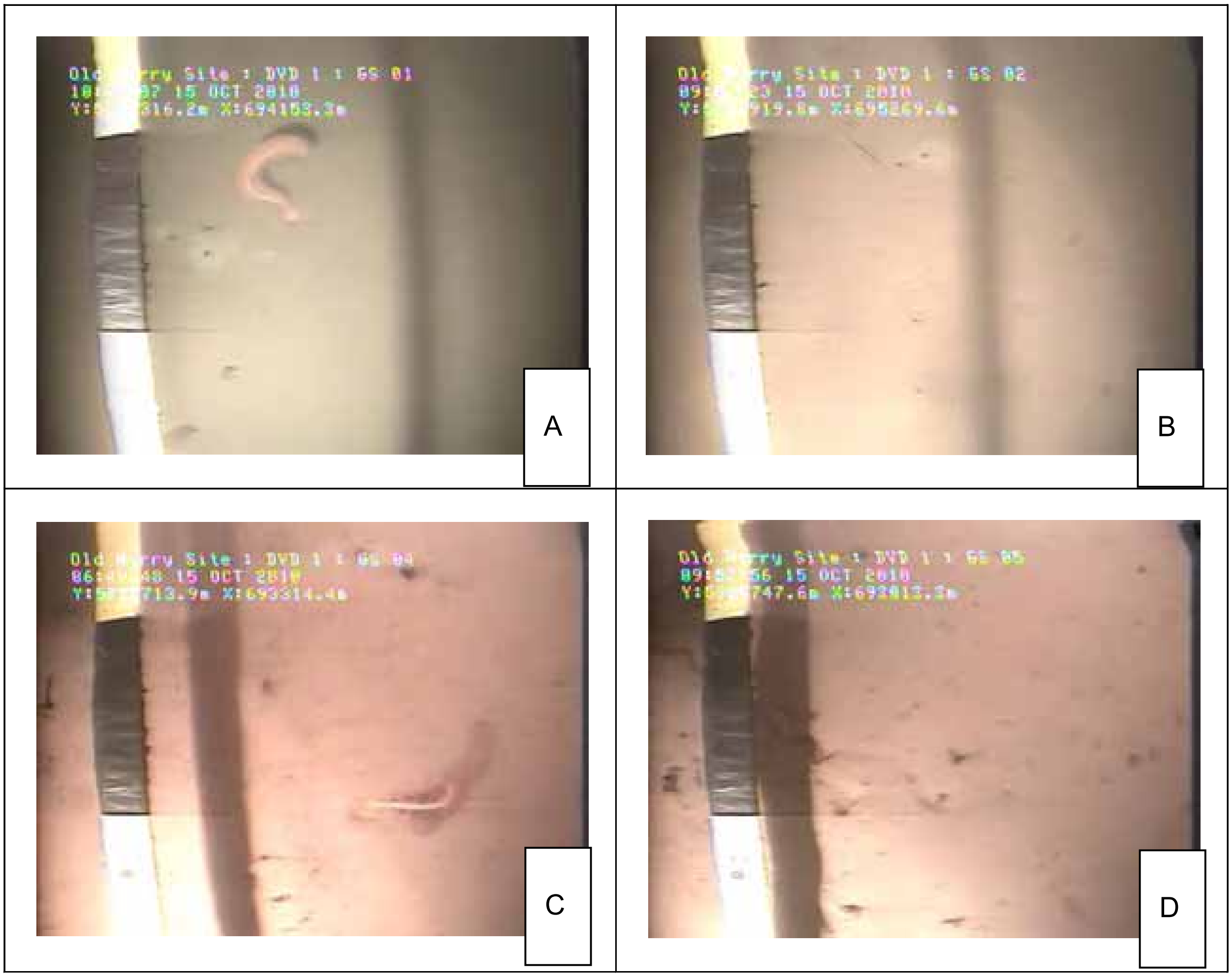


Figure 5.26 Location of Seafloor Videography and Benthic Sampling Stations during the Geohazard Survey Program (October 12 to 15, 2010)

The seafloor consists of soft, muddy sediment that appears uniformly distributed throughout the surveyed area. Images of the sea bottom are provided in Figure 5.27, where a benthic habitat with low species diversity can be observed, primarily the presence of holes and cast material deposited by burrowing infaunal invertebrates, such as polycheate worms. The occasional sea pen, *Anthoptilum grandiforum*, (also known as a feather boa sea pen and looks like a "question mark"), rising from the seabed can also be observed (Figure 5.27, A and C). The infrequently observed sea pen species is relatively common elsewhere in the Laurentian Channel and off the Scotian Shelf and is discussed further in Section 5.3.2.

The above description of a very fine sediment substrate supporting a benthic habitat with low species diversity (as compared to benthic species diversity on a substrate with coarse sediment) is typical for all the five videography stations that were surveyed. No fish, crustaceans, or true stony and soft corals (alcyonarians) were observed in any of the video images that were analyzed. Analysis of the video images also suggest that the bottom water currents appear to be relatively weak (likely <0.5 m/s) because it took a few seconds for the sediment cloud to disperse after the seafloor was accidentally disturbed with the video camera.



Note: The sea pen *Anthoptilum grandiflorum* and burrowing holes by infaunal marine organisms in the soft bottom are visible. (A, Station GS-01; B, Station GS-02; C, Station GS-04; D, Station GS-05 – refer to Figure 5.23 for the location of stations).

Figure 5.27 Underwater Photographic Images of the Seafloor in Water Depths of Approximately 460 to 490 m in the Area of the Old Harry Prospect

Fugro GeoSurveys Inc. collected sediment samples with a Van Veen grab from three locations on October 15, 2010 (stations GS-01, GS-02 and GS-05; Figure 5.26). Mechanical failure prevented collection of the fourth and fifth sediment samples (i.e., stations GS-03 and GS-04 to the south; Figure 5.26).

Physical and chemical sediment quality analyses were conducted on the three grab samples and included the following parameters:

- total metals;
- total organic carbon;
- total petroleum hydrocarbon / benzene, toluene, ethylbenzene and xylene (BTEX) / total extractable hydrocarbon;
- polycyclic aromatic hydrocarbons (PAHs);

- mercury; and
- grain size analysis.

The results are summarized in Tables 5.7 and 5.8.

Table 5.7 Grain Size Analysis of Sediment Samples from Sampling Stations

Parameter	Units	RDL	GS-01	GS-02	GS-05
Moisture	%	1	66	64	66
Gravel	%	0.1	ND	ND	0.5
Sand	%	0.1	3.8	4.6	4.0
Silt	%	0.1	32	33	34
Clay	%	0.1	64.2	62.4	61.5

RDL = Reportable Detection Limit
ND = Not detected

Table 5.8 Summary of Chemical Analyses of Sediment Samples from Sampling Stations

Parameter	Units	RDL	GS-01	GS-02	GS-05	CCME Marine PEL[A]	CEPA Disposal at Sea Guidelines[B]
Total Organic Carbon	g/kg	0.5	17	17	16	-	-
Aluminum	mg/kg	10	15,000	15,000	15,000	-	-
Antimony	mg/kg	2	ND	ND	ND	-	-
Arsenic	mg/kg	2	5	6	4	41.6	-
Barium	mg/kg	5	230	230	210	-	-
Beryllium	mg/kg	2	ND	ND	ND	-	-
Bismuth	mg/kg	2	ND	ND	ND	-	-
Boron	mg/kg	3	62	67	60	-	-
Cadmium	mg/kg	0.3	ND	ND	ND	4.2	0.6
Chromium	mg/kg	2	37	37	37	160	-
Cobalt	mg/kg	1	12	12	12	-	-
Copper	mg/kg	2	24	25	25	108	-
Iron	mg/kg	50	26,000	26,000	25,000	-	-
Lead	mg/kg	0.5	15	15	15	112	-
Lithium	mg/kg	2	28	29	28	-	-
Manganese	mg/kg	2	580	630	630	-	-
Mercury	mg/kg	0.1	0.2	0.1	0.1	0.7	0.75
Molybdenum	mg/kg	2	ND	ND	ND	-	-
Nickel	mg/kg	2	35	35	34	-	-
Rubidium	mg/kg	2	25	25	23	-	-
Selenium	mg/kg	2	ND	ND	ND	-	-
Silver	mg/kg	0.5	ND	ND	ND	-	-

Parameter	Units	RDL	GS-01	GS-02	GS-05	CCME Marine PEL[A]	CEPA Disposal at Sea Guidelines[B]
Strontium	mg/kg	5	140	130	120	-	-
Thallium	mg/kg	0.1	0.2	0.2	0.2	-	-
Tin	mg/kg	2	ND	ND	ND	-	-
Uranium	mg/kg	0.1	1.8	1.9	1.5	-	-
Vanadium	mg/kg	2	60	59	59	-	-
Zinc	mg/kg	5	81	85	82	271	-
Total PAHs	mg/kg	0.01	ND	ND	ND	-	2.5
Benzene	mg/kg	0.03	ND	ND	ND	-	-
Toluene	mg/kg	0.03	ND	ND	ND	-	-
Ethylbenzene	mg/kg	0.03	ND	ND	ND	-	-
Xylene	mg/kg	0.05	ND	ND	ND	-	-
C_6-C_{10} Hydrocarbons (less BTEX)	mg/kg	3	ND	ND	ND	-	-
>C_{10}-C_{16} Hydrocarbons	mg/kg	10	ND	ND	ND	-	-
>C_{16}-C_{21} Hydrocarbons	mg/kg	10	ND	ND	ND	-	-
>C_{21}-<C_{32} Hydrocarbons	mg/kg	15	ND	ND	ND	-	-
Total Petroleum Hydrocarbons	mg/kg	20	ND	ND	ND	-	-

RDL = Reportable Detection Limit
ND = Not detected
‘ - ‘ = Not available
[A] Marine Probable Effect Level (PEL) Sediment Quality Guidelines, Canadian Environmental Quality Guidelines, updated 2002.
[B] *Canadian Environmental Protection Act* Disposal at Sea sediment screening guidelines.

The grain size analysis results on the sediment samples are provided in Table 5.7. Results indicate that the sediment is predominantly fines (95 to 97 percent) and mainly comprised of silty clays (mud). This information supports the videography observations of the seafloor. It is also consistent with the description of the surficial geology at this location and over a broader area of the Laurentian Channel that has been classified as pelite (clastic rock with a grain size <0.0625 mm and typically mud) by Loring and Nota (1973) and postglacial basinal ponded muds by Josenhans and Zevenhuizen (1993).

The results of the chemical analyses for the sediment samples collected are provided in Table 5.8. No hydrocarbons or PAHs were detected in the samples and all metals including mercury concentrations in the sediment are below marine sediment quality guidelines.

During the Fugro GeoSurveys Inc. geohazard survey in October 2010, additional sediment grab samples were collected and preserved with 10 percent formalin. Samples were sieved and the organisms were collected for sorting and identification by Arenicola Marine. The results support the videography information in that there were few benthic macrofauna in the samples, which consisted of mainly polychaetes and molluscs (Table 5.9). This further corroborates and supports the low species diversity and abundance of the soft-bottom benthic habitat.

Table 5.9 Summary of Benthic Invertebrates Collected from Station Locations

Family	Species	Number of Individuals[A]		
		GS-01	GS-02	GS-05
Copepoda	*Calanus finmarchicus*[B]	3		
Polychaeta	*Spio limicola*	1	1	
	Brada inhabilis	1		
Mollusca	*Limacina helicina*	1		
	Littorina littorea		1	
Oligochaeta	unidentified		1	
Foraminifera[B]	*Triloculina* sp.	1		
	Lenticulina sp.	3		
Nematoda[B]	indeterminate		3	2

[A] Grab sampling area of 0.1 m^2.
[B] Not considered benthic macrofauna.

5.4.2 Shellfish

Shellfish are also known to frequent the Gulf and EL 1105 within the Laurentian Channel. Based on the 2006 to 2008 fish catch weight data for NAFO Unit Areas 4Ss and 4Tf and the Western Newfoundland SEA, lobster, snow crab, rock crab, Atlantic sea scallop, whelk and northern shrimp are designated as important commercial invertebrate species. Therefore, the life histories and distributions of these species are further described. Commercial fisheries species and activities relevant to the Project are discussed in Section 5.8.

It is worth noting as well that large snow crab have been reported to occur at similar depths as EL 1105 (i.e., 200 to 500 m) (LGL 2005b). A review of commercial fisheries data provided by DFO revealed several additional shellfish species that have been recorded in the vicinity of EL 1105, including whelk, scallop, toad crab (likely *Hyas araneus* and/or *Hyas coarctatus*), rock crab, and multiple types of clams (Atlantic razor (likely *Siliqua costata*), softshell (*Mya arenaria*) and surf clams) (DFO Fish Catch Data, pers. comm. 2011). Additional species-specific information is provided in the 2005 Western Newfoundland SEA document, Section 3.4.1 (LGL 2005b). Squid were also confirmed to be present in the vicinity of EL 1105 (DFO Fish Catch Data, pers. comm. 2011).

One invasive shellfish species has also been confirmed to occur in the waters off Newfoundland. The green crab (*Carcinus maenas*) was reported in Newfoundland waters in 2007 and is known as an aggressive invasive species. As with most invasive species, the presence of the green crab in the waters off Newfoundland has the potential to exert pressure on the ecosystem and on the existing fish and shellfish assemblage. A disruption to the natural balance of the ecosystem can, in turn, increase the vulnerability of indigenous species to further pressures, including interactions with potential anthropogenic activities.

5.4.2.1 American Lobster

American lobsters are distributed in localized populations in nearshore areas around the island of Newfoundland, including the west coast of Newfoundland, Magdalen Islands, Prince Edward Island, New Brunswick and Nova Scotia. The spring fishing season removes adult individuals from the population prior to moulting and spawning. Adult female moulting and spawning occurs during one summer, whereas the second summer is dedicated to laying the eggs. Young females will moult, spawn and lay eggs in the same summer (DFO 2003).

Courtship generally occurs before moulting for adult females. Immediately after moulting (when the female's carapace is still soft), the female will mate with a male and store the male's spermatophore within a receptacle under the female's abdomen until she spawns the following year. The eggs are extruded during the summer and autumn months and may number in the thousand to tens of thousands. Even with the large number of eggs released the survival rate is low, and about one in ten fertilized eggs will grow to become adults (DFO 2009f).

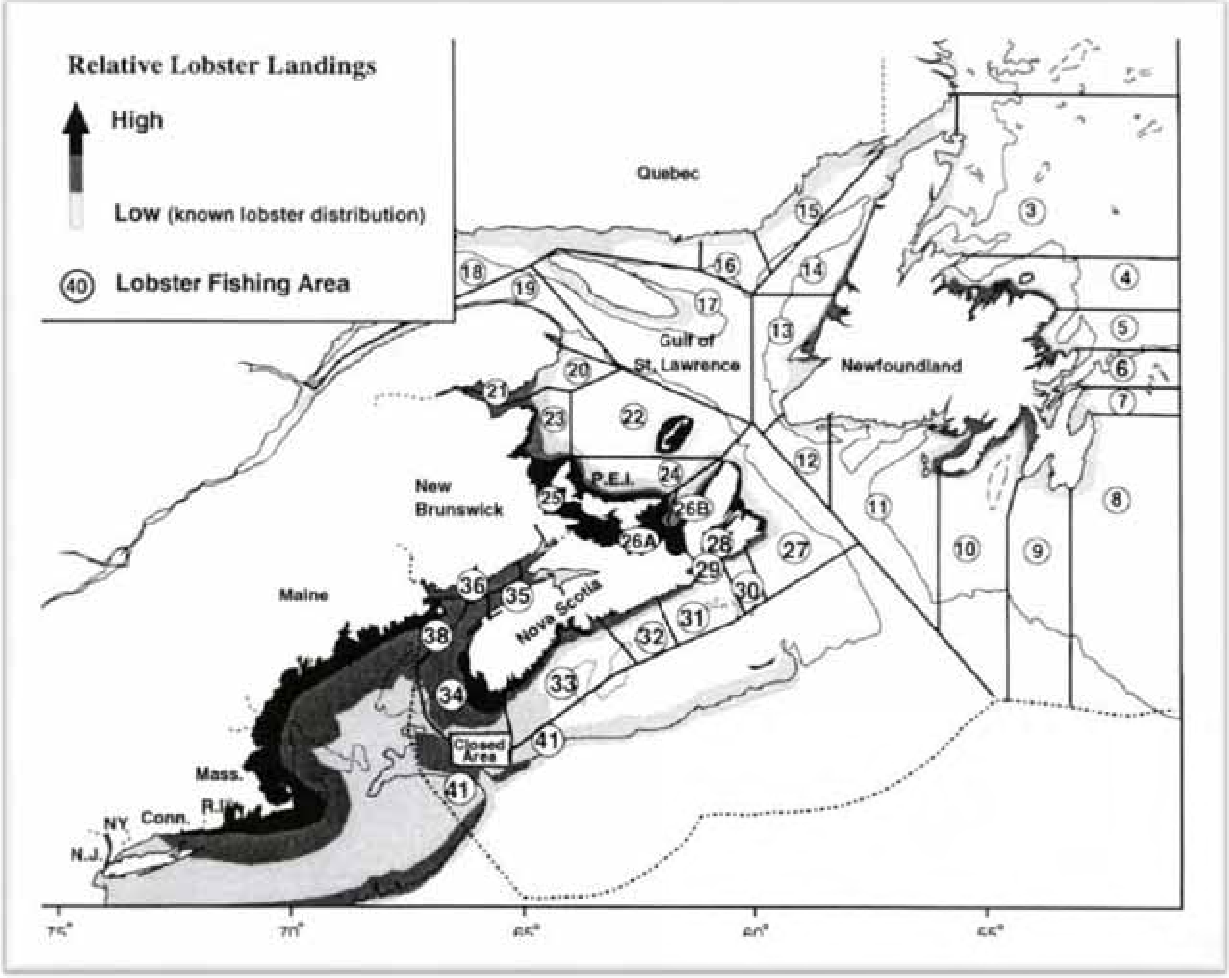
Once spawning has occurred eggs, are brooded for a year under the female's abdomen; hatching and larval release occurs and the post-larval lobsters live for 6 to 10 weeks in the water column in a planktonic phase, where they moult and pass through three larval stages before settling on the seafloor. Within the first three larval stages, the planktonic larvae spend most of the time in the upper 1 m of the water column. The feathery hairs on the legs provide mobility and along with currents, this aids in the larvae locating appropriate habitat for growth and development (DFO 2003).

The fourth larval stage is where the lobster begins the search for specific habitats. The post-larval lobster will move up and down in the water column, bobbing along in search of habitats. The preference for habitats seems to be for hard bottom with many interstitial spaces (e.g., cobble or larger rock). As the lobster settles into its new habitat, it moults into the fifth stage. The first year of benthic life is spent mostly hiding from enemies in tunnels or crevices in between rocks (Gulf of Maine Research Institute 2008).

The natural diets of immature lobsters remain similar to their mature counterparts. In Newfoundland, the most frequent prey found in a study of lobster stomach contents included green sea urchins, mussels, rock crab, polychaetes and brittle stars (DFO 2009g).

In Newfoundland waters, lobsters take between 8 to 10 years from time of hatching to grow, to where 50 percent of females become functionally mature and extrude eggs. This represents a mean carapace length of 81 mm (the minimum size to be retained when fishing). There is a lack of fishery independent data (and limited fishery-dependent data) on lobster caught in Newfoundland waters; however, relatively small animals seem to comprise the bulk of the population structure (DFO 2009h). Lobster caught in the Magdalen Islands have shown positive productivity indicators from 2006 to 2008, with a good abundance of berried females and juveniles remain high (DFO 2009h).

Relative lobster landings and approximate lobster distributions are provided in Figure 5.28 (from DFO's Review of Lobster Landing Trends in the Northwest Atlantic (DFO 1992)).



Source: DFO 1992.

Figure 5.28 Lobster Distribution in the Gulf of St. Lawrence and Northwest Atlantic

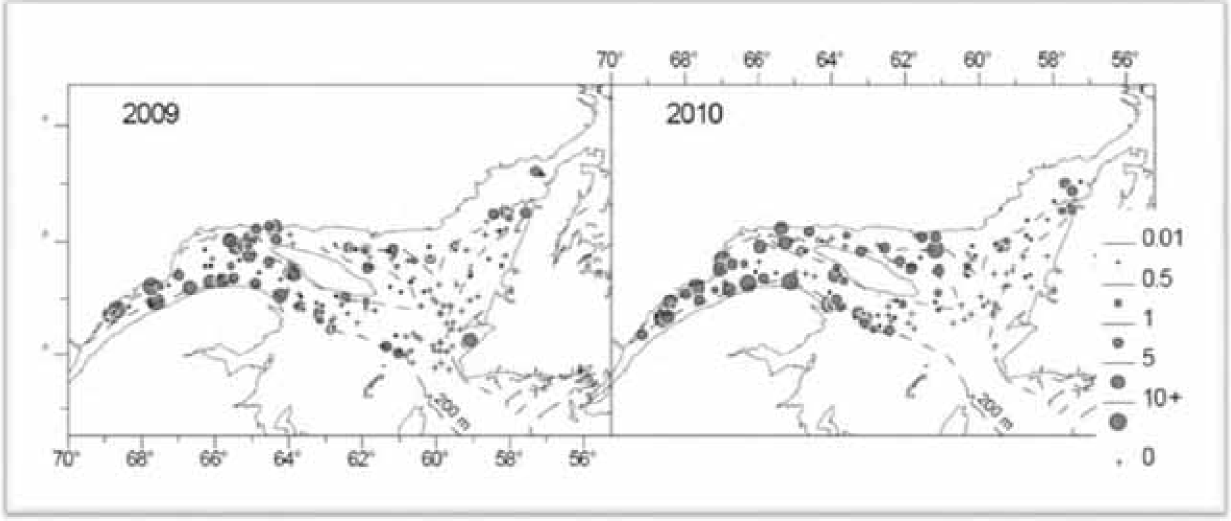
During SEA consultations with fishermen in July 2005 (LGL 2005b Appendix 1), the inshore area between the outer portion of Port-au-Port Bay and Shag Island to the north (4Rc) was identified as prime lobster spawning area. Fishermen indicated that lobster fishing grounds in the area between Long Point (outer Port-au-Port Bay) and Shag Island generally yield very large females. Fishers also noted lobster nursery areas near Shoal Point, Outer Bay of Islands located just above North Head (LFA 13B; Parcel 6), and at an area further north known as Trout River Bay (LFA 14A; Parcel 7). These two areas are presently closed to the lobster fishery as a means of conservation.

5.4.2.2 Snow Crab

Snow crab is a decapod crustacean that occurs over a broad depth range (50 to 1,300 m) in the Northwest Atlantic. The distribution of this decapod in waters off Newfoundland and southern Labrador is widespread but the stock structure remains unclear. Snow crab have a tendency to prefer water temperatures ranging between -1.0°C and 4.0°C. Snow crab generally move to shallower waters to mate, with the increase in temperature speeding up embryonic development. Fertilization occurs internally for snow crabs and mating occurs once the female has moulted. The fertilized eggs are extruded within 24 hours and are attached to the female's pleopods. The number of eggs released by the female in one clutch can number up to 128,000 (DFO 2010f). Subsequent clutches of eggs can be fertilized by spermatophores stored ventrally. The eggs are incubated up to 27 months, with embryonic development occurring more quickly in warmer waters (DFO 2010g). Hatching occurs during early spring (April to June), where the larvae, known as zoea, spend 12 to 20 weeks as zooplankton feeding on microzooplankton in the water column (DFO 2010f). There are a total of three larval stages before the snow crabs settle to the bottom.

Males continue to moult into adulthood and only a portion will recruit into the fishery, which defines a minimum carapace width of 95 mm (DFO 2009g). It takes on average eight years for snow crab to be large enough to be retained by the fishery (DFO 2010h). Commercial-size snow crab can be found on a variety of substrates but are most common on mud or mud / sand bottoms, while smaller crabs are found within the interstitial spaces of harder substrates. Adult snow crab typically feed on fish, clams, polychaete worms, brittle stars, shrimp and crustaceans, including smaller snow crab (DFO 2009j).

The 2009 and 2010 distribution of snow crab in the Estuary and northern Gulf is presented in Figure 5.29, as obtained by DFO during the annual summer trawl surveys conducted onboard the *CCGS Teleost* (Bourdages et al. 2010). The surveyed area includes EL 1105 and therefore provides an indication for the presence of this and other species (described below).



Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.29 **Snow Crab Distribution in the Estuary and Northern Gulf of St. Lawrence**

5.4.2.3 Rock Crab

Rock crabs are decapod crustaceans that congregate in waters typically less than 20 m deep and prefer rocky substrate to sandy bottom habitat. Preference is given to those habitat areas with macroalgal growth on the rocky substrate (DFO 2010i).

Sexual maturity is generally attained with three to six years of age, with carapace widths of 25 and 40 mm for females and males, respectively. Moulting typically occurs primarily in April and May, with mating occurring while the female is in a soft-shelled state. The fertilized eggs are generally extruded in late October and the eggs are stored under their abdomen for up to a year (DFO 2000a). Larval hatching occurs in the late spring / summer months, with the free-swimming larvae aggregating near the surface. The larvae moult through six stages (five zoeas and one megalopa) before settling to the seafloor (DFO 2010i). These six stages of planktonic larvae can take up to three months before becoming a benthic crab (DFO 2000a). Throughout these stages the larvae are omnivorous planktivores.

Adult rock crabs are one of the major predators in northern subtidal communities. Their diet includes juvenile scallops, mussels, snails, green sea urchins, seastars, amphipods, sand shrimp and polychaetes. Large rock crabs are known to take young lobsters. Adult rock crabs will reach commercial size at six years of age (DFO 2010i).

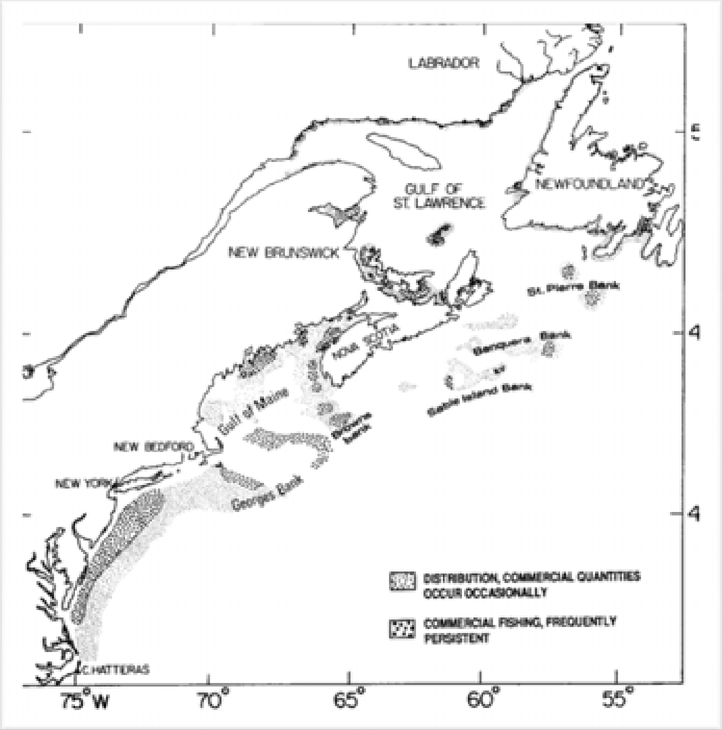
5.4.2.4 Atlantic Sea Scallop

The Atlantic sea scallop is a bivalve mollusk that lives in communal beds on the seafloor and is found from North Carolina to Newfoundland. It occurs on the Atlantic Continental Shelf and typically occurs in relatively shallow water, <100 m depth. In the Gulf, sea scallop are found at water depths of 10 to 25 m. Scallop occur in groups or beds that may be sporadic or last for numerous years. These beds correspond to areas of suitable temperature, food availability and substrate. Adult scallop are typically located on clean bottom such as gravel and where gyres occur, keeping larval stages in the vicinity of the spawning population (Stewart and Arnold 1994).

Sexual differentiation occurs at age 1, with sexual maturity reached at age 2, although mature scallop do not contribute substantially to reproduction until age 3. Spawning occurs in early fall (August to October), prompted by water temperature decreases. Within the western coast of Newfoundland, a second spawning season occurs between the months of June and July (Stewart and Arnold 1994).

Males and females release gametes synchronously and fertilization is external in the water column. Eggs develop in one to two days into the first of three larval stages, which all together will last five weeks. In the first larval stage, the sea scallops are planktonic but can swim freely and have been shown to undergo daily vertical migration (DFO 1996). During the planktonic stage, a shell, eye spot and foot develop. Scallop larvae are omnivorous planktonic feeders. The sea scallop larvae then settle to the bottom and develop the remainder of features. Planktonic larvae usually settle on suitable substrates such as sand to begin their benthic life (DFO 1996). Newly settled larvae attach to suitable substrate by secreting threads, which aid against movement from bottom currents. As young scallop age, they become less mobile and show less of a tendency to attach to the bottom.

Adult sea scallop are filter feeders that use gills to capture phytoplankton and other suspended particulate material from the water. The distribution of sea scallop is presented in Figure 5.30.



Source: Hart and Chute 2004.

Figure 5.30 Sea Scallop Distribution in the Gulf of St. Lawrence and Northwest Atlantic

5.4.2.5 Whelk

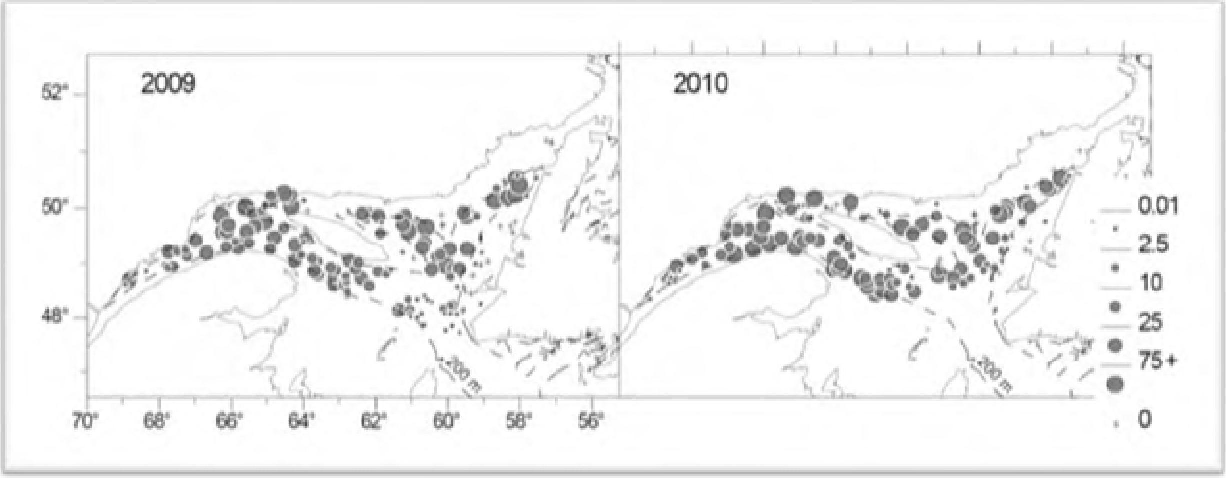
A whelk is a gastropod mollusk found from tidal levels to water depths of 180 m in a range of temperatures from 0°C to 16°C and a range of salinity from open ocean to estuarine conditions. The majority of whelk are observed in less than 30 m of water (DFO 2006a). Whelk feed on invertebrates such as polychaetes, mollusks and echinoderms and are primarily scavengers. Often whelk head on a shoreward migration prior to mating. Whelk fertilization occurs internally, with mating running from May to July. Eggs are laid two weeks after mating and are released in masses and attached to the substrate. Preferred egg laying areas appear to be irregular surfaces, face of boulders and kelp stalks, with the eggs vulnerable to predation by urchins and loss through detachment (DFO 2006a). It is estimated that 1 percent of the eggs fertilized result in hatching (DFO 2006a). The young larvae emerge after five to eight months and lack a planktonic larval stage, which limits the whelk's capacity for dispersal. As whelk grow, they move from deeper sand-mud substrates to shallower, coarser substrates. Even within the coarser substrates adults are sedentary, spending most of the time half-buried in sediments in between coarse substrate.

5.4.2.6 Northern Shrimp

Northern shrimp mating takes place in the fall and the females carry the fertilized eggs for approximately eight months (September to April). Larvae are pelagic upon hatching in the spring but eventually settle to the bottom by late summer. Shrimp migrations tend to be associated with breeding (berried females move into shallower waters in winter) and feeding (upward movement in water column at night to get to plankton) (DFO 2004b). Northern shrimp are generally found throughout the Estuary and northern Gulf in areas with water depths ranging between 150 and 350 m and prefer areas of soft mud and silt substrates (DFO 2004b, 2009j). The northern shrimp is usually a protandric hermaphrodite and first functions sexually as a male (at approximately 2.5 years) and then undergoes sexual inversion (between four and five years old) and spends the remainder of its life as a sexually mature female (DFO 2009k). Variations in its life history can occur depending on environmental temperatures. Northern shrimp spawns once a year, generally around late June or early July. The eggs are extruded and fertilized during late summer and fall, remaining attached to the female's abdomen until hatching the following spring / summer. Berried females may migrate to shallower / warmer waters in order to maximize the rate of embryonic development.

Upon egg hatching, the larvae swim to the surface to feed on plankton. This planktonic stage lasts for a few months before the larvae move down in the water column and metamorphose to adult form. Maturity usually occurs during year 2 as males, with female inversion occurring in the fourth year.

The 2009 and 2010 distribution of northern shrimp is presented in Figure 5.31, as obtained by DFO during the annual summer trawl surveys conducted onboard the *CCGS Teleost* (Bourdages et al. 2010).



Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.31 Northern Shrimp Distribution in the Estuary and Northern Gulf of St. Lawrence

5.4.3 Fish

A comprehensive review of the western Newfoundland offshore area was undertaken for a SEA completed in 2005 (LGL 2005b) and amended in 2007 (LGL 2007). The SEA amendment study area included the Old Harry Prospect and as such, these SEA documents provide a thorough assessment of the fish assemblage anticipated to inhabit the area of the Gulf under consideration for the current Project.

There are three main types of marine fish present in the Gulf: pelagic fish, those that live and feed close to the surface; demersal or groundfish, those that live and feed close to the bottom; and shellfish, which include crustaceans and bivalves discussed in Section 5.4.2. Approximately two-thirds of all marine fish species known to occur in the Gulf are demersal. A list of the most commonly occurring pelagic and demersal marine fish known to inhabit the Gulf in the vicinity of EL 1105 are presented in Table 5.10. Note that this table is limited to species that are not considered at risk. At-risk fish species that may occur in the vicinity of the Project are listed in Tables 5.1 and 5.2 and include northern wolffish, Atlantic wolffish, spotted wolffish, blue shark, porbeagle shark, winter skate, Atlantic cod, American plaice, deepwater redfish, Acadian redfish, roughead grenadier, roundnose grenadier, spiny dogfish, Atlantic bluefin tuna, and shortfin mako. These species at risk are further discussed in Section 5.2.

Table 5.10 Summary of Not-at-risk Fish Species with the Potential to Occur in or Near EL 1105

Common Name	Latin Name	Relative Level of Occurrence in EL 1105	Timing of Presence and Spawning
Pelagic Fish Species			
Atlantic herring	*Clupea harengus*	Moderate	Year round presence and fall spawning
Atlantic soft pout	*Melanostigma atlanticum*	Moderate	Year round presence
Atlantic argentine	*Argentina silus*	Low	Year round presence
Atlantic mackerel	*Scomber scombrus*	Low	Year round presence (adults)
Capelin	*Mallotus villosus*	Low	Mature fish migrate inshore in summer (to spawn)
Haddock	*Melanogrammus aeglefinus*	Low	Move to deeper water in winter; inhabit shallow banks in summer
Pollock	*Pollachius virens*	Low	Migrate inshore during summer, winter offshore; fall spawning
Swordfish	*Xiphius gladius*	Low (anticipated)^A	Migrate in summer and fall
Groundfish / Demersal Fish Species			
Greenland halibut	*Reinhardtius hippoglossiodes*	High	Year round presence
Longfin hake	*Urophycis chesteri*	High	Year round presence and fall spawning
Marlin-spike grenadier	*Nezumia bairdi*	High	Year round presence and fall spawning
Thorny skate	*Raja radiata*	High	Year round presence
White hake	*Urohycis tenuis*	High	Year round presence
Witch flounder (greysole)	*Glyptocephalus cynoglossus*	High	Year round presence
Atlantic hagfish	*Myzine glutinosa*	Moderate	Year round presence

Common Name	Latin Name	Relative Level of Occurrence in EL 1105	Timing of Presence and Spawning
Atlantic halibut	*Hippoglossus hippoglossus*	Moderate	Migrate to shallow waters in summer, return for winter
Black dogfish	*Centroscyllium fabricii*	Moderate	Year round presence
Lumpfish	*Cyclopterus lumpus*	Moderate	Migrate to shallow waters to spawn, return during fall
Monkfish (goosefish)	*Lophius americanus*	Moderate	Year round presence
Smooth skate	*Raja senta*	Moderate	Year round presence
Spotted barracudina	*Notolepis rissoi*	Moderate	Year round presence
White barracudina	*Arctozenus risso*	Moderate	Year round presence
Atlantic hookear sculpin	*Artediellus atlanticus*	Low	Migrate inshore in the spring; occupy moderately deep waters in winter
Checker eelpout	*Lycodes vahilii*	Low	Year round presence
Fourbeard rockling	*Enchelyopus cimbrius*	Low	Year round presence
Greater eelpout	*Lycodes esmarki*	Low	Year round presence
Polar sculpin	*Coltunculus microps*	Low	Year round presence
Sea raven	*Hemitripterus americanus*	Low	Year round presence and fall spawning
Silver hake	*Merluccius bilinearis*	Low	Year round presence
Threebeard rockling	*Gaidropsarus ensis*	Low	Year round presence
Windowpane flounder	*Scophthalmus aquosus*	Low	Year round presence
Wrymouth	*Cryptacanthodes maculatus*	Low	Year round presence
Yellowtail flounder	*Limanda ferruginea*	Low (anticipated)[A]	Move from shallow to deep waters in the fall

References: Scott and Scott 1988; Environment Canada 2002; Government of Canada 2008; DFO (pers. comm.)
[A] Not included in the *Biodiversity Portrait of the St. Lawrence* (Environment Canada 2002) distribution mapping.

According to the *Biodiversity Portrait of the St. Lawrence* (Environment Canada 2002), the most abundant pelagic species found near EL 1105 include Atlantic hagfish, thorny skate, smooth skate, black dogfish and Atlantic herring. The most abundant groundfish species include white barracudina, marlin-spike grenadier, Atlantic cod, longfin hake, white hake, redfish, lumpfish, witch flounder, American plaice and the Greenland halibut.

Based on fish catch weight data collected from 2006 to 2008, the following fish species represent the principal commercial fisheries in zones 4Ss and 4Tf (i.e., the zones of most relevance to the Project): Atlantic cod, Atlantic halibut, bluefin tuna, haddock, Atlantic hagfish, Greenland halibut, Atlantic mackerel, monkfish, pollock, redfish, swordfish, white hake, witch flounder and yellowtail flounder. Species-specific distribution and life history information for these commercially-fished species is described below, with the exception of Atlantic cod and redfish, which are discussed at length in Section 5.2 as they are designated as at risk species by COSEWIC. In 2010, COSEWIC assessed cod in the Laurentian North and Laurentian South Channel populations as endangered, though they are not listed with SARA. Despite the COSEWIC assessment, they are still being fished but with a restricted annual fishing quota on the landings imposed by DFO. Similarly for redfish, in April 2010, COSEWIC designated them as endangered, but no listing/status with SARA. They too can be fished but with a quota imposed by DFO. Commercial fisheries data are further discussed in Section 5.8.

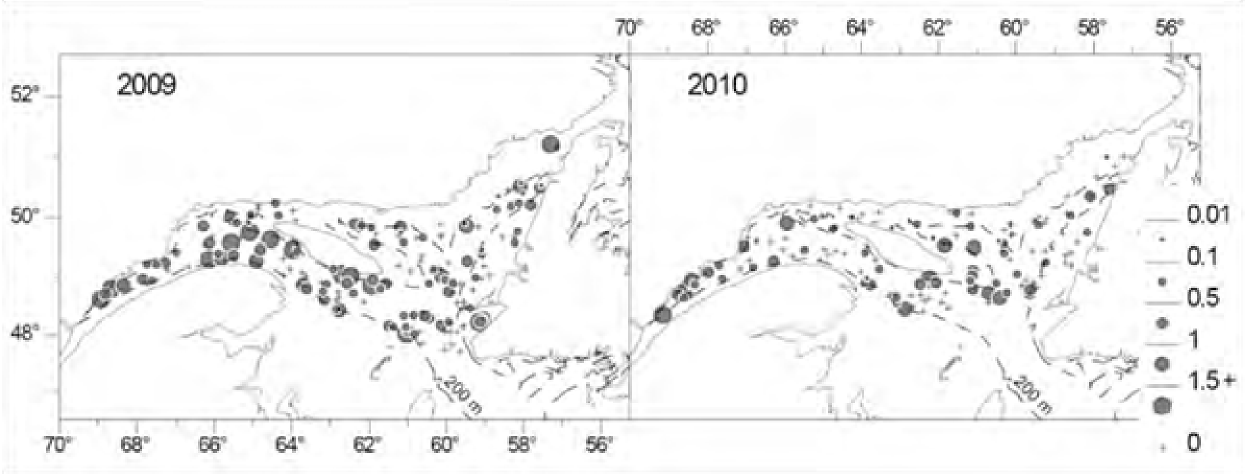
5.4.3.1 Pelagic Fish

Atlantic Herring

Atlantic herring is a cold-water, coastal, pelagic species that can be found within waters on both sides of the North Atlantic Ocean. Juveniles undergo complex north-south and inshore-offshore migrations during their lives for spawning, feeding and overwintering (DFO 2010j).

Herring eggs are heavier than water and the demersal eggs are laid on substrates as large as boulders to as fine as sand, shell fragments and even macrophytes. Spawning in the southern Gulf occurs in the spring (April to May / June) in waters less than 10 m deep and fall (mid-August to October) in water depths of 5 to 20 m (DFO 2010k). Eggs hatch in 10 to 15 days (DFO 2010j). The larval stage lasts from four to eight months depending on the time of spawning and the associated water temperatures. During this time, the larvae survive on the attached yolk sac and feed opportunistically on zooplankton. The planktonic herring larvae make vertical migrations daily or semi-daily. The purpose for these migrations is not completely understood (DFO 2010j). The larval stage ends in early spring (April to May), when Atlantic herring larvae metamorphose into juveniles. Juveniles form large schools in coastal waters and in the fall and in early winter, move to deep bays or near the seafloor in offshore areas to overwinter (DFO 2010j). Males and females mature at approximately three to four years of age and adults have a diet consisting of euphausiids (krill), chaetognaths and copepods, with the juvenile diet similar to that of the adults (DFO 2010j).

The 2009 and 2010 distribution of Atlantic herring in the Estuary and northern Gulf is presented in Figure 5.32, as obtained by DFO during the annual summer trawl surveys conducted onboard the *CCGS Teleost* (Bourdages et al. 2010).



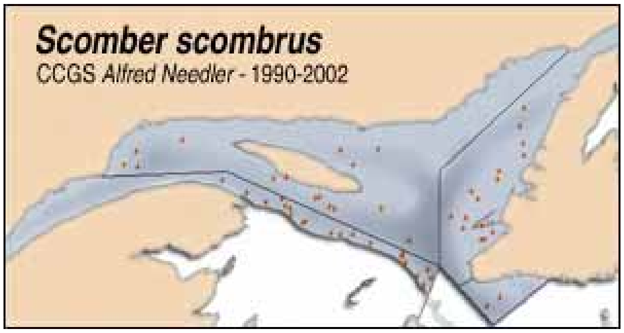
Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.32 Atlantic Herring Distribution in the Estuary and Northern Gulf of St. Lawrence

Atlantic Mackerel

Atlantic mackerel belong to the order Perciformes, family Scombridae. The family Scombridae is widely distributed through temperate and tropical waters and of the three species that occupy the genus *Scomber*, the Atlantic mackerel has the most northerly distribution. The Atlantic mackerel is found on the eastern and western coasts of the Atlantic from the Mediterranean to Norway and North Carolina to Newfoundland. In the spring and summer, mackerel are found in coastal waters, where they move to deeper waters in the fall to overwinter (DFO 2007a). Within Canadian waters, the Gulf is recognized as prime mackerel spawning grounds. Spawning generally occurs in June and July in coastal regions (Studholme et al 1999). Spawning occurs near the surface and the eggs incubate for approximately one week. During incubation, the eggs float above the thermocline (Studholme et al. 1999). Mackerel go through a larval stage where the yolk sac is absorbed into the body over the course of a couple months while fins are being developed. Once the fins are developed and the yolk sacs absorbed, the juvenile mackerel form schools and remain in coastal waters (DFO 2007a).

Maturity is reached generally at a younger age than other species and by the age of four, all mackerel are sexually mature. Adult mackerel feed on zooplankton including copepods, planktonic crustaceans, euphausiids, amphipods and chaetognaths. The distribution of Atlantic mackerel in the Estuary and northern Gulf is presented in Figure 5.33.



Source: http://slgo.ca/app-guidesp/en/poiss/sp/s-scombrus.html

Figure 5.33 Atlantic Mackerel Distribution in the Estuary and Northern Gulf of St. Lawrence

Swordfish

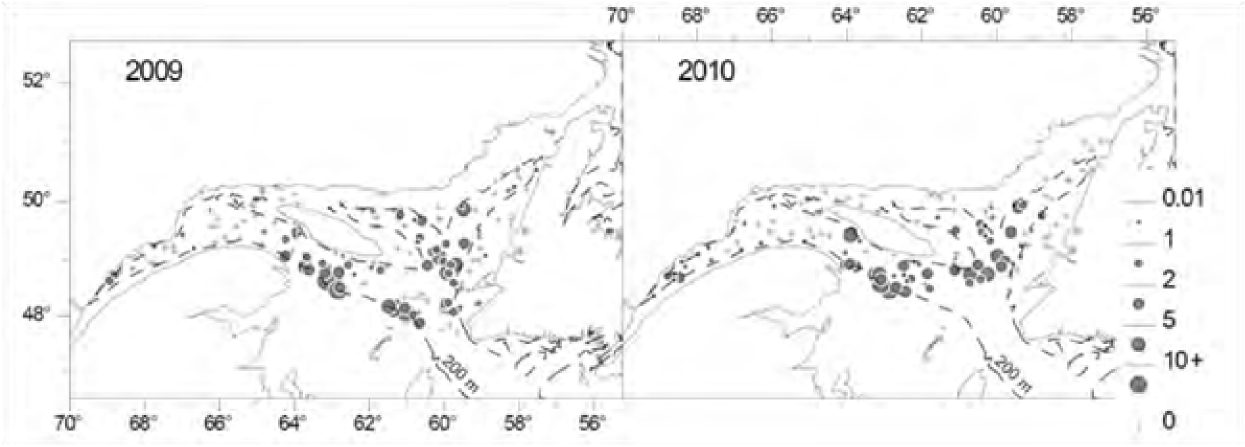
A highly migratory species, swordfish spawn in the southern Atlantic Ocean in the Sargasso Sea in the spring (Bigelow and Schroeder 1953). Migration beginning in the spring brings numerous individual swordfish to the waters of the North Atlantic. They are commonly found off the east coast of Nova Scotia throughout June to October and are also found within the western Gulf. The fish migrate north in search of food stocks, mostly other pelagic species such as Atlantic mackerel, silver hake, redfish and herring. The typically oceanic species can occur at water depths of up to 375 m and may on occasion be found in coastal waters (Bigelow and Schroeder 1953).

5.4.3.2 Demersal Fish

Atlantic Halibut

A cold-water demersal flatfish, the Atlantic halibut can be found in waters on both sides of the North Atlantic and into parts of the Arctic. They are found throughout the Estuary and Gulf, occurring at depths of 200 m and more in the northern Gulf and less than 100 m in the southern Gulf (DFO 2009l). Atlantic halibut spawn annually between winter and spring (January to May in the Gulf (DFO 2009l)), synchronous within a group. Females are batch spawners able to ovulate several batches of eggs during one winter. Atlantic halibut eggs are some of the largest in the fish community, measuring up to 4 mm. Once fertilized, the eggs are deposited into the water column and free-float at depths ranging from 54 to 200 m (Scott and Scott 1988). The eggs are neutrally buoyant in salinities ranging from 35 to 37 ppt, meaning the Atlantic halibut eggs would sink towards the seafloor. Incubation of the eggs lasts for up to 20 days. Upon hatching into a larval state, the larvae are 6 to 7 mm long and have no pigment, functional eyes, or mouth (DFO 2011i). Little is known on the larval stage of the Atlantic halibut, but it is thought that the larvae remain close to the water surface. The larvae survive on a relatively large yolk sac, which is completely absorbed after 50 days. Eye migration begins approximately at day 80 (Scott and Scott 1988). Juveniles are known to inhabit distinct nursery grounds for three to four years before migration to spawning habitat (DFO 2006b). Sexual dimorphism is present within adult of the species, with females substantially larger than males. Adult populations feed on fish, mollusks and crustaceans, with a similar diet in the juvenile stages.

The 2009 and 2010 distribution of Atlantic halibut in the Estuary and northern Gulf is presented in Figure 5.34, as obtained by DFO during the annual summer trawl surveys conducted onboard the *CCGS Teleost* (Bourdages et al. 2010).

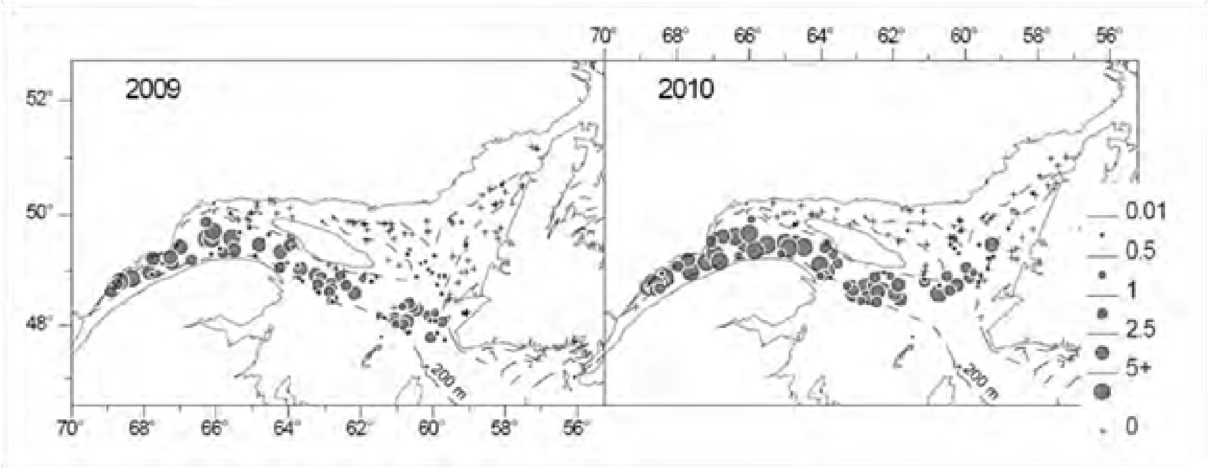


Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.34 Atlantic Halibut Distribution in the Estuary and Northern Gulf of St. Lawrence

Atlantic Hagfish

Atlantic hagfish are eel-shaped, demersal species characterized by soft-scaled skin and four pairs of barbells surrounding the terminal mouth. It is a cold water species that prefers soft mud seafloor habitat and lives at depths varying from 30 to 1,200 m. Hagfish are generally found concealed beneath the soft mud with the anterior region extruding. Details of the reproductive cycle are limited and there appears to be no pre-determined timeframe for spawning. Although not hermaphrodites, mature hagfish do possess underdeveloped gonads of the opposite sex. Fertilization occurs externally and no larval stage occurs. Eggs are large (approximately 25 mm) and few, with females having a count of only 19 to 30 eggs released per clutch. The eggs have terminal filaments that allow them to attach to the substrate or other eggs (Bigelow and Schroeder 1953). Atlantic hagfish feed predominantly on immobile or injured organisms and consume internal organisms and flesh, often entering the corpse through the mouth or gills (Newfoundland and Labrador Department of Fisheries and Aquaculture undated A). The distribution of Atlantic hagfish in the Estuary and northern Gulf is presented in Figure 5.35.

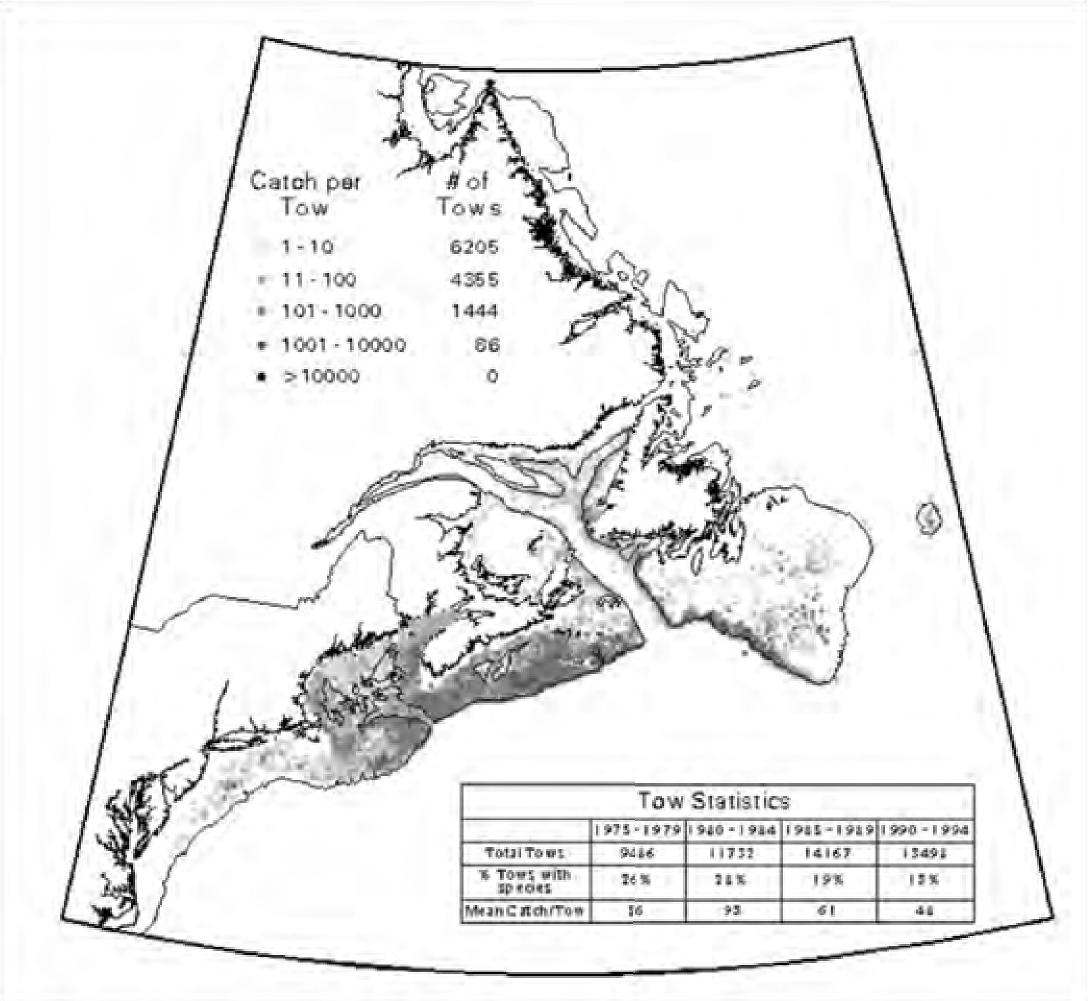


Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.35 Atlantic Hagfish Distribution in the Estuary and Northern Gulf of St. Lawrence

Haddock

Haddock is a demersal species that is distributed from Greenland to the eastern mid-Atlantic. Haddock spawn over pebble and gravel substrate (avoiding rocks, kelp and soft mud) between March and April. The eggs are spawned on the seafloor but become buoyant after fertilization and rise in the water column (Cargnelli et al. 1999a). Hatching occurs 9 to 32 days after spawning. Larvae metamorphose into juveniles in 30 to 42 days, with an average length of 2 to 3 cm. The juveniles inhabit the upper water column, where they are opportunistic feeders on zooplankton. After three to five months, the juveniles migrate to the seafloor, where they begin their demersal life (Cargnelli et al. 1999a). Early juveniles feed on less motile prey such as invertebrate eggs, copepods and phytoplankton. Adults tend to feed more on polychaetes and ophiuroids, but haddock are mostly opportunistic and will feed on crustaceans, polychaetes, mollusks and echinoderms. Adults are strongly associated with hard substrate seafloors of pebble and gravel and found in water depths from 40 to 150 m (Cargnelli et al. 1999a). The distribution of haddock in the western Atlantic (according to Cargnelli et al. (1999a)) is provided in Figure 5.36.



Tow Statistics

	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
Total Tows	9466	11732	14167	13498
% Tows with species	26%	28%	19%	15%
Mean Catch/Tow	36	93	61	48

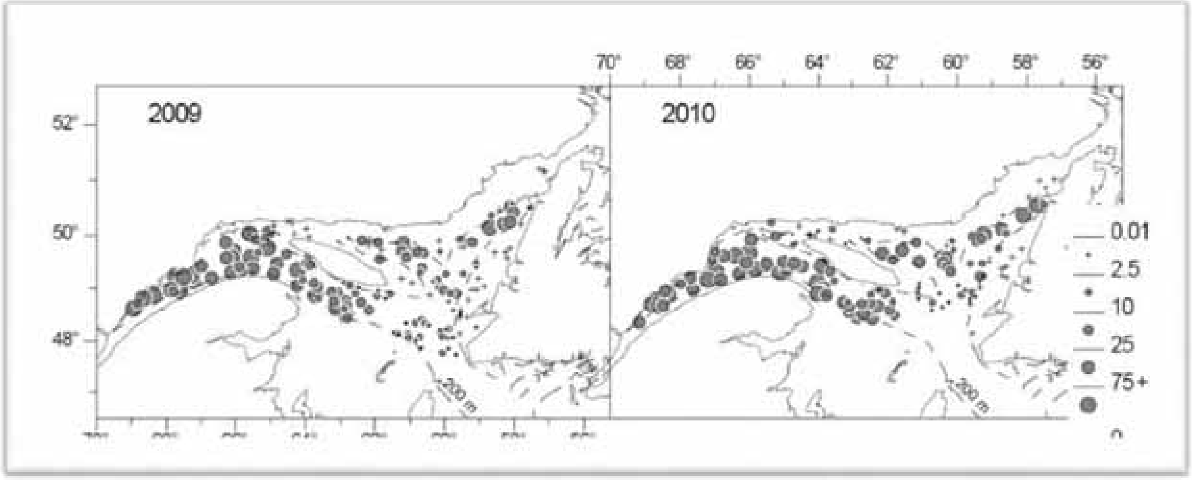
Source: Cargnelli et al. 1999a.

Figure 5.36 Haddock Distribution along the Western Atlantic

Greenland Halibut (Greenland turbot)

Greenland halibut, also fished under the name Greenland turbot, is a cold-water, demersal flatfish species. Greenland halibut is described as having an amphiboreal distribution, meaning it is found in both the Atlantic and Pacific oceans. In the Atlantic Ocean, Greenland halibut can be located from Davis Strait through Newfoundland to as far south as the Gulf of Maine. Greenland halibut are widely distributed through the Gulf. In summer, the main populations are found in the St. Lawrence Estuary, the areas west and northeast of Anticosti Island, and near the west coast of Newfoundland in the Esquiman Channel (DFO 2010l).

Spawning generally occurs in the winter (November to February) within the Cabot Strait and can occur in depths of up to 1,000 m (DFO 2000b). Eggs are fertilized externally and float low within the water column. Eggs incubate for up to 12 weeks until metamorphosis into the larval stage. Early larval stages are also buoyant and found within the water column. Once the yolk sac has been absorbed, the larvae have been observed to rise in the water column. This is thought to correspond with the onset of feeding. Larval development lasts for up to 15 weeks and results in larval drift and dispersal from spawning areas (Chiperzak et al. 1995). In August or September and nearly one year post-spawning, the larvae settle to the seafloor, at which time the left eye has migrated to the right side of the fish. Unlike most flatfish, the migrating eye stops at the dorsal margin of the head (Alton et al. 1988). Adults reach maturity sooner in the Gulf (on average in 7.8 years). Adults generally feed on small crustaceans, demersal fishes (particularly redfish) and squid. The distribution of Greenland halibut in the Estuary and northern Gulf is presented in Figure 5.37.

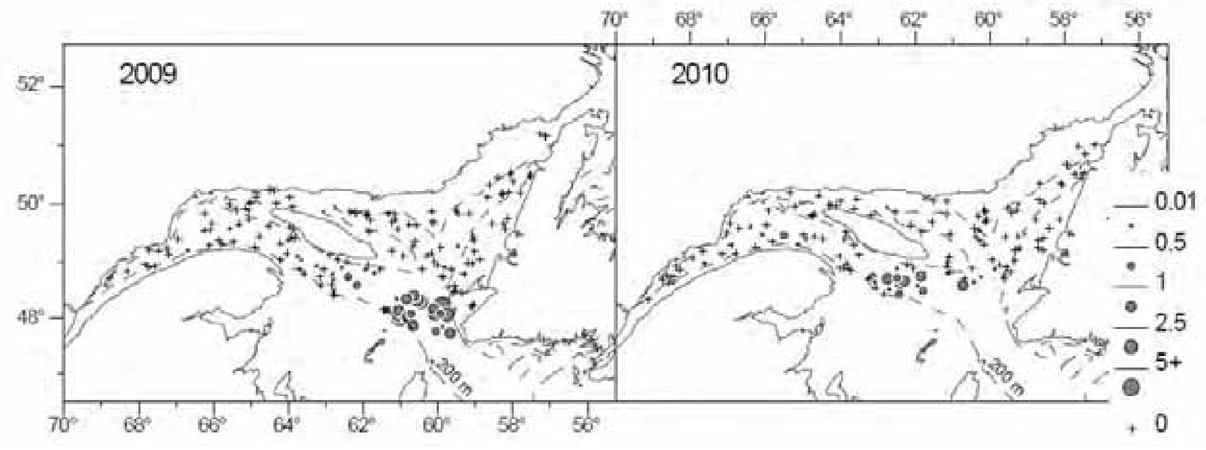


Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.37 Greenland Halibut Distribution in the Estuary and Northern Gulf of St. Lawrence

Longfin Hake

Longfin hake is a benthic species distributed along the outer continental shelves of the western North Atlantic. This sedentary species is often found on the seafloor and often associated with silty-sand substrates at water depths from 360 to 800 m. The most recent distribution of longfin hake in the Estuary and northern Gulf for 2009 and 2010 is presented in Figure 5.38. It should be noted that 2010 is the lowest recorded indices of longfin hake and that the highest catch rates are generally made in the eastern portion of the Laurentian Channel and near Cabot Strait, as seen in 2009 in Figure 5.38 (Bourdages et al. 2010). However, because of technical issues, this particular area was not sampled in 2010 and smaller catches were recorded further upstream in the Laurentian Channel, as illustrated in Figure 5.38 (Bourdages et al. 2010). Spawning of longfin hake occurs from late September to April, peaking in December and January (Cohen et al. 1990). Fecundity is generally high and development resembles that of other gadiforms with buoyant eggs that contain a large oil globule and where the eggs most likely develop in the pelagic zone. Young longfin hake remain pelagic for up to 18 months before descending to the seafloor (Coad et al. 1997). Longfin hake's diet is poorly documented and includes crustaceans (shrimp) and euphausiids (Collette and Klein-Macphee 2002).

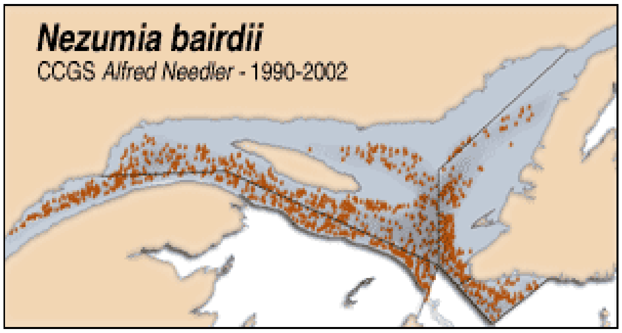


Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.38 Longfin Hake Distribution in the Estuary and Northern Gulf of St. Lawrence

Marlin-spike Grenadier

Marlin-spike grenadier is a demersal species distributed along the outer continental shelves of the western North Atlantic. This species lives on or near the bottom and is often associated with silty-sand substrates and generally found at water depths from 360 m to 1,700 m. Spawning occurs during summer and into autumn (Collette and Klein-Macphee 2002). Development Marlin-spike grenadier eggs most likely resemble that of other gadiforms with buoyant eggs that contain a large oil globule and which likely develop below the thermocline. The young are pelagic for up to two years and inhabit shallower regions than the mature adults (Collette and Klein-Macphee 2002). Langton and Bowman (1980) and NAFO (1987) provide some information on their diet; while both studies were limited by the sample size, similarities in the diet composition exist and indicate that marlin-spike grenadiers feed on amphipods, crustaceans (shrimp), polychaetes and small bivalves. The distribution of marlin-spike grenadier in the Estuary and northern Gulf is presented in Figure 5.389

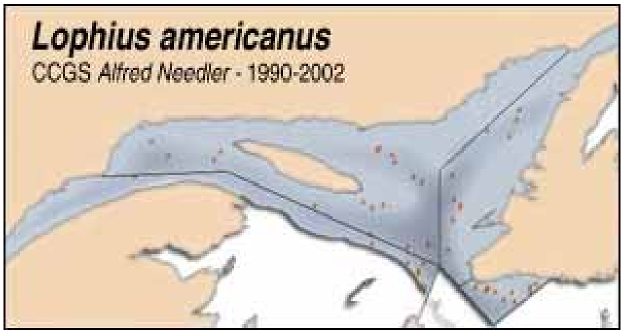


Source: http://slgo.ca/app-guidesp/en/poiss/sp/l-americanus.html

Figure 5.39 Marlin-spike Grenadier Distribution in the Estuary and Northern Gulf of St. Lawrence

Monkfish

Monkfish, sometimes known as goosefish, is a large demersal fish from the family Lophiidae. The large, bulky head and enormous mouth characterize this species. Monkfish are distributed throughout the Western Atlantic Ocean from Florida to Labrador (Newfoundland and Labrador Department of Fisheries and Aquaculture undated B). The Gulf provides habitat for an abundant population within the warmer shelf waters. The monkfish prefer waters of between 6°C and 10°C (DFO 2000c) and research has shown that the monkfish will migrate to shallower water in summer and into deeper water throughout the winter (DFO 2000c). Monkfish can inhabit depths ranging from subtidal to 650 m. Spawning generally occurs in the fall (June to September), with the eggs deposited on the seafloor within large mucus sheets. Once fertilized, the eggs hatch in approximately seven days into larvae complete with pelvic fins and dorsal head spines (DFO 2000c). The larvae are pelagic for the first several months as opportunistic planktonic feeders prior to starting their demersal lives. Sexual maturity is reached between four and seven years. Adults consume a variety of marine organisms but are mainly piscivorous, with prey that includes herring, sand lance, alewife (*Alosa pseudoharengus*), smelt, cod, mackerel, striped bass, sculpin, sea raven, flounder, skate, crab, shrimp, starfish and marine worms (DFO 2000c). The distribution of monkfish in the Estuary and northern Gulf is presented in Figure 5.40.

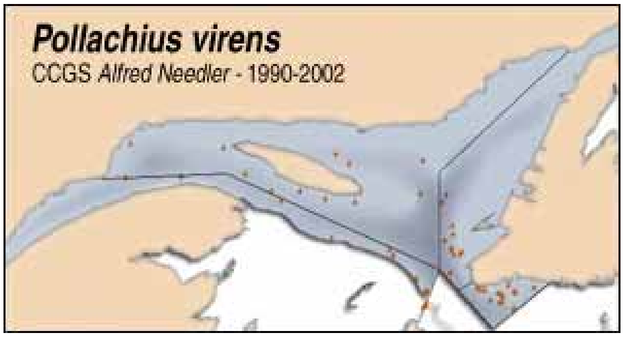


Source: http://slgo.ca/app-guidesp/en/poiss/sp/l-americanus.html

Figure 5.40 Monkfish Distribution in the Estuary and Northern Gulf of St. Lawrence

Pollock

Pollock are a cold water fish of the same family as cod, although pollock generally spend less of their life on the seafloor as a true demersal species. Stocks are generally distributed from Cape Hateras to the Labrador Shelf. The timeframe for spawning is variable in the northern habitats and generally occurs from fall to spring (September to April), peaking in December to February. The principle pollock spawning areas include the Scotian Shelf, Georges Bank, the Great South Channel and the Gulf of Maine. Pollock prefer hard stony or rocky bottoms. Pollock eggs are buoyant and after fertilization rise in the water column. Upon metamorphosis to a larval state, the pelagic larvae feed on zooplankton, including copepods, for several months. The juvenile pollock migrate inshore to inhabit rocky subtidal zones and undergo onshore-offshore migration based on temperature fluctuations (Cargnelli et al. 1999b). Pollock remain generally stationary with the exception of short migrations for spawning. Sexual maturity is reached between the ages of four to seven years (DFO 1999b). Adults consume euphausiids, fish and mollusks, juvenile diets are similar but composed of more coastal species (DFO 1999c). The distribution of pollock in the Estuary and northern Gulf is presented in Figure 5.41.

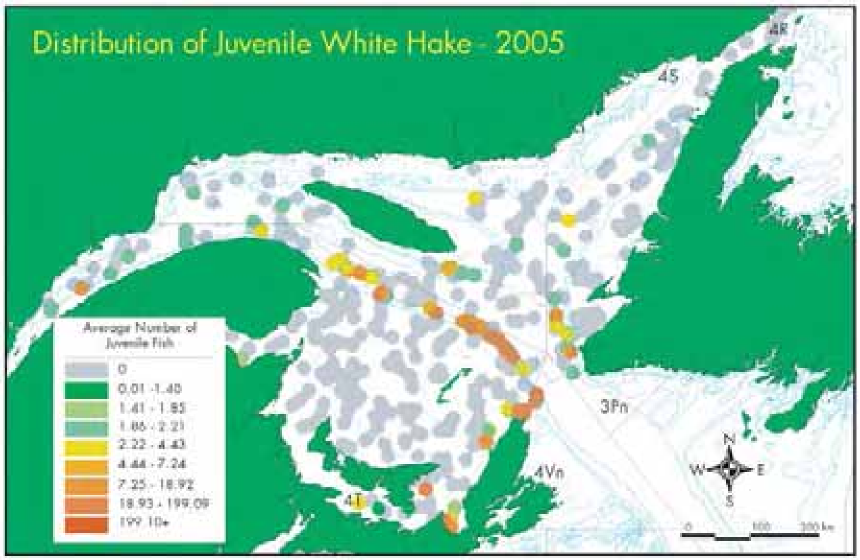


Source: http://slgo.ca/app-guidesp/en/poiss/sp/p-virens.html

Figure 5.41 Pollock Distribution in the Estuary and Northern Gulf of St. Lawrence

White Hake

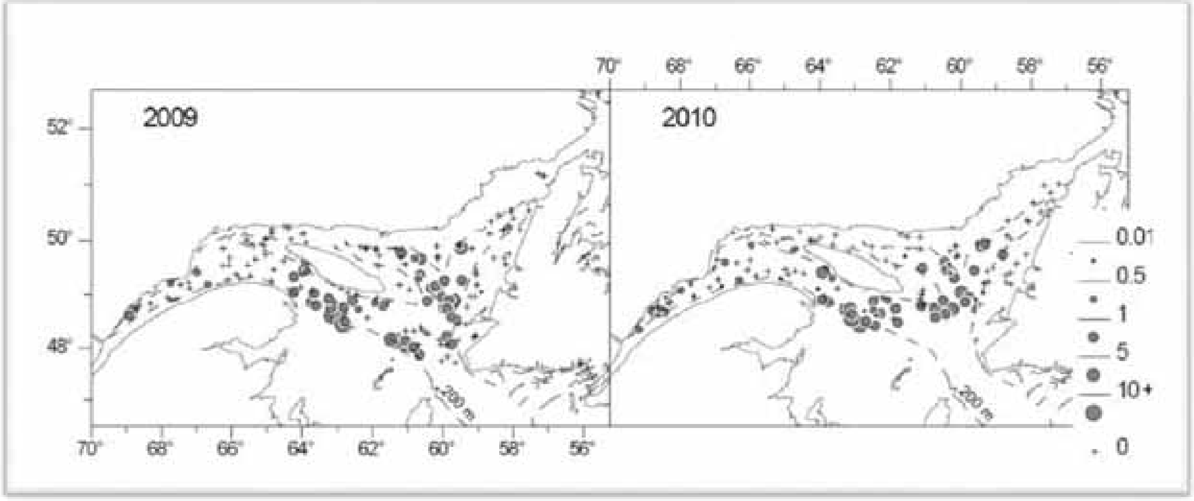
White hake are a demersal species occurring from the Middle Atlantic Bight to the Gulf. White hake spawn in the summer (June to September) (DFO 2009m). Spawning occurs in open water, with the fertilized eggs remaining near the surface. Eggs hatch in three to seven days, with larvae remaining in the water column to feed. Juveniles migrate toward coastal habitats and can often be found within beds of eelgrass, feeding on shrimps and polychaetes. Sexual maturity is reached between two and five years. Food sources for adults include shrimp, krill and some fish. It is believed that the long pelvic fins are used to feel prey in the soft sediments that the white hake often inhabit as adults (DFO 2009m). Modelled juvenile white hake densities (from DFO RV data) for 2005 are illustrated in Figure 5.42.



Source: Ollerhead and Lawrence 2007.

Figure 5.42 Distribution of Juvenile White Hake, 2005

The distribution of white hake in the Estuary and northern Gulf is presented in Figure 5.43, as obtained by DFO during the annual summer trawl surveys (Bourdages et al. 2010).



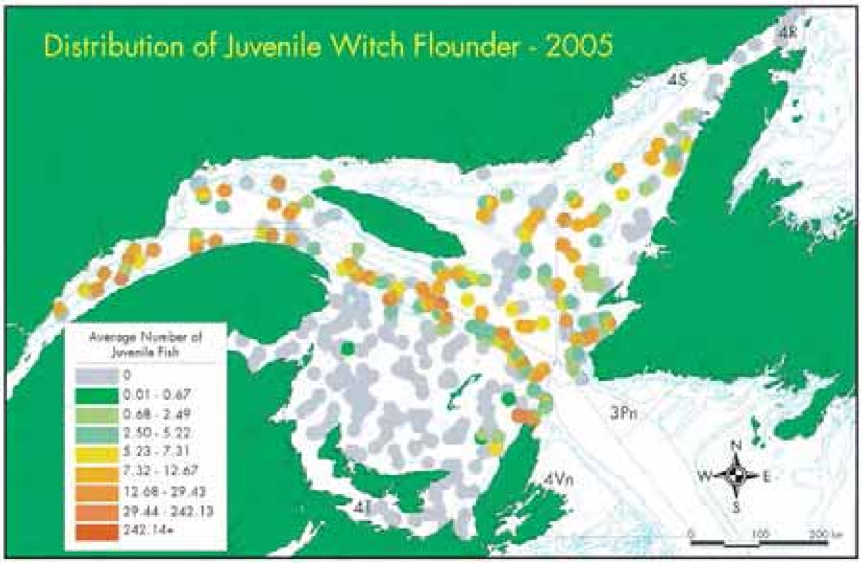
Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.43 White Hake Distribution in the Estuary and Northern Gulf of St. Lawrence

Witch Flounder

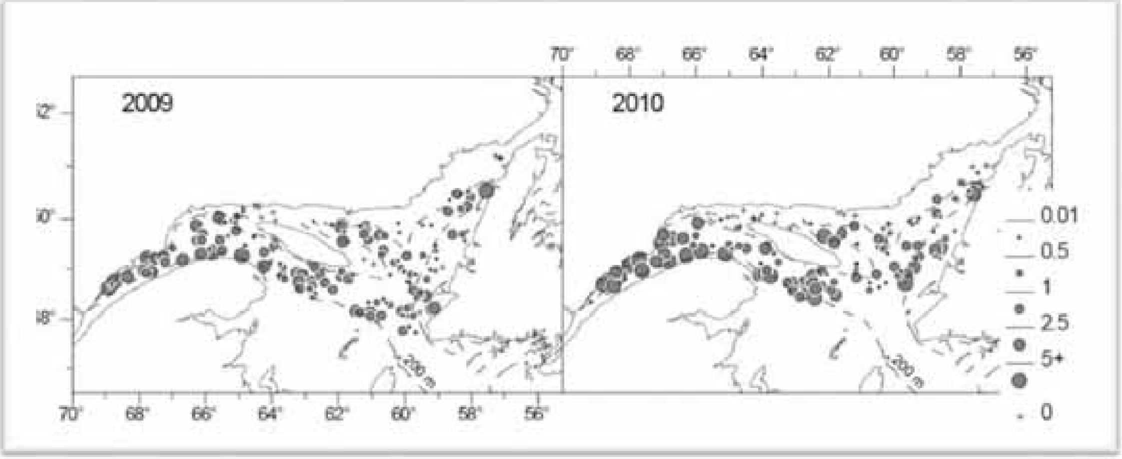
Witch flounder, also known as greysole, are a demersal flatfish found in deep waters of the North Atlantic from lower Labrador to Cape Hatteras, North Carolina. Witch flounder aggregate in deep channel waters like those found in the Laurentian Channel, just southwest of St. Georges Bay, from January to February prior to spawning. Spawning occurs from spring to late summer (DFO 2009n). The fertilized eggs float and hatch after several days (Cargnelli et al. 1999c). The larvae undergo a pelagic existence for up to a year, feeding on plankton before the juveniles settle to the bottom to begin their demersal life. In the Gulf, witch flounder move to deep water during the winter, where feeding can cease. Modelled juvenile witch flounder densities (from DFO RV data) for 2005 are illustrated in Figure 5.44.

Witch flounder can be found in waters up to 1,569 m off the coast of Nova Scotia, although the highest abundance is caught within 185 to 400 m (DFO 2009n). Witch flounder are sedentary and appear to undertake very minimal migrations, with the populations aggregating in spawning habitats (Cargnelli et al. 1999c). The small head and mouth of the witch flounder restricts the size of prey available for consumption. Main prey includes marine worms, small crustaceans, or shellfish (Cargnelli et al. 1999c). The distribution of witch flounder in the Estuary and northern Gulf is presented in Figure 5.45.



Source: Ollerhead and Lawrence 2007.

Figure 5.44 Distribution of Juvenile Witch Flounder, 2005

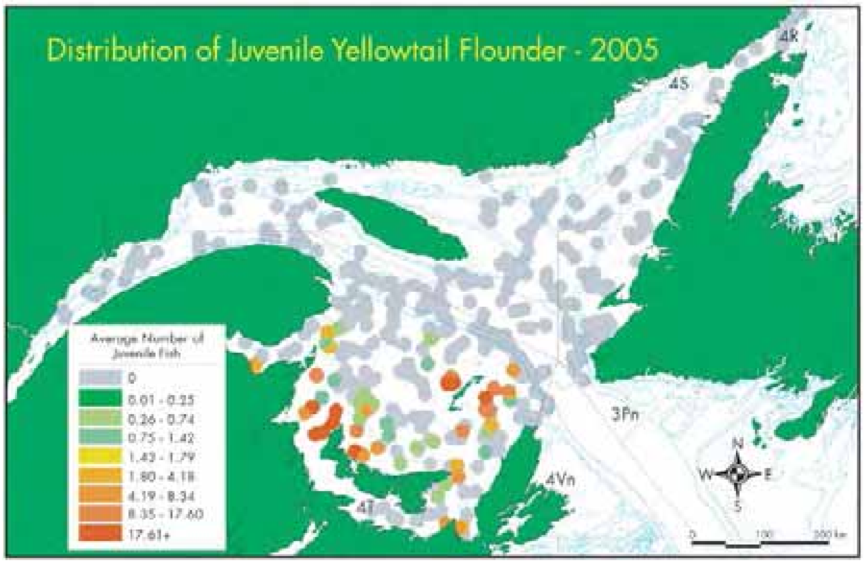


Source: Bourdages et al. 2010; distribution data presented as catch rate (kg/15 minute tow)

Figure 5.45 Witch Flounder Distribution in the Estuary and Northern Gulf of St. Lawrence

Yellowtail Flounder

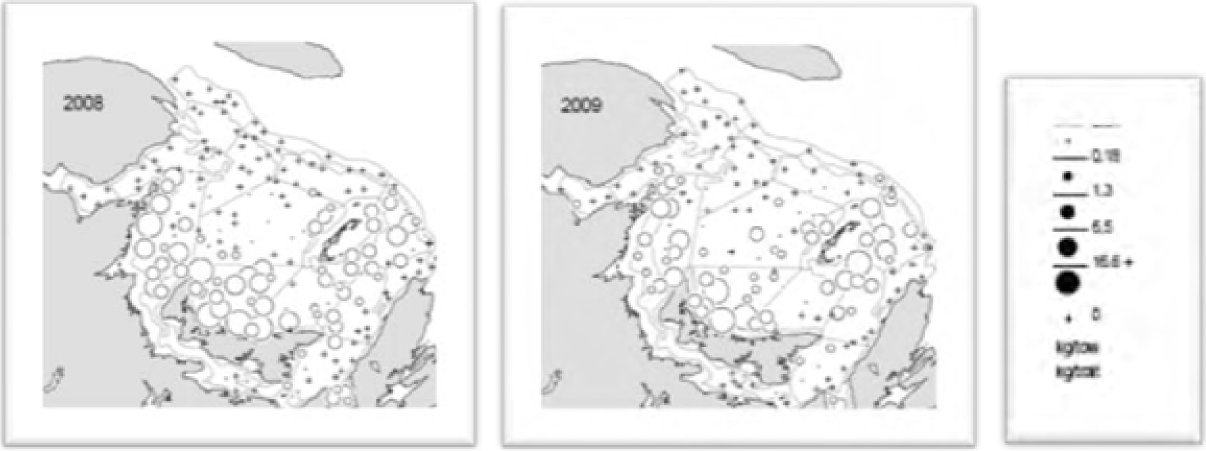
Yellowtail flounder is a demersal flatfish found in the waters from Chesapeake Bay to Labrador. Yellowtail flounder are prevalent around the Magdalen Islands and within the coastal waters of New Brunswick, Prince Edward Island and Nova Scotia within the Northumberland Strait (DFO 2009o). Spawning occurs on or near the seafloor in spring to early summer (May to July) (Johnson et al. 1999). The fertilized eggs float to the surface and drift during development. Hatching of the eggs occurs approximately five days after fertilization (DFO 2009o). The larvae remain in a pelagic state for a short time before drifting downward. Yellowtail flounder mature after three to five years and tend to inhabit waters less than 100 m deep where the bottom is composed of sand-mud sediments (Johnson et al. 1999). Yellowtail flounder have recently been discovered to move off the bottom and, using mid-water tidal currents, displace from one area to another, although no clear migration patterns have been discovered. Adults tend to feed on crustaceans, polychaete worms and amphipods (DFO 2009o). Modelled juvenile yellowtail flounder densities (from DFO RV data) for 2005 are illustrated in Figure 5.46.



Source: Ollerhead and Lawrence 2007.

Figure 5.46 Distribution of Juvenile Yellowtail Flounder, 2005

The distribution of yellowtail flounder in the southern Gulf (as determined by DFO in bottom-trawl surveys (Hurlbut et al. 2010)) is presented in Figure 5.47.



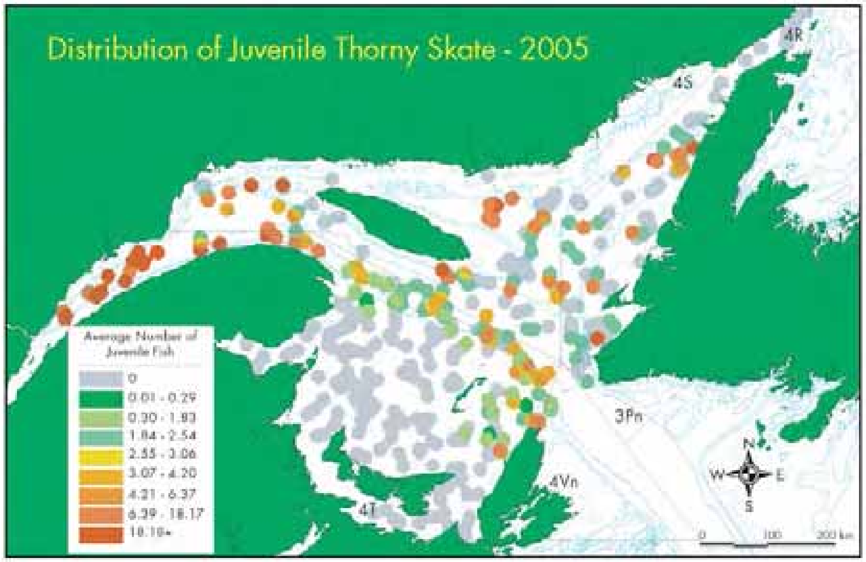
Source: Hurlbut et al. 2010.

Figure 5.47 Yellowtail Flounder Distribution in the Southern Gulf of St. Lawrence

Thorny Skate

The distribution range of the thorny skate extends from Greenland to South Carolina. Thorny skate occur at depths ranging from 20 to greater than150 m and at temperatures ranging from -1.4°C to 6.0°C. In recent years, skate have been concentrating along the southwest slope and edges of the Grand Banks and it is estimated that approximately 80 percent of the biomass reside in this region (Kulka et al. 2004b). The greatest decline in thorny skate abundance has occurred in the northern extent of its range.

Skate rarely move more than 100 km and is considered a sedentary species. However, there are indications of seasonal migration from the plateau of the Grand Banks in winter to the edge and slope, returning in early summer (Kulka et al. 2004b). Egg cases are released in the fall and winter and hatching occurs approximately six months later. Young skates emerge from the egg case as free-swimming fish. They feed on polychaetes, crabs, whelks, sculpins, redfish, sand lance and haddock, with fish being more important prey items for larger skate (Scott and Scott 1988). Modelled juvenile thorny skate densities (from DFO RV data) for 2005 are illustrated in Figure 5.48.



Source: Ollerhead and Lawrence 2007.

Figure 5.48 Distribution of Juvenile Thorny Skate, 2005

5.4.4 Biologically Sensitive Periods

The activities for the proposed Project will occur during the ice-free season. Therefore, those fish known or suspected to spawn within the vicinity of EL 1105 during ice-free periods are of highest concern for potential interactions with the Project activities. The annual spawning activities of the principal commercial fish and shellfish species recorded in or near EL 1105 are provided (Table 5.11). The Gulf fish species anticipated to spawn or mate outside the winter season include most fish such as Atlantic herring, roundnose grenadier, roughhead grenadier, marlin-spike grenadier, pollock, longfin hake, white hake, redfish, Atlantic hookear sculpin, sea raven, northern wolffish, Atlantic wolffish and spotted wolffish (Scott and Scott 1988;

LGL 2005b; Rodger 2006; FishBase 2010). Spawning activities range from the deep waters preferred by the grenadiers and wolffishes (Rodger 2006; FishBase 2010), to the variable depths within which pollock will spawn (approximately 27 to 91 m), to the sea raven's use of marine sponges as spawning beds, and to the summer spawning activities of the bottom-dwelling white hake (Rodger 2006). Atlantic mackerel move inshore to spawn in the spring, primarily in the southwestern Gulf, which is outside the area of interest for this Project (Rodger 2006). Atlantic cod also spawn in the spring, although the spawning period can extend into the early fall as well. In the southwestern Gulf, cod spawning typically peaks in late June, although there is substantial diversity in spawning peaks across the population (Scott and Scott 1988). Atlantic cod also spawn at a wide range of depths, from 180 m to over 600 m (Rodger 2006). Witch flounder are known to form large pre-spawning concentrations in the Laurentian Channel (southwest of St. George's Bay) in January and February (DFO 2010m). Peak spawning in this area is anticipated to occur in late spring or early summer, based on observations of fish maturity during the January pre-spawning aggregation in the Laurentian Channel (DFO 2010m).

Potentially sensitive areas located near EL 1105, including a cod spawning area, a potential redfish larvae extrusion area and a potential redfish mating area, are discussed in Section 5.7.2. Redfish are slow growing and long-lived, deep-swimming fish that typically live at depths ranging from approximately 100 to 700 m (DFO 2010n). They stay close to the bottom during the day and move into the water column to feed at night (Rodger 2006). Redfish are lecithotrophic viviparous with internal fertilization (LGL 2005b). This means they give birth to live young (Scott and Scott 1988). They mate in the fall but extrusion of the larvae (i.e., the birth of the live young) does not occur until the spring, typically between April and July (LGL 2005b). It has been suggested that seismic and fishing activities can exert stress (prior to larval release), thereby potentially affecting the survival of redfish larvae (LGL 2007). Larval development of redfish, which precedes larval extrusion, occurs from February to June (Scott and Scott 1988). EL 1105 does not overlap physically with the delineated larvae extrusion area (LGL 2007). The recent designation of the Gulf, Laurentian Channel deepwater redfish and the Atlantic population of Acadian redfish as endangered by COSEWIC provides further confirmation that these fish are considered sensitive species, highly vulnerable to mortality from human activities (COSEWIC 2010b).

Table 5.11 Summary of Spawning and Hatching Periods for Principal Commercial Fisheries Species with the Potential to Occur in EL 1105

Common Name	Latin Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Atlantic halibut	*Hippoglossus hippoglossus*		🟧	🟥	🟧	🟧							
Atlantic herring	*Clupea harengus*								🟧	🟧	🟧	🟧	🟧
Atlantic haddock	*Melanogrammus aeglefinus*			🟧	🟧	🟧							
Atlantic mackerel	*Scomber scombrus*						🟧	🟧					
Atlantic cod	*Gadus morhua*					🟧	🟥	🟧	🟧	🟧			
Greenland halibut	*Reinhardtius hippoglossoides*	🟧	🟧	🟧	🟧							🟧	🟧
Monkfish	*Lophius americanus*						🟧	🟧	🟧	🟧			
Pollock	*Pollachius virens*	🟧	🟧	🟧	🟧					🟧	🟧	🟧	🟧
Redfish (deepwater and Acadian)	*Sebastes mentella / Sebastes fasciatus*			🟧	🟧	🟧	🟧	🟧		▨	▨	▨	▨
White hake	*Urophycis tenuis*					🟧	🟧	🟧	🟧				
Witch flounder (greysole)	*Glyptocephalus cynoglossus*	🟩	🟩	🟧	🟥	🟥	🟥	🟥	🟧	🟧			
Yellowtail flounder	*Limanda ferruginea*					🟧	🟧	🟧					
Lobster	*Homarus americanus*					🟧	▤	▤	▨				
Snow crab	*Chionoecetes opilio*		▨	▨	🟧	🟧	🟧						
Northern shrimp	*Pandalus borealis*				🟧	🟧			▨	▨	▨	▨	
Rock crab	*Hemigrapsus sexdentatus*					🟧	🟧	🟧	🟧		▨	▨	
Whelk	*Buccinum undatum*	🟧	🟧	▨	▨	▨	▨	▨	🟧	🟧	🟧	🟧	🟧
Scallop	potential for multiple species								🟧	🟧			

Data sources: Scott and Scott 1988; DFO 1997, 1998, 2000a, 2000b, 2002, 2006b, 2009h, 2009j, 2010d, 2010g; Cargnelli et al. 1999a, 1999b; LGL 2005b; Rodger 2006; Newfoundland and Labrador Department of Fisheries and Aquaculture undated B.

🟧	potential spawning and hatching periods
🟩	pre-spawning aggregation in Laurentian Channel
🟥	peak spawning period anticipated
▨	mating period
▤	overlap of spawning and mating periods

The principal commercial shellfish species in the vicinity of EL 1105 represent a range of mating and spawning periods (Table 5.11). The reproductive cycle of a lobster lasts approximately two years. Fertilization of eggs typically occurs in the summer, with hatching occurring 9 to 12 months after fertilization (DFO 2009i, 2009j). Snow crab mating occurs typically sometime from February to March, with mating pairs migrating to shallow waters in the spring. Female rock crab seems to typically extrude eggs in late October; the eggs mature over the winter and hatch the following spring or summer into free-floating larvae (DFO 2000a). Mature northern shrimp breed in the late autumn or early winter, with the eggs hatching in spring (Rodger 2006).

Scallop spawning takes place from late August to early September. Whelks inhabit most bottom types from low water levels to depths of more than 50 m (Environment Canada 2009). They have the potential to mate and spawn over long periods of time, resulting in their reproductive activities ranging over the full year.

5.5 Marine Birds

Many species of marine birds can be found in the Gulf and are divided into four groups:

- inshore / neritic birds;
- waterfowl;
- shorebirds; and
- offshore / pelagic birds.

Neritic seabirds feed in shallow waters, including shelf areas, and tend to return to land to rest over night. They include species such as cormorants, gulls and terns.

Waterfowl species can be divided into seaducks, bay ducks and dabbling ducks. All of the waterfowl species found in the Gulf (with the exception of eiders) nest near fresh water. Eiders typically nest on coastal islands and raise their broods in coastal waters. Outside of the breeding season, seaducks are found only on coastal waters. They often forage in exposed areas such as the waters around headlands but will also forage in sheltered bays. Seaduck species include eiders, scoters, Long-tailed Duck and Harlequin Duck. Outside of the breeding season, bay ducks forage in open freshwater or sheltered coastal waters such as bays and estuaries. Bay ducks found in the Gulf include Greater Scaup, Bufflehead, Common Goldeneye and Red-breasted Merganser. Dabbling ducks are most frequently encountered in shallow freshwater but will forage in highly sheltered coastal areas such as salt marshes and estuaries. American Black Duck is the most common dabbling duck present in the Gulf.

Shorebirds typically nest in wetland or upland habitats. Most species nest in inland habitats, but some species such as Willet and Piping Plover will raise their young in coastal habitats. Outside of the breeding season, most shorebirds forage along coastal beaches, mud flats or salt marshes, although phalaropes typically forage on the surface of the sea in areas where upwelling brings plankton to the surface. Some of the more abundant shorebird species found in the Gulf include Semipalmated Sandpiper, Semipalmated Plover, Greater Yellowlegs and Black-bellied Plover.

Pelagic seabirds feed at sea over deep waters and do not have to return to land to rest. However, they do return to land to breed on rocky cliffs and on islands. Common pelagic seabird species found in the Gulf include Northern Gannet, Greater Shearwater, Northern Fulmar, Common Murre, Dovekie, Atlantic Puffin, Leach's Storm-Petrel and Razorbill.

Neritic and pelagic seabirds can be referred together as seabirds, and there are approximately 18 different species of breeding seabirds found in the Gulf. Accidental spills of hydrocarbons represent the most important potential adverse effect of hydrocarbon exploration on seabirds. To this end, seabirds can be classified into two groups based on their vulnerability to oil pollution. Highly vulnerable seabirds are those that spend a considerable amount of time on the water, increasing the likelihood that they will come in contact with floating hydrocarbons. Highly vulnerable species also have low reproductive rates such that their populations are slow to recover from mortality events. Pelagic seabirds considered to be highly vulnerable to oil pollution include murres, Dovekies, Razorbill, Atlantic Puffin, Northern Gannet, Black-legged Kittiwake and Northern Fulmar. Neritic seabirds that are highly vulnerable include loons and grebes. Some species such as cormorants and seaducks are highly susceptible to oiling but have relatively high reproductive rates and are able to recover from mortality events more rapidly. These species are classed as vulnerable rather than highly vulnerable. Seabirds such as storm-petrels, terns and gulls that spend relatively little time on the water are not considered to be vulnerable.

A list of marine birds that could potentially occur in EL 1105 and off the western coast of Newfoundland is provided in Table 5.12. A discussion of vulnerable seabird nesting sites and tern colonies is contained in Sections 5.7.3 and 5.7.4.

Table 5.12 Marine Birds that Could Occur in the Vicinity of Exploration Licence 1105 and off Western Newfoundland

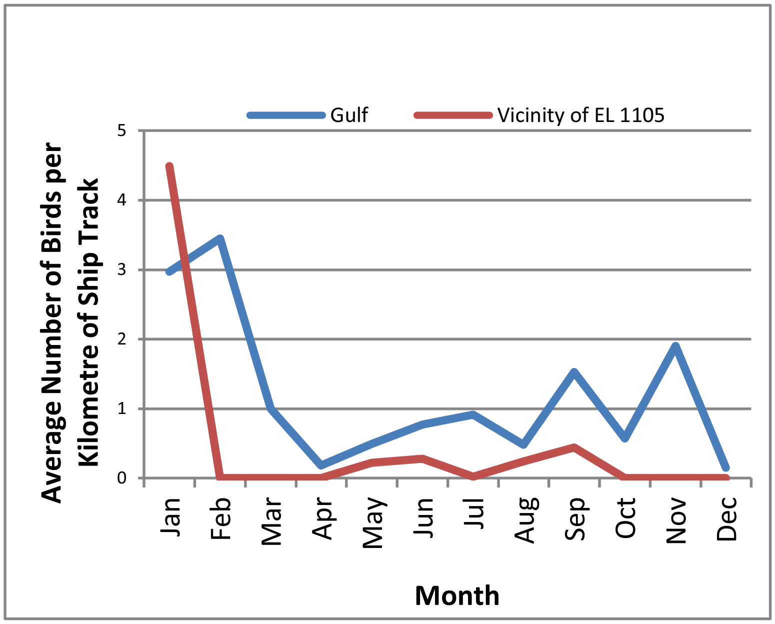
Common Name	Species Name
Waterfowl	
Harlequin Duck	*Histrionicus histrionicus*
Long-tailed Duck	*Clangula hyemalis*
Common Eider	*Somateria mollissima*
Red-breasted Merganser	*Mergus serrator*
Greater Scaup	*Aythya marila*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
American Black Duck	*Anas rubripes*
Shorebirds	
Semipalmated Sandpiper	*Calidris pusilla*
Semipalmated Plover	*Charadrius semipalmatus*
Greater Yellowlegs	*Tringa melanoleuca*
Black-bellied Plover	*Pluvialis squatarola*
Willet	*Tringa semipalmata*
Piping Plover	*Charadrius melodus*

Common Name	Species Name
Pelagic Seabirds	
Northern Gannet	*Morus bassanus*
Greater Shearwater	*Puffinus gravis*
Sooty Shearwater	*Puffinus griseus*
Northern Fulmar	*Fulmarus glacialis*
Common Murre	*Uria aalge*
Dovekie	*Alle alle*
Atlantic Puffin	*Fratercula arctica*
Leach’s Storm-Petrel	*Oceanodroma leucorhoa*
Wilson’s Storm-Petrel	*Oceanites oceanicus*
Razorbill	*Alca torda*
Black-legged Kittiwake	*Rissa tridactyla*
Great Cormorant	*Phalacrocorax carbo*
Double-crested Cormorant	*Phalacrocorax auritus*
Black Guillemot	*Cepphus grille*
Thick-billed Murre	*Uria lomvia*
Great Black-backed Gull	*Larus marinus*
Herring Gull	*Larus argentatus*
Ring-billed Gull	*Larus delawarensis*
Black-headed Gull	*Larus ridibundus*
Terns	
Caspian Tern	*Sterna caspia*
Common Tern	*Sterna hirundo*
Arctic Tern	*Sterna paradisaea*
Roseate Tern	*Sterna dougallii*

5.5.1 Seasonal Distribution of Seabirds and Coastal Waterfowl at Sea in the Gulf of St. Lawrence

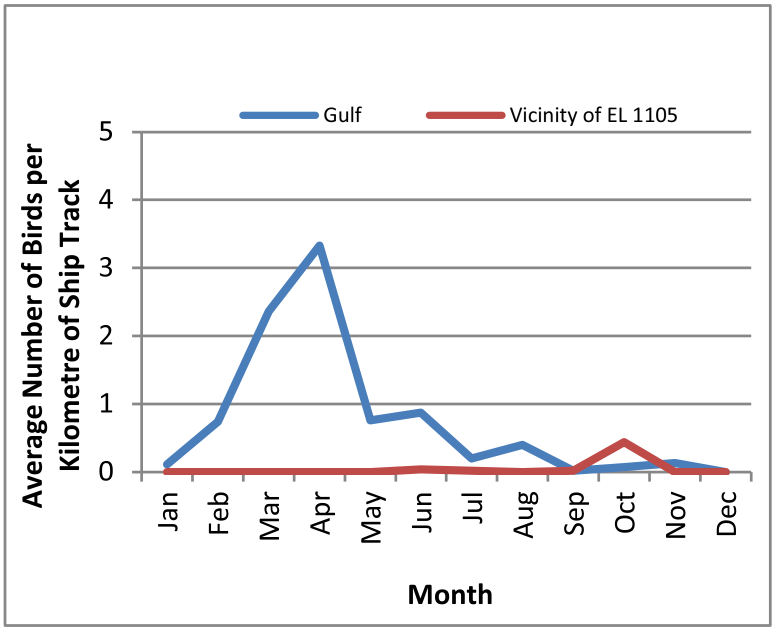
5.5.1.1 Seabirds

The abundance of various seabird species or seabird guilds by month in the Gulf are presented in Figures 5.49 to 5.56. These data are derived from PIROP (Programme Integre de Recherches sur les Oiseaux Pelagiques) data collected during the 1970s and 1980s (Lock et al. 1994) (note: the PIROP data set is the largest data set available describing the distribution and abundance of seabirds at sea. The Eastern Canadian Seabirds at Sea (ECSAS) data base is more recent but only includes three years of data compared to approximately 20 years for the PIROP data set; therefore, the PIROP data set still provides valuable information. In addition, the PIROP data set can be subdivided into smaller units to look at local patterns of seabird abundance and distribution. The ECSAS data are not presented in a way that allows investigation of subareas within the Gulf).



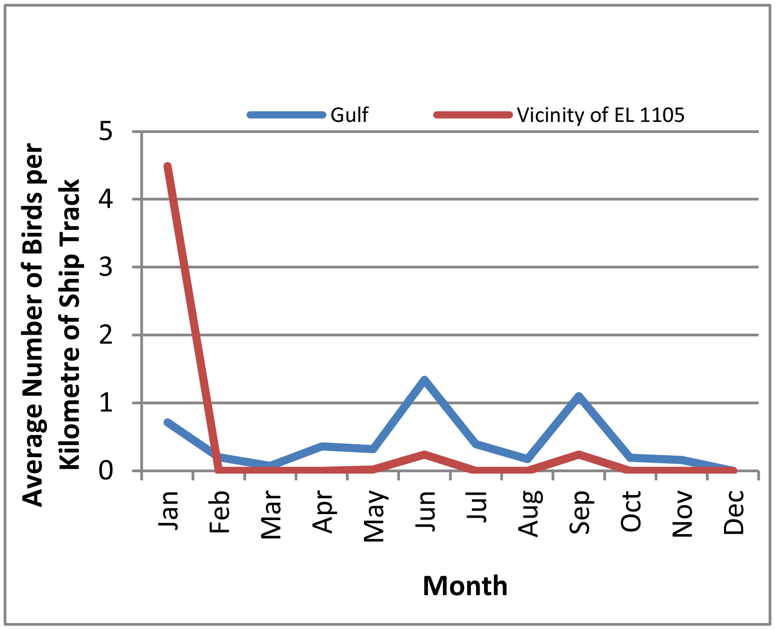
Source: Lock et al. 1994

Figure 5.49 Monthly Seabird Abundance of Black-legged Kittiwake in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



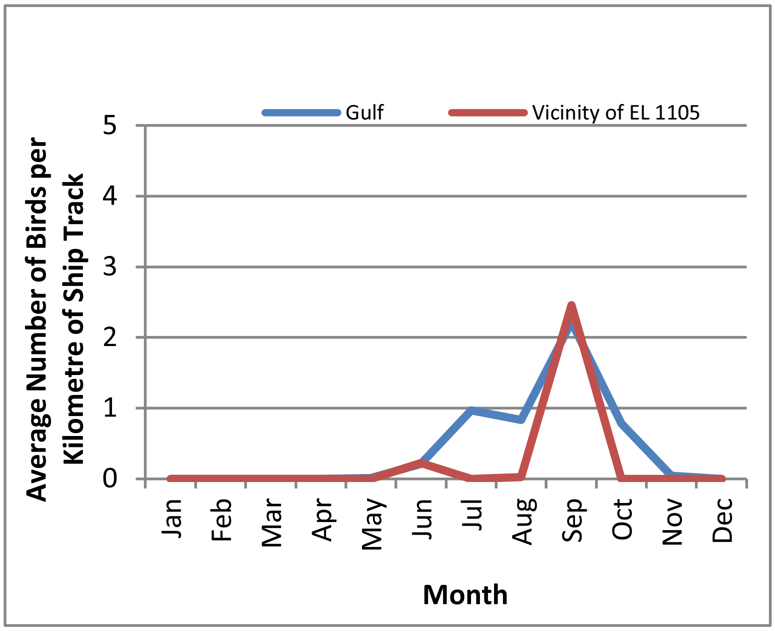
Source: Lock et al. 1994

Figure 5.50 Monthly Seabird Abundance of Large Auks in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



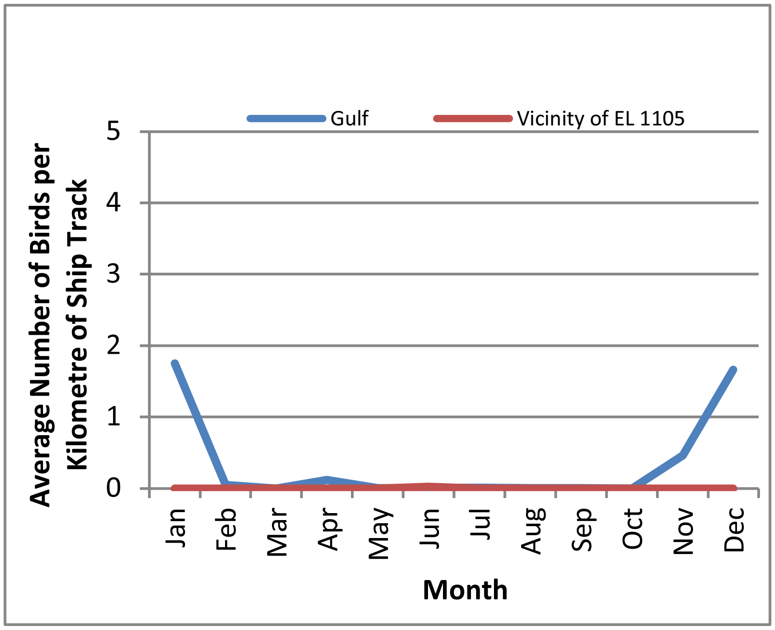
Source: Lock et al. 1994

Figure 5.51 Monthly Seabird Abundance of Northern Fulmars in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



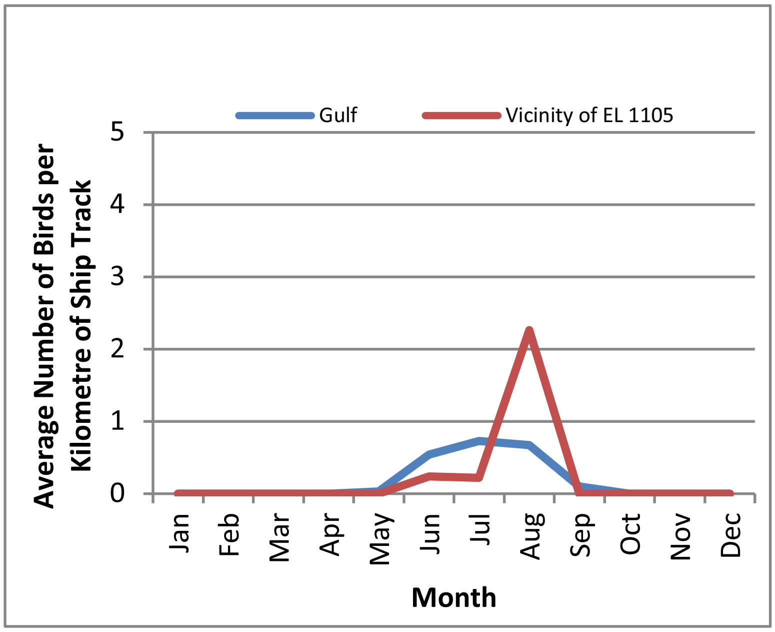
Source: Lock et al. 1994

Figure 5.52 Monthly Seabird Abundance of Greater Shearwater in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



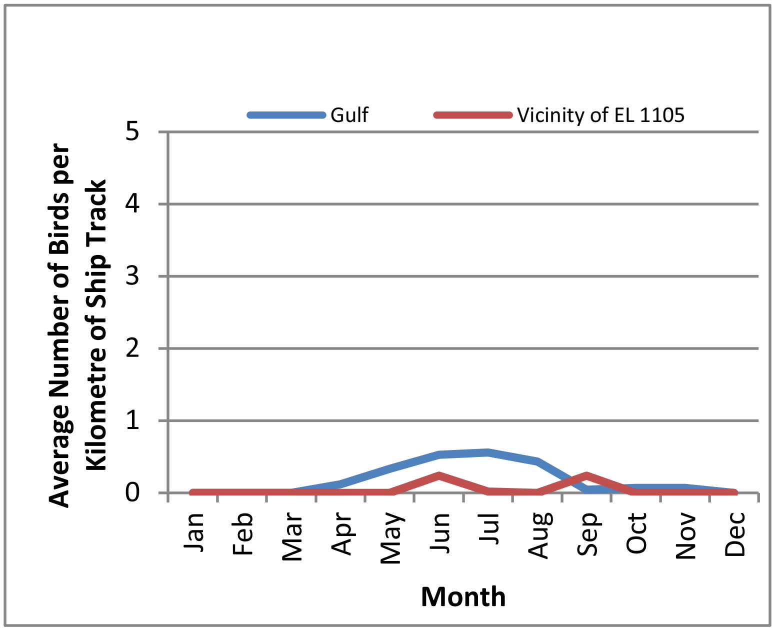
Source: Lock et al. 1994

Figure 5.53 Monthly Seabird Abundance of Dovekie in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



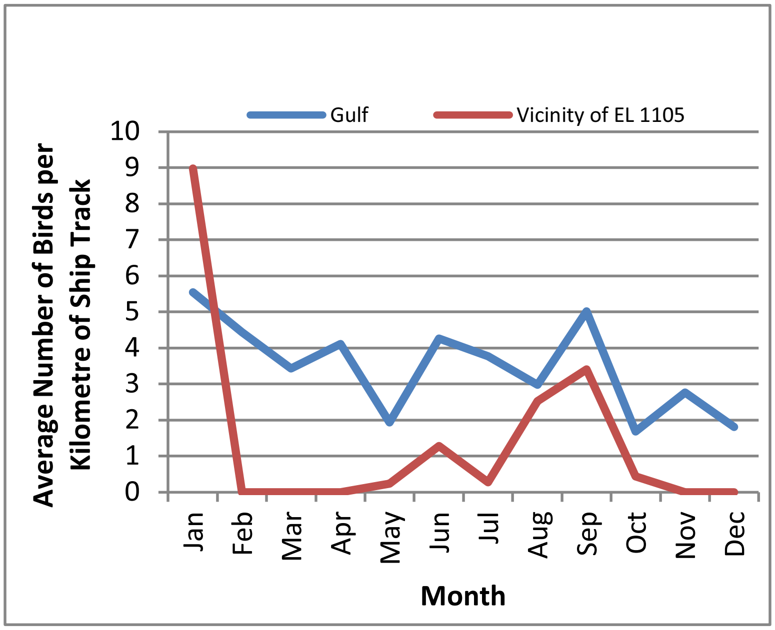
Source: Lock et al. 1994

Figure 5.54 Monthly Seabird Abundance of Storm Petrels in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



Source: Lock et al. 1994

Figure 5.55 Monthly Seabird Abundance of Northern Gannets in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105



Source: Lock et al. 1994

Figure 5.56 Monthly Abundance of Total Seabirds in the Gulf of St. Lawrence and in the Vicinity of Exploration Licence 1105

The species composition of pelagic seabirds in the Gulf changes seasonally. During January and February, Black-legged Kittiwakes are the most abundant species (Figure 5.49); however, late in the winter, Black-legged Kittiwake abundance decreases while the abundance of large auks (Common Murre, Thick-billed Murre, Razorbill and Atlantic Puffin) increases (Figure 5.50). From March through May, the large auks are the most abundant seabird species in the Gulf. Large auk abundance peaks in April then decreases until September, when very few large auks are present.

In June, Northern Fulmar is the most abundant pelagic seabird in the Gulf. Northern Fulmar numbers vary substantially over the year with two periods of high abundance in June and September (Figure 5.51).

Greater Shearwater are the most abundant pelagic seabird species between August and October (Figure 5.52). Greater Shearwater breed in the South Atlantic Ocean and spend the austral winter in the North Atlantic. They are one of the most abundant seabirds in waters off of Newfoundland and Labrador during the summer months. Concentrations of Greater Shearwater in the Gulf are not as high as elsewhere in Atlantic Canada. Nevertheless, this species is one of the most abundant pelagic seabirds in the Gulf during the summer. Greater Shearwater are present in the Gulf from June to November with the highest densities occurring in September.

Dovekies are the most abundant pelagic seabird species in November and December. Dovekies occur in low numbers in the Gulf during most months of the year but reach their peak densities between November and January, with peak densities occurring in January (Figure 5.53). Dovekies nest in the high Arctic. During the spring and summer, most Dovekies are present near their northern breeding colonies, hence the low Dovekie densities experienced in the Gulf at that time.

Storm-Petrels (Leach’s Storm-Petrel and Wilson’s Storm-Petrel) are absent from the Gulf from October through April (Figure 5.54). Storm-Petrels return to the Gulf in May and reach peak densities in July. This is attributable to the return of Leach’s Storm-Petrels to their breeding colonies and an influx of Wilson’s Storm-Petrels from the southern hemisphere to the North Atlantic, where they spend the austral winter.

Northern Gannets have a similar seasonal abundance trend. Northern Gannets are absent from the Gulf from December through March (Figure 5.55). They begin to return to their breeding colonies in the Gulf in April, with peak densities occurring in July. Most birds have left the Gulf by September, although small numbers of Northern Gannets are present until December.

More recent data regarding seasonal abundance of seabirds were acquired from Environment Canada’s ECSAS program. This information pertains to seasonal distributions and abundance of the most common nine groups of seabirds (Northern Fulmar, shearwaters, storm-petrels, Northern Gannet, large gulls, Black-legged Kittiwake, Dovekie, murres and other alcids) found within the Scotian Shelf-Gulf of Maine, the Gulf and the Newfoundland-Labrador Shelves from March 2006 to November 2009 (Fifield et al. 2009). A summary of these data by seabird group and season is presented in Table 5.12.

Seabird abundance in the Gulf was highest in the fall (September and October) (Table 5.13). This is likely attributable to the presence of large numbers of newly fledged young from local seabird colony sites, as well as an influx of wintering Greater Shearwater from the South Atlantic. Comparatively, some of the lowest seabird abundances were observed in the fall in both the Scotian Shelf-Gulf of Maine and the Newfoundland and Labrador Shelf. The data indicate that this is largely attributable to the fact that large numbers of Northern Gannet are not present in these areas during the fall and higher concentrations of Greater Shearwater are present in the Gulf during the fall than in either the Scotian Shelf or the Grand Banks.

Table 5.13 Seasonal Weighted Median (and range) of Densities (birds/km^2) by Seabird Group in Each of the Three Ocean Regions in Atlantic Canada

Species	Season	Scotian Shelf - Gulf of Maine	Gulf of St. Lawrence	Newfoundland and Labrador Shelves
All Waterbirds	Spring	7.92 (0.68 to 25.37)	3.10 (0.37 to 4.52)	14.30 (1.89 to 31.77)
	Summer	8.30 (1.73 to 148.56	5.27 (2.21 to 14.31)	11.51 (0.34 to 48.78)
	Fall	4.23 (0.97 to 21.18)	11.57 (7.41 to 12.11)	9.24 (0 to 46.73)
	Winter	7.67 (4.39 to 29.44)	-	9.53 (2.31 to 45.12)
Northern Fulmars	Spring	0.75 (0 to 4.24)	1.19 (0 to 1.61)	1.00 (0 to 22.44)
	Summer	0.15 (0 to 1.64)	0.64 (0 to 4.19)	0.48 (0 to 24.17)
	Fall	0.30 (0 to 3.31)	0.27 (0.17 to 0.39)	0.65 (0 to 7.59)
	Winter	1.08 (0 to 12.37)	-	1.91 (0 to 36.77)
Shearwaters	Spring	0 (0 to 0.46)	0 (0 to 0)	0 (0 to 6.30)
	Summer	1.78 (0.29 to 84.02)	0.24 (0 to 0.87)	0.12 (0 to 16.39)
	Fall	2.20 (0 to 18.40)	5.06 (0.20 to 8.27)	0.80 (0 to 31.57)
	Winter	0 (0 to 3.74)	-	0 (0 to 7.20)
Storm-Petrels	Spring	0 (0 to 1.36)	0.12 (0 to 0.12)	0.08 (0 to 6.66)
	Summer	0.78 (0 to 12.74)	0 (0 to 0.21)	0.17 (0 to 8.46)
	Fall	0.02 (0 to 1.47)	0 (0 to 0)	0.26 (0 to 4.41)
	Winter	0 (0 to 0)	-	0 (0 to 0.04)
Northern Gannets	Spring	0.40 (0 to 1.03)	0.94 (0 to - 0.94)	0 (0 to 2.75)
	Summer	0 (0 to 1.69)	0.42 (0 to 1.37)	0 (0 to 3.31)
	Fall	0.19 (0 to 2.83)	2.42 (0.88 to 2.42)	0 (0 to 0.83)
	Winter	0.04 (0 to 0.22)	-	0 (0 to 0)
Large Gulls	Spring	1.22 (0 to 21.33)	0.34 (0 to 0.64)	0.74 (0 to 23.43)
	Summer	0.08 (0 to 8.39)	0.40 (0.16 to 1.70)	0.16 (0 to 9.38)
	Fall	0.58 (0 to 2.86)	0.93 (0.28 to 0.93)	0.13 (0 to 4.51)
	Winter	0.62 (0 to 2.31)	-	0.95 (0 to 20.83)
Black-legged Kittiwakes	Spring	0.06 (0 to 3.74)	0.50 (0 to 0.50)	0.72 (0 to 7.06)
	Summer	0 (0 to 0.76)	0.14 (0 to 2.34)	0.38 (0 to 7.87)
	Fall	0.11 (0 to 1.39)	0.79 (0.15 to 5.81)	0.05 (0 to 14.81)
	Winter	1.96 (0 to 21.31)	-	2.45 (0 to 19.93)
Dovekies	Spring	0.71 (0 to 36.98)	0 (0 to 0)	0.59 (0 to 32.10)
	Summer	0 (0 to 2.68)	0 (0 to 0.25)	0.18 (0 to 47.62)
	Fall	0 (0 to 0.25)	0.10 (0.10 to 4.37)	0.20 (0 to 35.76)
	Winter	2.13 (0 to 10.93)	-	0.93 (0 to 11.20)
Murres	Spring	0.88 (0 to 4.37)	0.74 (0 to 2.33)	3.73 (0 to 12.49)
	Summer	0.06 (0 to 2.60)	0.65 (0 to 4.62)	1.79 (0 to 46.57)
	Fall	0 (0 to 0.14)	0 (0 to 0.11)	0.07 (0 to 11.59)
	Winter	0.61 (0 to 7.71)	-	3.05 (0 to 15.21)
Other Alcids	Spring	0.14 (0 to 1.53)	0.20 (0 to 0.20)	0.25 (0 to 9.36)
	Summer	0.04 (0 to 0.91)	0.11 (0 to 4.03)	0.13 (0 to 13.06)
	Fall	0.05 (0 to 0.65)	0.04 (0.04 to 1.12)	0 (0 to 3.16)
	Winter	0.37 (0 to 4.69)	-	0.36 (0 to 3.45)

Source: Fifield et al. (2009).

Overall seabird abundance in the Gulf was lowest during the summer months (May through August). At this time, only half of the nesting adult birds will be at sea at any particular time, resulting in lower numbers of observed birds. Seabird abundance in both the Scotian Shelf-Gulf of Maine and the Newfoundland and Labrador Shelf were also relatively low in the summer months.

The ECSAS data indicate that Northern Fulmar, Northern Gannet and murres are the most abundant seabirds in the Gulf during the spring (March and April). The spring data for the PIROP data set indicate that large auks (includes murres), Black-legged Kittiwake and Northern Fulmar are the most abundant species in the Gulf overall. In the Scotian Shelf-Gulf of Maine and the Newfoundland and Labrador Shelf ocean regions, the Northern Fulmar and murres are also abundant seabirds in the spring; however, Northern Gannet are not abundant in these regions, probably due to the fact that 70 percent of the Northern Gannet in Canadian waters nest in the Gulf. Large gulls are the most abundant seabird in the Scotian Shelf-Gulf of Maine region in the spring.

The ECSAS data indicate that Murres, Northern Fulmar and Northern Gannet are the most abundant seabirds in the Gulf during the summer months (May through August; Table 5.13). The PIROP data set indicates that Black-legged Kittiwake, large auks and Northern Fulmar are the most abundant seabirds during the summer months in the Gulf. In the Scotian Shelf-Gulf of Maine and the Newfoundland and Labrador Shelf ocean regions, the Northern Fulmar and murres are also abundant seabirds in the summer; however, Northern Gannet were not observed in these regions since they are remote from the largest breeding colonies. Shearwaters are the most abundant seabird in the Scotian Shelf-Gulf of Maine region in the summer.

During the fall, the ECSAS data indicate that Greater Shearwater, Northern Gannet, large gulls, and Black-legged Kittiwake are the most abundant species. The fall data for Scotian Shelf-Gulf of Maine and the Newfoundland and Labrador Shelf ocean regions indicate similarly abundant Greater Shearwater and large gull populations at this time; however, Northern Gannet and Black-legged Kittiwake were low compared to other seabirds in these areas. The Gulf is an important nesting area for both Northern Gannet and Black-legged Kittiwake. The large numbers of these species present in the Gulf in the fall may be fledged young and adults tarrying in the Gulf before migrating. The PIROP data indicate that Greater Shearwater, Black-legged Kittiwake and Northern Fulmar are the most abundant species. It should be noted that large gulls are not one of the seabird guilds presented in the PIROP data. The seasonal abundance patterns for the two data sets are similar but not identical. It is not possible to determine with certainty whether the differences between the two data sets are attributable to changes in the relative abundance of seabird species or are attributable to differences in the way the data were collected or processed.

5.5.1.2 Coastal Waterfowl

Common Eider are the only waterfowl species present in large numbers in coastal waters of the Gulf during the breeding season. At this time, eiders are present throughout most of the coastal waters; however, there are certain areas that support relatively large numbers of breeding pairs of eiders. The area with the greatest concentration of breeding eiders covers the area of the north shore of Québec from the Mingan Archipelago to the Iles Ste.-Marie and along the north shore and eastern tip of Anticosti Island. Other areas with relatively high concentrations of eider breeding pairs include the eastern tip of the Gaspé Peninsula, the New Brunswick coast and the portion of the north shore of Québec extending from the Mingan Archipelago to Sept-Iles. In western Newfoundland, the islands of St. John Bay north of Port aux Choix support high numbers of nesting eiders. During fall migration, eiders are most abundant along the north shore of Québec between Sept-Iles and Les Iles Ste. Marie and along the shore of Anticosti Island.

During spring migration following ice-out in the Gulf, coastal waterfowl (all species) are most highly concentrated along the north shore of Québec between Sept-Iles and Les Iles Ste. Marie, along the north shore of Anticosti Island and in the inner part of the Bay of Chaleur. Local areas of high concentrations are also found in bays and estuaries in New Brunswick, Prince Edward Island and the Gaspé Peninsula.

During the summer, coastal waterfowl (all species) are not abundant in the Gulf. Areas of higher concentrations tend to be found along the north shore of Québec between Sept-Iles and the Mingan Archipelago, along the shores of the Gaspé Peninsula and at scattered locations along the north shore of New Brunswick and Nova Scotia.

During the fall, concentrations of coastal waterfowl (all species) occur in scattered patches in sheltered bays and estuaries throughout the western half of the Gulf. High concentrations are found in Nova Scotia between Amet Sound and Baie Verte, along the south coast of Prince Edward Island, and along the north shore of Québec at scattered locations between Sept-Iles and the Mingan Archipelago.

During the winter, ice cover in the Gulf is highly variable; consequently, the distribution of coastal waterfowl can vary substantially from year to year. Winter survey data are only available for the western half of the Gulf. In general, during the winter months, large concentrations of coastal waterfowl can occur along the north shore of Québec between Sept-Iles and the Mingan Archipelago, along the shores of Anticosti Island and along the eastern tip of the Gaspé Peninsula.

5.5.2 Seasonal Distribution of Seabirds and Coastal Waterfowl

5.5.2.1 Seabirds

The abundance of various seabird species or seabird guilds by month in the Gulf are presented in Figures 5.49 to 5.56. These data are compiled in survey blocks that are approximately 25,000 km^2. EL 1105 is situated near the southern boundary of one of these survey blocks. The monthly seabird data for this survey block and the survey block to the south of it were used to provide a description of the use of the area of interest by pelagic seabirds. The highest concentrations of seabirds occur during the month of January (Figure 5.56). Black-legged Kittiwake and Northern Fulmar (Figures 5.49 and 5.51, respectively) are the most abundant species at this time of the year and the only pelagic seabirds recorded in the area. Ice coverage in the Gulf is discussed in Section 4.2.6. Much of the Gulf is typically ice-covered by the end of January and seabirds would tend to concentrate in areas of open water. EL 1105 is located in an area that has an average ice freeze up date of January 29 (Section 4.2.6; Figure 4.25). No survey data are available for February, March and April. In May, Black-legged Kittiwake and Northern Fulmar are still the only pelagic seabirds recorded, with Black-legged Kittiwake being the most abundant species.

Black-legged Kittiwake are still the most abundant species in June (Figure 5.49); however, all seven seabird species or guilds for which data were recorded are present in the vicinity of EL 1105 (Figures 5.50 to 5.55). Other species that are relatively common at this time include Northern Fulmar (Figure 5.49), Northern Gannet (Figure 5.55), storm-petrels (Figure 5.54) and Greater Shearwater (Figure 5.52). The high seabird species richness at this time is attributable to several factors. Seabirds that breed in the Gulf would already have arrived and begun nesting. Species that breed mostly in the high Arctic such as Dovekie and Northern Fulmar would still be migrating through the Gulf. Species that breed in the South Atlantic but migrate to the North Atlantic during the austral winter, such as Greater Shearwater and Wilson's Storm-Petrel, would be starting to arrive in the Gulf in June.

Pelagic seabird abundance decreases substantially in July, as does the number of seabird species present (Figure 5.56). Species recorded during July include storm-petrels, Northern Gannet, Black-legged Kittiwake and large auks. Storm-petrels are the most abundant species in July (Figure 5.54). Many seabirds are feeding nestlings in July and adults may tend to forage more frequently in areas adjacent to colony sites. This would result in a reduction in seabird abundance in areas remote from colony sites such as EL 1105. In addition, only half of the adult birds would be at sea foraging while the other half would be tending the nestlings.

Storm-petrels are also the most abundant pelagic seabird guild in August (Figure 5.54). Pelagic seabird abundance increases substantially in August; however, species richness remains low. Storm-petrels, Black-legged Kittiwake and Greater Shearwater are the only species or guilds recorded during August. The higher pelagic seabird abundance in August may be attributable to influxes of migrating Greater Shearwater and Wilson's Storm-Petrel into the Gulf.

Pelagic seabird abundance continues to increase in September, as does the number of seabird species or guilds present. Greater Shearwater are the most abundant pelagic seabird in September (Figure 5.52). Other species recorded at this time include Black-legged Kittiwake, Northern Fulmar, Northern Gannet and large auks. The increase in seabird abundance and species richness at this time is probably attributable to several factors, including a continued influx of wintering Greater Shearwater and the cessation of nesting activity at seabird colonies, resulting in a wider distribution of adults and young of these species in the Gulf. The Cabot Strait would provide a migration corridor for seabirds moving out of the Gulf and into the Atlantic Ocean, increasing the number of seabirds present.

Seabird abundance and species richness decrease substantially in October. Large auks are the only species recorded in the PIROP data set in the Project area (Figure 5.50). Many seabirds such as Northern Gannet, storm-petrels and Greater Shearwater would be migrating out of the Gulf at this time. In addition, the level of effort in the PIROP sampling program also decreases at this time, resulting in fewer seabirds being detected.

Incidental seabird presence data were collected during the geohazard survey program conducted between October 12 and 15, 2010, (LGL 2010). This survey indicated that seabirds were scarce in survey area at this time. Eight species were recorded during the survey, including Northern Gannet, Black-legged Kittiwake, Northern Fulmar, Greater Shearwater, murres, Great Black-backed Gull, Herring Gull and tern species. The species composition of pelagic seabirds recorded during this survey is identical to that recorded during the PIROP surveys for the month of September. No PIROP data are available for either November or December.

The trends of total seabird abundance observed in EL 1105 roughly follow the trends in the Gulf, with abundance peaks observed in January, June and September.

5.5.2.2 Coastal Waterfowl

Coastal waterfowl use nearshore habitats and are not expected to be present on a regular basis in offshore areas, such as EL 1105. Migrating waterfowl would pass through the area and may on rare occasions rest on the water in this area.

5.5.3 Long Term Trends for Nesting Seabirds

Seabirds breeding in the sanctuaries on the North Shore of the Gulf have been monitored approximately every five years since Migratory Bird Sanctuaries were established in this region in 1925 (e.g., Rail and Chapdelaine 2004; Rail and Cotter 2007). CWS undertakes this census of 15 species of seabirds to detect changes in the distribution and population levels and to orient future research and management. Data from the most recent three census periods (1993, 1998-1999 and 2005) are presented in Table 5.14.

In each of the three most recent census periods, 4 of the 15 monitored species account for over 80 percent of the total seabird population on the North Shore, including Common Eider, Common Murre, Razorbill and Atlantic Puffin. This long-term data source indicates a sharp increase in the abundance of Common Eider, nearly doubling in most sanctuaries on the North Shore of the Gulf since 1998-1999, following a slight decline in the early 1990s. Razorbill abundance has shown a similar increase, nearly doubling between each of the three recent census periods from 8,389 in 1993 to 22,472 in 2005. Common and Arctic Terns quadrupled in abundance, from 545 in 1993 to 2,324 in 2005. Conversely, some of the larger colonies of Common Murre and Atlantic Puffin inexplicably and substantially declined between the 1993 and 2005 census periods. The substantial decline in Black-legged Kittiwake between 1993 and 1998-1999 had ceased by 2005. Leach's Storm-Petrel was not observed in 2005, following a steep decline between the 1993 and 1998-1999 census periods.

Table 5.14 Census of Seabirds (number of individuals) in the Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence (1993, 1998-1999, and 2005)

Species	Ile du Corossol			Betchouane			Watshishou			Ile a la Brume			Baie des Loups			Iles aux Perroquets			Iles Sainte-Marie			Gros Mecatina			Baie de Brador			Total		
	1993[1]	1998[1]	2005[2]	1993[1]	1998[1]	2005[2]	1993[1]	1998[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1999[1]	2005[2]	1993[1]	1998-1999[1]	2005[2]
Common Eider	1,010	1,162	1,960	4,872	3,088	5,596	444	47,541	110,241	1,072	916	1,004	1,392	2,090	3,898	560	484	866	1,198	578	1,218			4				14,548	13,072	25,570
Red-throated Loon										2	2	2	10	12	6	10	24	28	44	42	54		2	2				66	82	92
Leach's Storm Petrel	1,614	718											226															1,840	718	-
Double-crested Cormorant	1,278	950	312				714	1,078	1,688										1,480	802	1,300			46				3,472	2,830	3,346
Great Cormorant																	14	2	78	326	46		2					78	342	48
Ring-billed Gull								443	54	28	41	48	76					1,242										104	484	1,344
Herring Gull	1,224	1,968	1,278	1,006	950	1,004	443	831	833	164	202	454	404	391	527	174	187	169	860	342	206		59	166	83	58	175	4,879	4,988	4,812
Great Black-backed Gull	662	1,160	658	112	122	156	338	185	176	28	22	52	320	206	239	96	95	106	518	385	169		46	35	210	206	279	2,284	2,427	1,870
Black-legged Kittiwake	5,898	3,384	3,318	144	170	146										120	22	14	132	182	516		40			58		6,294	3,856	3,994
Caspian Tern												3																-	-	3
Common and Arctic Terns							260	38	331	113	46	55	34	32	15	72	65	81	66	96	49		100	1,789		17	4	545	394	2,324
Common Murre	280	316	522			128							8	32	187	5,233	3,593	1,598	25,308	26,156	12,131		13	67		14	244	30,829	30,124	14,877
Razorbill	589	815	2,197	142	244	328		8		8	8		241	990	1,062	3,113	2,046	5,555	3,342	7,220	8,964		388	192	954	2,622	4,174	8,389	14,341	22,472
Black Guillemot	99	223	321				13	43	21	74	30	25	75	64	16	47	124	76	101	167	223		137	240	2		2	411	788	924
Atlantic Puffin		3	6	276	324	524							13,834	8,318	1,774	3,354	1,585	620	5,650	3,020	2,208		103	123	23,570	15,780	20,080	46,684	29,133	25,335

Source: [1]Rail and Chapdelaine 2004; [2]Rail and Cotter 2007

Seabird colonies on the Gaspé Peninsula have also been monitored by CWS since 1979. The results of the first three census periods (1979, 1989 and 2002; as published by Cotter and Rail (2007)) are presented in Table 5.15. A total of 14 species of seabirds was recorded at 59 breeding sites on the Gaspé Peninsula during the census periods. In each of the census periods, three species accounted for over 75 percent of the total seabird population - Northern Gannet, Black-legged Kittiwake and Common Murre. Common Murre was also abundant on the North Shore (Table 5.14).

Common Eider populations on the Gaspé Peninsula showed increases over the monitoring period, consistent with the findings from the North Shore monitoring (from 41 pairs in 1979 to 235 pairs in 2002). Double-crested Cormorant and Great Black-backed Gull were observed to increase substantially in the eighties. This population stabilization was observed in other populations of Double-crested Cormorant in Nova Scotia and New Brunswick (Boyne and Beukens 2004; Boyne and Hudson 2002) and on the North Shore of the Gulf from 1993 to 2005 (Rail and Cotter 2007). These same studies reported declines in Great Black-backed Gull populations in these regions during the same time period. A steady upward trend in Black Guillemot was observed, consistent with the reported increases in the North Shore Sanctuaries (Table 5.14). The Ring-billed Gull was first reported in the Maritime Provinces in 1965 (Lock et al. 1994); it was absent during the 1979 Gaspé monitoring but increased from 21 pairs in 1989 to 1,663 pairs in 2002. This species has been on the rise in other monitored regions nearby (Boyne and Hudson 2002; Rail and Cotter 2007).

Common Tern populations were observed to decline substantially between the 1989 and 2002 census periods, after a previous population growth period. The population in Prince Edward Island showed a similar decline during the same period (Boyne and McKnight 2006, in Cotter and Rail 2007). Elsewhere, Common Tern populations were stable to increasing from 1990 to 2000, such as on the Magdalen Islands (CWS, unpublished data, in Cotter and Rail 2007), the North Shore Sanctuaries (Rail and Cotter 2007) and New Brunswick (Boyne et al. 2006, in Cotter and Rail 2007).

Herring Gull were the only species in the Gaspé census that showed a consistent decline from 1979 to 2002. Both the number and size of colonies were observed to decrease. This observation is consistent with monitoring in other areas of the Gulf (Boyne and Hudson 2002; Boyne and Beukens 2004). It is suspected that the cod fishery activities provided an anthropogenic food source that resulted in a population boom until the end of the 1980s, when the cod fishery collapsed. The decline in abundance may be a return to a more normal or natural population (Cotter and Rail 2007).

Table 5.15 Distribution, Species Composition and Changes in Population Size of Eiders, Cormorants and Alcids Breeding Between Îlot Mahy Nord and Baie des Capucins on the Gaspé Peninsula in 1979, 1989 and 2002 (population sizes are given in pairs except for Razorbill, which is individual birds)

	Ring-billed Gull			Herring Gull			Great Black-backed Gull			Black-legged Kittiwake			Common Tern			Double-crested Cormorant			Great Cormorant			Common Murre			Razorbill			Black Guillemot			Common Eider		
Colony	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**	**1979**	**1989**	**2002**
Miguasha to Saint-Omer				1																													
Saint-Omer			1,663	209	495	703	2	62	104					133																			
Banc de Carleton				40	136	12	2	27	1				390	841																			
Île au Pique-Nique				175	29	29	17	62	102																								
Île Taylor					202	351		27	124					318																			
New Richmond to Bonaventure				527	506	902	3		13			83						393								1		31	68	175			
Pointe Howatson																5	11																
Caps Noirs																363	415																
Caplan											22					134	62	75															
Ruisseau Leblanc												572					152	116															
Marais de Saint-Siméon					2									36	15																		
Bonaventure to Paspébiac				487	482	144	1	3	2			127																91	62	194			
Îlots de la rivière Bonaventure					12																												
Paspébiac Ouest																224	22	198															
Marais de Paspébiac					239	390		21	33						20																		
Paspébiac to Shigawake				589	797	172	1	20										98								10		13	54	318			
Pointe aux Corbeaux																52	106																
Pointe Huntington																34	24																
Pointe à Ritchie											56	4				88	281	128															
Saint-Godefroi											405	288				177	246	250			3												
Shigawake to Chandler				233	453	110	4	1	4			3						8								17		159	230	236			
Shigawake																	17							2									
Colline de Port-Daniel											15					25	7																
La Vieille (Pointe Pillar)										13	324	7				116	173	119															
Gascons-Ouest												121				27	18	27															
Pointe Reddish											202	159					3	10															
Anse à Pierre Loiselle											18	263																					
Îlot Mahy sud					142			94	264							58	353	673															
Îlot Mahy nord				3,360	836	525	54	358	26								233	736													1	23	70
Banc de la baie du Grand Pabos						102			8																								
Barachois de Chandler		15		586	108	5		3						217																			
Île Dupuis				480	20	38		8	9							161	60	513															
Chandler to Grande-Rivière				4		101			8																			27		27			
Barachois de Pabos				70																													
Grande-Rivière to Cap d'Espoir				251	365	202		15	2																			87	79	193			
Grande-Rivière											301	12																					
Sainte-Thérèse-de-Gaspé										45	135						145	68			2												
Cap d'Espoir to Percé				386	624	250	3	6	4																			72	96	215			
Cap Malin																	2																
Weygand																	10	14															
Cap Blanc											45						15									2							
Percé to Cannes de Roches				37	91	2		5	1																			119	107	81			
Les Trois Soeurs						33				420	1,774	413														6	42			547			
Coin-du-Banc to Pte St-Pierre				3																								41	230	26			
Barachois de Malbaie				66	210	38		28	45																								
Île Plate				755	525	125	2	166	237							35	142	227													35	102	150
Pointe St-Pierre to Douglastown				239	352	79		6	6									41			1							228	495	387			
La Grande Anse																23	75																
Bois-Brûlé																12	210	121															
Douglastown to Sandy Beach				42	87	7																						7	59	28			
Cap Haldimand																198	183	46															
Pointe de Sandy Beach		6		+	488	429	+	241	151				69	862	20																	3	15
Pointe Jacques-Cartier (Gaspé)						1											158	312															
Cloridorme to Marsoui					21																							511	474	871			
Marsoui to Baie des Capucins																												`+	107	341			
Total	**-**	**21**	**1,663**	**8,540**	**7,222**	**4,750**	**89**	**1,153**	**1,144**	**478**	**3,297**	**2,052**	**459**	**2,407**	**55**	**1,732**	**3,123**	**4,173**	**-**	**-**	**6**	**-**	**-**	**2**	**-**	**36**	**42**	**1,386**	**2,061**	**3,639**	**36**	**128**	**235**

Source: Cotter and Rail 2007

+ = a species was believed to have been present but there are no population estimate available

5.6 Marine Mammals and Sea Turtles

Marine mammals present in the Gulf can be sub-divided into two orders - Cetacea (whales, dolphins, and porpoises) and Pinnipedia (seals). A total of 22 species of marine mammals and sea turtles can be found in the Gulf (LGL 2007) and may be expected to occur with varied frequency in EL 1105. A summary of these species is provided in Table 5.16, noting that the species which are considered at risk are also addressed in Tables 5.1 and 5.2.

Table 5.16 Marine Mammals and Sea Turtles Potentially Present Within or Near the Project

Common Name	Latin Name	Potential Occurrence in relation to the Project
Cetaceans		
Mysticetes (Toothless or Baleen Whales)		
North Atlantic right whale[A]	*Eubalaena glacialis*	Rare
Humpback whale	*Megaptera novaeangliae*	Common
Minke whale	*Balaenoptera acutorostrata*	Common
Fin whale[A]	*Balaenoptera physalus*	Common
Blue whale[A]	*Balaenoptera musculus*	Uncommon
Odontocetes (Toothed Whales)		
Harbour porpoise[A]	*Phocoena phocoena*	Common
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Common
White-beaked dolphin	*Lagenorhynchus albirostris*	Common
Long-finned pilot whale	*Globicephala melas*	Common
Killer whale[A]	*Orcinus orca*	Uncommon
Beluga[A]	*Delphinapterus leucas*	Rare
Northern bottlenose whale	*Hyperoodon ampullatus*	Uncommon
Sperm whale	*Physeter macrocephalus*	Common
Pinnipedea		
Harp seal	*Phoca groenlandica*	Common
Hooded seal	*Crystophora cristata*	Common
Grey seal	*Halichoerus grypus*	Common
Harbour seal	*Phoca vitulina*	Uncommon
Sea Turtles		
Leatherback turtle[A]	*Dermochelys coriacea*	Seasonally Common
Loggerhead turtle[A]	*Caretta caretta*	Uncommon
Kemp's ridley turtle	*Lepidochelys kempii*	Uncommon
[A] at-risk species discussed in Section 5.2		

Profiles on each of the above listed species can be found in the 2005 Western Newfoundland SEA document (LGL 2005b), Sections 3.6.1 to 3.6.4, and in the 2007 Western Newfoundland SEA Amendment document (LGL 2007), Section 3.5.1.3. A brief summary of the information presented in these sections is provided below in terms of species distribution. Note that any species considered at risk are described in Section 5.2.3 and 5.2.4.

The Ocean Biogeographic Information System (OBIS) also provides information and is a database that can be consulted to obtain a census of marine life and as a resource for scientists. Recognized science institutes or survey programs can submit recorded observations to contribute to this online database. Records of observations can be retrieved from the OBIS website (OBIS 2011). For the purposes of this study, an area was analyzed ranging from northern Nova Scotia and Magdalen Islands, northward to the southwest Newfoundland, including EL 1105. The total number of species recorded in this area is provided in Table 5.17, and includes further details about the number of individuals sited and the year in which they were observed.

Table 5.17 Marine Mammals and Sea Turtles Observed in the Vicinity of the Project

Common Name	Latin Name	Total Number of Individuals Recorded through OBIS in the Vicinity of the EL 1105	Year and Number of Individuals Recorded with OBIS [A]	Total number of individuals recorded by DFO in the SEA and Amendment Area [B]
Cetaceans				
Mysticetes (Toothless or Baleen Whales)				
North Atlantic right whale	*Eubalaena glacialis*	1	1969	1
Minke whale	*Balaenoptera acutorostrata*	4	1964 (3), 1976 (1)	130
Fin whale	*Balaenoptera physalus*	5	1969 (1), 1973 (1), 1999 (3)	43
Sei whale	*Balaenoptera borealis*	0		1
Blue whale	*Balaenoptera musculus*	1	1998	47
Humpback whale	*Megaptera novaeangliae*	2	1987 (1), 1993 (1)	191
Odontocetes (Toothed Whales)				
Harbour porpoise	*Phocoena phocoena*	108	1969 (85), 1999 (23)	96
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	75	1975 (1), 1995 (74)	133
White-beaked dolphin	*Lagenorhynchus albirostris*	0		49
Long-finned pilot whale	*Globicephala melas*	51	1971 (10), 1977 (12), 1978 (12), 1982 (4), 1986 (13)	92
Killer whale	*Orcinus orca*	0		5
Beluga	*Delphinapterus leucas*	1	1999	18
Northern bottlenose whale	*Hyperoodon ampullatus*	0		Not recorded

Common Name	Latin Name	Total Number of Individuals Recorded through OBIS in the Vicinity of the EL 1105	Year and Number of Individuals Recorded with OBIS [A]	Total number of individuals recorded by DFO in the SEA and Amendment Area [B]
Sperm whale	*Physeter macrocephalus*	2	1968 (2)	2
Common (short-beaked) dolphin	*Delphinus delphis*	133	1971 (125), 2005 (8)	108
Pinnipedea				
Harbour seal	*Phoca vitulina*	0		Not recorded
Grey seal	*Halichoerus grypus*	0		Not recorded
Harp seal	*Phoca groenlandica*	9	1973 (9)	Not recorded
Hooded seal	*Crystophora cristata*	0		Not recorded
Sea Turtles				
Leatherback turtle	*Dermochelys coriacea*	2	1995 (1), 2002 (1)	Not recorded
Loggerhead turtle	*Caretta caretta*	0		Not recorded
Kemp's ridley turtle	*Lepidochelys kempii*	0		Not recorded

Source:
[A] OBIS 2011;
[B] DFO 2007, in LGL 2007 (these are sightings within a approximately 100 to 150 km of EL 1105

During the geohazard survey program that was carried out between October 12 and 15, 2010, a Marine Mammal Observer was onboard the vessel to identify and note the behaviour of any marine mammals and sea turtles present when the seismic survey was being conducted. Four sightings totalling 11 marine mammals were made over the course of the survey program (LGL 2010). In only one of the four sightings was it possible to identify the marine mammals to the species level (four long-finned pilot whales swimming on October 14). For the other three sightings, two of these were unidentified swimming dolphins (a group of two dolphins on October 13 and a group of four dolphins on October 14), and the third sighting at a distance of approximately 1.2 km was the blow of an unidentified whale observed on October 14. All marine mammal sightings occurred in water depths ranging from 462 to 487 m (LGL 2010). No sea turtles were sighted during the survey. The sightings of long-finned pilot whales and dolphins support the findings in Table 5.17 in that they are two of the more common marine mammals likely to be present in EL 1105.

5.6.1 Mysticetes (Toothless / Baleen Whales)

Of the 15 cetacean species found in the Gulf, there are six species of baleen whales (fin, minke, blue, humpback, sei and the northern right whale). The majority of these species use the Gulf as feeding grounds, with the Laurentian Channel and the Magdalen Islands being popular areas (DFO 2005a). Humpback, fin and minke whales are less common off the west and southwest coasts of Newfoundland than elsewhere off the coasts of the Island (LGL 2005b). Humpback whales feed in the Gulf during the summer; however, the majority of their sightings have been in the northeastern part of the Gulf. They prefer to breed in waters that have a temperature between 24°C and 28°C and therefore conduct their breeding in southern latitudes during the winter (DFO 2011j). There is evidence that fin whales are present in the Gulf from July to

September and tend to migrate through the Laurentian Channel to winter off northern Nova Scotia. Minke whales have also been observed in the Gulf from July to September but are more frequent in the northern Gulf (LGL 2005b). Blue whales can be found in the Gulf from January through November; however, they are most abundant from August to October (LGL 2005b). They are considered uncommon for EL 1105 (Table 5.16). North Atlantic right whales are only occasionally sighted in the Gulf and have been seen in the spring and fall seasons in the lower north shore, and to the east of the Gaspé Peninsula (DFO 2011j). They are however, rare to waters off western Newfoundland (LGL 2005b). Sei whale sightings in the vicinity of the EL 1105 have also been limited (LGL 2007).

In 2007, a cetacean distribution study was conducted by DFO, and one area ranged from southwest Newfoundland to the Magdalen Islands, which included EL 1105. Several species of Mysticetes were spotted, including blue, humpback and minke whales (Lawson and Gosselin 2009).

Species profiles for the three not at risk species of baleen whales that may occur in the area are described in the following sections. At risk species are described in Section 5.2.3.

5.6.1.1 Humpback Whale

The humpback whale is the most common whale species in Newfoundland waters. Like most whale species, the humpback whale migrates to high-latitudes during the summer and low-latitudes during the winter months (Winn and Reichley 1985). During the summer, approximately 900 humpbacks are thought to use the Southwest Shoal of the Grand Banks to feed on capelin (Whitehead and Glass 1985). The Newfoundland population of Humpback whales is estimated at 1,700 to 3,200 individuals (Whitehead 1982), while the Northwest Atlantic population is estimated at 5,505 individuals (Katona and Beard 1990), and the entire North Atlantic population is estimated at approximately 11,570 individuals (Baird 2003).

Humpbacks are common in coastal waters, occurring in groups of several individuals while feeding on capelin, herring, krill and shrimp. Humpback whales undergo seasonal migrations from high-latitude feeding areas in the summer (i.e. Canadian Waters) to low-latitude breeding and calving grounds (COSEWIC 2003c).

Humpbacks from western and eastern North Atlantic use the West Indies as the primary breeding and calving grounds with small numbers breeding and calving in the Cape Verdes (COSEWIC 2003c). There are three feeding stocks located in Eastern Canada; the Gulf of Maine, the Gulf and the Newfoundland and Labrador stocks. There is some interchange between feeding stocks and juveniles from all three stocks mix in mid-latitude feeding area.

5.6.1.2 Minke Whale

Minke whales also commonly occur within the Gulf and EL 1105. Minke whales are common in the waters of Newfoundland and Labrador during the summer but occur worldwide. The size of the Canadian East Coast stock population of minke whales is not well known, but the best available estimate is approximately 3,300 individuals (Waring et al. 2009), which does not include all of the minke whales range in the Northwest Atlantic. An estimate of 1,000 minke whales was made in the Gulf during one summer, 600 of which were seen in the northern Gulf (Kingsley and Reeves 1998). A 2007 survey resulted in an estimated abundance of 360 minke whales in the Gulf (Lawson and Gosselin 2009). Minke whales are more commonly sighted during the summer months in Newfoundland waters, but some may stay in the winter. They are commonly seen nearshore in approximately 200 m of water (Hooker et al. 1999), but occur offshore in deeper waters. The minke whale diet consists of capelin and sand lance (Naud et al. 2003), but they are also known to eat planktonic crustaceans, herring, mackerel and occasionally squid.

5.6.1.3 Sei Whale

Available information suggests that sei whales are not likely as common near EL 1105 as other baleen whale species. Sei whales are often observed in open, pelagic waters and along the edge of the continental shelf of the Northwest Atlantic (COSEWIC 2003d). They feed on schooling fish and squid, but mostly copepods and euphausiids (COSEWIC 2003d). Although their occurrence may be sporadic from year to year, they migrate northward along the continental slope during the summer months and return along the slope during the fall months (Mitchell 1974, Mitchell and Chapman 1977). The sei whale is rarely seen visiting shallow banks close to the coast and tends to occur well offshore (Proctor and Lynch 2005).

The North Atlantic stock and the Nova Scotia stock of sei whale are considered different subspecies in Atlantic Canada with a possibility of a third stock found off Labrador (COSEWIC 2003d). The Atlantic population of the sei whale is considered data deficient by COSEWIC. The western North Atlantic population was estimated to be between 1,393 to 2,248 animals in the late 1970s, and this is still considered the most accurate information (COSEWIC 2003d). No sei whales were reported in the Cape Breton, Gulf and Scotian Shelf survey areas during a 2007 survey (Lawson and Gosselin 2009).

5.6.2 Odontocetes (Toothed Whales)

As presented in Table 5.16, there are nine species of toothed whales that could potentially be found in the vicinity of EL 1105. The sperm whale, long-finned pilot whale, Atlantic white-sided and common dolphin and harbour porpoise are likely to be common in the western Newfoundland offshore region, whereas the northern bottlenose whale, killer whale and white-beaked dolphin are likely to be uncommon in this area and the beluga is considered rare (LGL 2005b). The distribution of sperm whale is based highly on their social structure, whereby adult females and young are typically found in tropical and subtropical waters and adult males in higher latitude waters. Sperm whales are generally distributed over areas of steep underwater topography, as are the long-finned pilot whales. Sperm whales are capable of diving to depths greater than 1,200 m to feed and can stay submerged for greater than two hours at a time, but the majority of their dives last approximately 30 minutes. The majority of the sightings of the Atlantic white-sided dolphin in the Gulf were also recorded in areas with steep bottom topography. Evidence suggests that the harbour porpoise is common to the northern portion of the Gulf from July to September; however, sightings also show this species to be present in the southern and central portions of the Gulf as well (LGL 2005b). It has been noted that a distinct population of harbour porpoise exists in the Gulf and that the species is generally seen close to coastlines (DFO 2011j).

Similarly, the beluga population within the Gulf is also believed to be isolated from other beluga populations (DFO 2011j). The Gulf population doesn't appear to migrate far, as they are rarely seen beyond the boundaries of the Gulf.

The cetacean distribution study completed in 2007 (Lawson and Gosselin 2009), which includes the waters off southwest Newfoundland out to and including EL 1105, observed several species of Odontocetes, including harbour porpoise, long-finned pilot whale and the Atlantic white-sided dolphin.

The not at risk toothed whales that have the most potential to occur in and around the area are described in the following sections. At risk species are described in Section 5.2.3.

5.6.2.1 Atlantic White-sided Dolphin

The Atlantic white-sided dolphin is common from Labrador to Cape Cod with spotty occurrences south of Cape Cod to Maryland (Proctor and Lynch 2005). The North Atlantic population is estimated at several hundred thousand (Reeves et al. 1999). Those in the western North Atlantic may be comprised of three distinct populations; Gulf of Maine, Gulf of St. Lawrence and Labrador Sea populations (Palka et al. 1997). A population estimate of 12,000 individuals was made during one summer in the Gulf, but the estimate varied greatly during the next summer (Kingsley and Reeves 1998). A 2007 survey resulted in an estimated abundance of 1,044 white-sided dolphins in the Gulf (Lawson and Gosselin 2009).

The Atlantic white-sided dolphin usually travels in groups numbering between 50 and 60, but sometimes number in the hundreds (Reeves et al. 1999). They are usually spotted near feeding groups of whales and seabirds and feed on squid and herring. They are most likely to occur near EL 1105 during summer and fall. The Atlantic white-sided dolphin is not listed under *SARA* and was declared 'not at risk' by COSEWIC in 1991.

5.6.2.2 White-beaked Dolphin

The white-beaked dolphin has a more northern distribution than the white-sided dolphin and is more common north of the Gulf of Maine and very rare south of Cape Cod (Proctor and Lynch 2005). The total population in the North Atlantic could be as high as a few hundred thousand individuals (Reeves et al. 1999). Although they are genetically distinct, white-beaked dolphins do occur on both sides of the North Atlantic (Kinze 2002), with the largest population off Labrador and southwestern Greenland. In the 2007 survey, there were no sightings of this species in the survey area which includes EL 1107; however, this species was the second most common species recorded in the survey zone just north of this (i.e., the zone which includes the Strait of Belle Isle) (Lawson and Gosselin 2009).

The white-beaked dolphin feeds mainly on squid, although it will also take fish. The white-sided dolphin was declared 'not at risk' by COSEWIC in 1998 and is not listed under SARA.

5.6.2.3 Long-finned Pilot Whale

As indicated in Table 5.16, long-finned pilot whale are common in the Gulf and in EL 1105. In the 2007 survey, 15 pilot whales were sighted in the survey area which includes EL 1105 (Lawson and Gosselin 2009). The Newfoundland population of long-finned pilot whales has been estimated to be between 4,000 and 12,000 individuals with a world-wide estimate of 750,000 individuals. Long-finned pilot whales would be common off the southwest coast of Newfoundland during the summer (Kingsley and Reeves 1998). They are frequently observed along shelf breaks, offshore, but may occur coastally as well. Groups of long-finned pilot whales are occasionally found stranded on beaches. They commonly come close to shore, especially if squid are abundant in the area.

Long-finned pilot whales are a very social species and most often are seen in groups of 10 to 20 individuals, but may also appear in groups of hundreds (Proctor and Lynch 2005). This species favours cold waters near the continental shelf well offshore. Squid and pelagic schooling fish species are the primary prey of the long-finned pilot whale. It is considered ‘not at risk’ and has not been assessed by COSEWIC and is not listed under SARA.

5.6.2.4 Sperm Whale

Sperm whales are considered common (LGL 2005) and are occasionally seen in the Gulf. Sperm whales range widely through the world’s oceans and males are found off both coasts of Canada and are considered ‘not at risk’ by COSEWIC. The worldwide population is reasonably large despite historical large reductions by commercial whaling which was discontinued in 1972 in Canada. The population of sperm whales in the western North Atlantic has been estimated to be approximately 4,800 animals. They are most commonly found feeding in the waters above submarine canyons and along the edge of the continental shelf in very deep water (Proctor and Lynch 2005). This species routinely dives to depths of hundreds of metres and is capable of remaining submerged for longer than two hours but most dives probably last a half-hour or less (Rice 1989). The sperm whales diet consists of squid and fishes (Reeves and Whitehead 1997).

5.6.3 Pinnipeds (Seals)

There are four species of seals potentially found near and within EL 1105 (harp, hooded, grey and harbour; Table 5.16). Both the harp and hooded seals are migratory species, whereas the harbour and grey seals are year round resident species (DFO 2005a). The harp seal is likely common in the western Newfoundland offshore area during late fall to early spring and rare during other times of the year (LGL 2005b). There are two herds within the North Atlantic, with one breeding on drifting Arctic ice packs off the coast of southern Labrador, and a second herd primarily breeding off the Magdalen Islands (DFO 2011j). The hooded seal is likely to be common offshore western Newfoundland in the spring and rare during other times of the year. Both the harbour and grey seals are likely to be common in the western Newfoundland offshore regions, with the distribution of the harbour seal being continuous in the Gulf and that of the grey seal to be more concentrated in the south (LGL 2005b). One of the three main breeding locations for the grey seal is on ice in the southern Gulf region (DFO 2011j).

Each of the above species of seal is hunted commercially on the Atlantic coast of Canada. Ice conditions often determine the amount of hunting effort in any given area, however, the majority of the seal hunt occurs off the north and east coasts of Newfoundland and off southern Labrador. The majority of the sealing in this area occurs between late March and the end of April (DFO 2008).

The four species of seals known to occur in the Gulf and in EL 1105 are described in the following sections.

5.6.3.1 Harp Seal

Harp seals whelp during the spring in the Gulf and in an area known as the 'Front' off southern Labrador and northeastern Newfoundland (Sergeant 1991; DFO 2000d). Individuals from these two areas spend the summer months in the Canadian Archipelago, Davis Strait and Baffin Bay and then migrate approximately 10,000 km south along the Newfoundland and Labrador coast and Gulf (Whitaker 1996). In recent years, there has been an apparent change in their distribution as more harp seals are occurring south of this area. McAlpine et al. (1999) documented an increase in extralimital occurrences (south of normal range) of harp seals in the northern Gulf of Maine. The total population in 2004 was estimated at 5.9 million (ICES 2005).

Arctic cod (*Boreogadus saida*) is the primary food of the harp seal, comprising an estimated 54 percent of their diet from October to March (DFO 2000d), but this tends to vary with age, season, year and location (Kapel 2000; Nilssen et al. 2000). Capelin, followed by sand lance, Greenland halibut and other flatfish are the preferred prey of harp seals (Wallace and Lawson 1997). Harp seals consume less Atlantic cod than once believed as seals apparently spend more time offshore than previously thought (Hammill and Stenson 2000).

5.6.3.2 Hooded Seal

Like the harp seal, the majority of the hooded seal population in the Atlantic whelp in the area off southern Labrador and Northern Newfoundland (known as the "Front") in mid-to late March (Lyderson and Kovaks 1999). The southern Gulf is also one of several whelping habitats for the hooded seal. Congregations occur in March and April near Prince Edward Island and the Magdalen Islands for pupping and breeding. They then migrate northward to the sub-Arctic and Arctic (to the waters off Greenland) to feed during the summer (Lydersen and Kovacs 1999). Hooded seals are widely distributed throughout the western North Atlantic in the winter and spring (Stenson and Sjare 1997; Kovacs 2002); however, some individuals may remain in Atlantic waters year round. Population estimates are on the order of 500,000 seals (Kovacs 2002), a small portion of which whelps in the southern Gulf (Hammill 1993). Hooded seals feed on benthic invertebrates, Greenland halibut, redfish, Arctic cod and squid. Therefore, they may occasionally be present in EL 1105, although none have been observed to date.

5.6.3.3 Grey Seal

The Northwest Atlantic stock of grey seals occurs in the Gulf, off Nova Scotia and Newfoundland and Labrador. Grey seals on the Grand Banks are likely from the Sable Island and Gulf breeding populations. The largest breeding colony occurs on Sable Island, with a range of 208,000 to 223,000 individuals (Trzcinski et al. 2005) and the Gulf population (which pups on the ice in the southern Gulf) is estimated at 52,500 (Hammill 2005), which accounts for all of the pup production in the Northwest Atlantic. Grey seals also congregate in the Gulf, between the eastern end of Prince Edward Island and Cape Breton Island and on the ice in St. George's Bay, for pupping and breeding from mid-December to late February (Stobo and Zwanenburg 1990). Grey seals will most likely occur in the Gulf and EL 1105 during July and August but could potentially be present year round (Stenson 1994).

Grey seals are benthic and pelagic predators of at least 40 species including Atlantic cod, herring, squid and mackerel (Benoit and Bowen 1990; Hammill et al. 1995).

5.6.3.4 Harbour Seal

Harbour seals are year-round residents of the Gulf, the St. Lawrence estuary and coastal Newfoundland (Burns 2002). The primary prey of harbour seals in Newfoundland waters are winter flounder, Arctic cod, shorthorn sculpin (*Myoxocephalus scorpius*) and Atlantic cod, with some regional variability (Sjare et al. 2005). Harbour seals are common in nearshore shallow waters near river mouths or at particular haul-out sites. Pupping is expected to occur in May or June and pups are nursed for approximately 24 days (Bowen et al. 2001). The pups spend time in the water with the mother following weaning.

They are expected to occur in coastal waters off northwestern Newfoundland year-round, but are considered uncommon in offshore areas like EL 1105 (Table 5.16). The eastern Canadian population of harbour seals was estimated as 30,000 to 40,000 individuals in 1993 (Burns 2002). Harbour seals are not listed by SARA and considered to have data gaps by COSEWIC, insufficient to determine the status of the population; however, the east coast population appears to be increasing (Baird 2001).

5.6.4 Sea Turtles

There are three species of sea turtles that could potentially be found within the Gulf and in the vicinity of EL 1105 (Table 5.16). The leatherback and loggerhead sea turtles are considered an at-risk species and are discussed in Section 5.2.4. The presence of the Kemp's ridley turtle in the offshore area of western Newfoundland is considered to be rare, and therefore the presence of Kemp's ridley in EL 1105 would be considered 'very rare' (LGL 2005). The Kemp's ridley is listed as endangered by US National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (Plotkin 1995). Kemp's ridley are the smallest (40 to 50 kg) and rarest of all sea turtles within the Newfoundland area (Cook 1984). These turtles apparently prefer shallow water and while adults rarely range beyond the GOM, juveniles have been sighted along the southeast coast of Newfoundland near St. Mary's Bay and along southern Nova Scotia (Ernst et al. 1994). However, the number of Kemp's ridley turtles that may visit the area is unknown. They apparently prefer shallow water and feed primarily on crabs, but occasionally they eat molluscs, fish, shrimp and vegetation (Shaver 1991).

5.7 Sensitive Areas

The sensitive areas identified in the vicinity of EL 1105 are indicated in Figure 5.57.

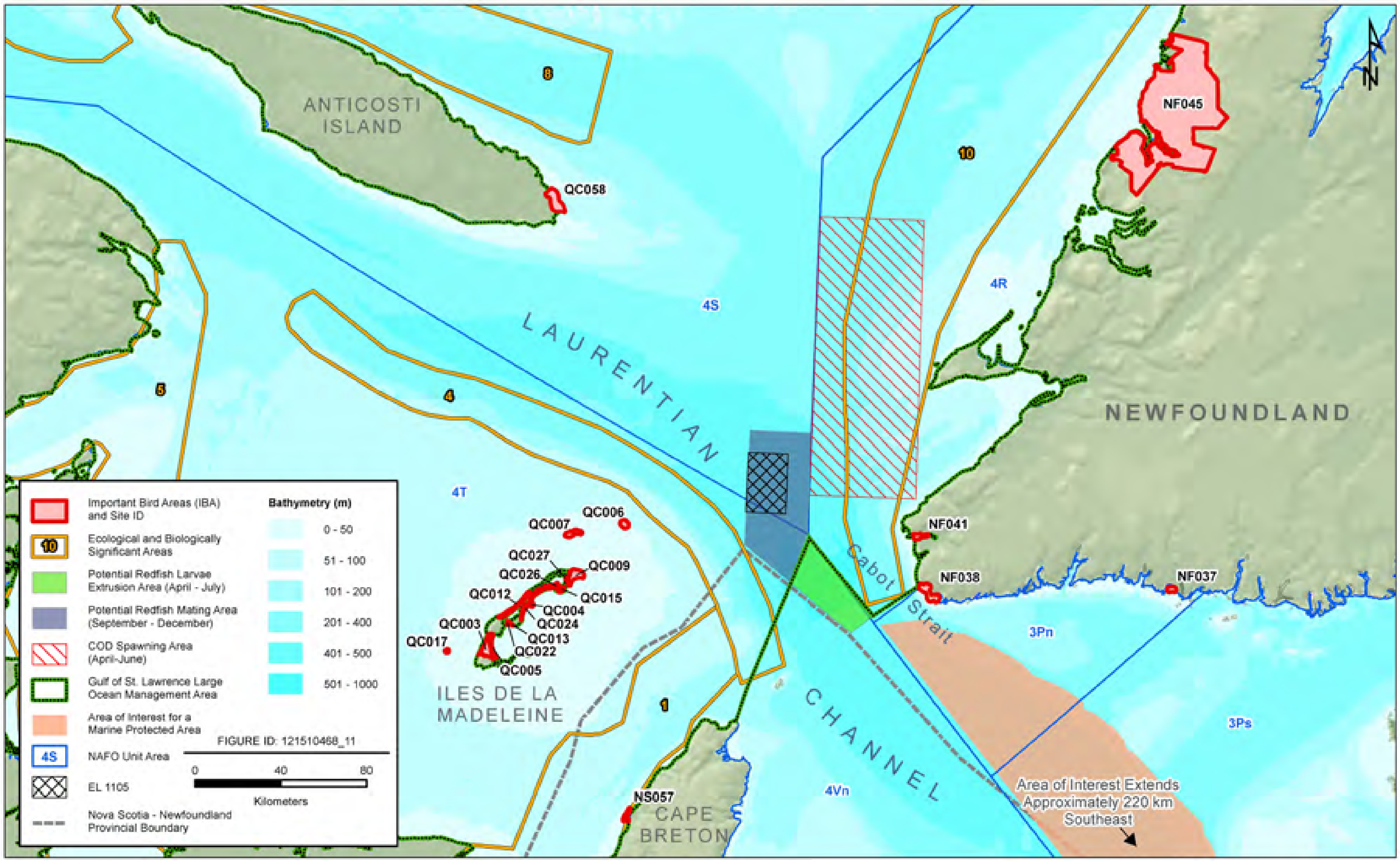


Figure 5.57 Sensitive Areas Located near Exploration Licence 1105

5.7.1 Ecological and Biologically Sensitive Areas

Protection of marine sensitive areas is provided by DFO's *Oceans Act*. The *Oceans Act* allows for the development of a national oceans strategy based on the principles of sustainable development, integrated management and the precautionary approach. Importantly, the Act also authorizes DFO to provide enhanced protection to marine areas which are determined to be ecologically or biologically significant (DFO 2004c). EL 1105 is within an area currently being considered as part of an Integrated Management process for the Gulf of St. Lawrence Large Ocean Management Area (GSL-LOMA) (DFO 2009p). As part of this plan, DFO has identified ecologically and biologically significant areas (EBSAs), which may require specific management measures. Some EBSAs are put forward as Areas of Interest for Marine Protected Area status and other EBSAs are considered for protection under other management tools. The potential management implications of the identification of these EBSAs are still being determined through on-going planning processes within DFO. Within the GSL-LOMA, ten areas have been designated as EBSAs based on pre-established criteria, including primary criteria of uniqueness, aggregation and fitness consequences and secondary criteria of resilience and naturalness (DFO 2004c).These areas include:

- Western Cape Breton;
- St. George's Bay;
- Northumberland Strait;
- the southern fringe of the Laurentian Channel;
- the south-western coast of the Gulf;
- the lower estuary;
- western Anticosti Island;
- northern Anticosti Island;
- the Strait of Belle Isle; and
- the west coast of Newfoundland.

These EBSAs form the planning basis for implementation of integrated-management plans (DFO 2009q). The areas closest to the proposed Project include the southern fringe of the Laurentian Channel and the west coast of Newfoundland.

The southern fringe of the Laurentian Channel EBSA covers approximately 5,941 km^2 and is illustrated in Figure 5.57 as EBSA 4 (DFO 2007b, 2009q). This area is characterized by its average to maximum uniqueness, average concentration and adaptive values for pelagic fish and for its low to average uniqueness and average concentration and adaptive values for groundfish. However, this area only partially covers an important wintering area for the Atlantic cod, leaving out the southern slope in the Cabot Strait. The middle of the channel also serves as wintering areas for a number of groundfish species. The southeastern boundary of this area overlaps slightly with the Cape Breton Channel (EBSA 1 in Figure 5.57), which serves as a migration corridor for southern Gulf stock such as Atlantic cod, coastal white hake and other groundfish species during the spring and fall. This area also serves as feeding grounds for witch flounder and deep water white hake. The north-eastern boundary of this area is also important for marine mammals (DFO 2007b, 2009q).

The west coast of Newfoundland EBSA covers approximately 18,238 km^2 and is illustrated in Figure 5.57 as EBSA 10 (DFO 2007b, 2009q). This area is characterized for its maximum uniqueness, concentration and adaptive values for groundfish, its low to average uniqueness, average to maximum concentration and adaptive values for pelagic fish and its low to maximum uniqueness, concentration and adaptive values for marine mammals. Groundfish populations concentrate in a number of areas found within or partially within this EBSA. Western Newfoundland serves as the main area for juvenile Atlantic cod, redfish, American plaice and Atlantic wolffish. The Esquiman Channel, which is not entirely covered by this EBSA, is used as a migration corridor for Atlantic cod and redfish. This corridor can be heavily populated during spring and fall. The Esquiman Channel serves as a refuge area for Atlantic herring and a summer feeding ground for the Atlantic herring, spiny dogfish, silver hake and pollock. This area also serves as the principal cod spawning area and capelin and Atlantic herring larvae are also in abundance. The northern and southern most areas of this EBSA are most significant for marine mammals.

In 2010, the Laurentian Channel to the southeast of Cabot Strait and approximately 100 km from the Project was announced as an Area of Interest for potential designation as a Marine Protected Area under the *Oceans Act* (DFO 2011k). This Area of Interest is located to the south of Newfoundland within the Placentia Bay-Grand Banks LOMA (DFO 2009q) and is approximately 17,950 km^2, or 50 percent of the Laurentian Channel area (Figure 5.57). Designation of this area of the Laurentian Channel as an Area of Interest was determined on the basis of identified ecological and biological significance in that it contains the highest concentration of black dogfish in Canadian waters and is the only place where their young occur. It is also determined to be an important spawning, nursery and feeding area for a variety of species (including porbeagle shark, smooth skate, monkfish, pollock, and white hake) and a migration route for marine mammals moving in and out of the Gulf (DFO 2011k). In addition, this Area of Interest provides overwintering habitat for cod and redfish stocks whose populations have been identified as either threatened or endangered.

5.7.2 Other Marine Sensitive Areas

In addition to the EBSA, there are a few other potentially sensitive areas located near EL 1105, as outlined in the 2005 and 2007 Western Newfoundland SEA (LGL 2005b, 2007), which include a cod spawning area, a potential redfish larvae extrusion area and a potential redfish mating area. The location of each of these areas is presented in Figure 5.57.

The cod spawning area is located west of the Port au Port Peninsula and is closed to groundfish fishing between April 1 and June 15. This area was originally established in 2002 and was resized since then (LGL 2007).

As identified in Section 5.2, redfish mate during the fall (September to December), and as illustrated in Figure 5.57, the Project lies within the boundaries of the redfish mating area. Redfish larvae extrusion also occurs near the Project, approximately 30 km away, as illustrated in Figure 5.57; this occurs during April to July.

5.7.3 Vulnerable Seabird Nesting Sites

Lock et al. (1994) list 136 known colonies of vulnerable seabirds in the Gulf. Seabird colonies are patchily distributed around the Gulf. There are only six colonies along the western shore of Newfoundland. Four of the six colonies are found at the mouth of the Humber River. The lack of seabird colonies on the west coast of Newfoundland is attributable to a general lack of suitable nesting sites and the relatively low productivity of the waters along this coast. Seabird species breeding in these colonies include Black-legged Kittiwake, Great Cormorant, Double-crested Cormorant and Black Guillemots, with Black-legged Kittiwake the most abundant species.

The southern portion of the Gulf is not an important area for nesting vulnerable seabirds. Only 13 colonies of vulnerable seabirds are found along the portion of the Gulf that borders Nova Scotia. Fourteen colonies are present in Prince Edward Island and five colonies are present in New Brunswick. All of these colonies are occupied primarily by Double-crested Cormorants and Great Cormorants. The paucity of seabird colonies in the southeastern part of the Gulf is believed to be attributable to oceanographic conditions rather than a lack of suitable nesting habitat.

Ninety-seven vulnerable seabird colonies are present in Québec. These include the largest seabird colonies in the Gulf, such as Bonaventure Island, Refuge des Isle Ste-Marie, Falaise Aux Goelands, Presqu'ile de Forillon and Rocher aux Oiseaux, each of which supports more than 10,000 pairs of seabirds. In Québec, vulnerable seabird colonies are concentrated on the southeastern shore of the Gaspé Peninsula, along the north shore of Québec, on the northern shore of Anticosti Island and in the vicinity of the Magdalen Islands. These colonies support approximately 90 percent of the vulnerable seabird population breeding in the Gulf.

Seabird colonies present in the western and northern portions of the Gulf also tend to support a greater variety of seabird species. Species characteristic of the western and northern portion of the Gulf include Northern Gannet, Common Murre, Black-legged Kittiwake, Black Guillemot, Atlantic Puffin and Razorbill. Of particular note is the presence of three Northern Gannet colonies (Bonaventure Island, Falaise Aux Goelands and Rocher aux Oiseaux), which represents half of the Northern Gannet colonies present in Canada and approximately 70 percent of all the breeding pairs in Canada.

Coastal locations designated as Important Bird Areas (IBAs) for marine birds, on the basis of bird populations, global or national significance, and/or conservation status, were identified within a range of approximately 200 km to the Project (Figure 5.57). These IBAs are presented in Table 5.18 and are mostly found on the Magdalen Islands. Each of these IBAs lies more than 75 km away from the Project. A number of Piping Plover habitat locations, though not designated as IBAs, were also identified on the coast of Newfoundland (Stephenville Crossing, Sandy Point, Flat Pay Peninsula, Searston, Little Codroy, East of Windsor Point, J.T. Cheeseman Provincial Park, Jerret Point-Windsor Point, Big Barrachois, Second) (LGL 2007).

The colonies closest to the Project include four colonies in the Magdalen Island Archipelago and one colony in southwestern Newfoundland. The nearest vulnerable seabird colony to EL 1105 is the large seabird colony on Rocher aux Oiseaux at the northeastern edge of the Magdalen

Island Archipelago (QC006). This colony is the third largest vulnerable seabird colony in the Gulf. It is one of only three seabird colonies in the Gulf that supports a breeding population of Northern Gannets and is the second largest Northern Gannet colony in Canada. This colony also supports large numbers of Black-legged Kittiwakes and Common Murres, as well as small numbers of Thick-billed Murres and Atlantic Puffins.

The colony on Ile Brion (QC007) is also a large seabird colony consisting mainly of Black-legged Kittiwakes, along with smaller numbers of Black Guillemots, Atlantic Puffin, Razorbill, Great Cormorants and Common Murres. The next closest vulnerable seabird colony in the Magdalen Island Archipelago is a large Double-crested Cormorant colony located on Ile aux Loups Marins (QC027).

Table 5.18 Important Bird Areas for Marine Birds

Location	Site ID*	Important Bird Area	Bird Species
Newfoundland			
Burgeo	NF037	Big Barasway	Piping Plover
Port aux Basques	NF038	Grand Bay West to Cheeseman Provincial Park Beach	Piping Plover
Doyles	NF041	Codroy Valley Estuary	American Black Duck American Green-winged Teal American Wigeon Blue-winged Teal Canada Goose Common Goldeneye Common Merganser Greater Scaup Northern Pintail Northern Shoveler Red-breasted Merganser Ring-necked Duck
Rocky Harbour	NF045	Gros Morne National Park	Common / Arctic Tern Harlequin Duck
Nova Scotia			
Inverness, Cape Breton	NS057	The Capes	Black-legged Kittiwake Great Cormorant
Québec			
Magdalen Islands	QC003	Lagune du Havre aux Basques et Plage de l'Ouest	American Black Duck Arctic Tern Black-bellied Plover Black-headed Gull Caspian Tern Common Tern Great Cormorant Greater Yellowlegs Hudsonian Godwit Least Sandpiper Lesser Yellowlegs Piping Plover Red Knot (Low Arctic) Roseate Tern Semipalmated Plover Semipalmated Sandpiper Shorebirds Short-billed Dowitcher Whimbrel White-rumped Sandpiper

Location	Site ID*	Important Bird Area	Bird Species
Magdalen Islands	QC004	Ile Shag	Black Guillemot Black-legged Kittiwake Great Black-backed Gull Great Cormorant Herring Gull
Magdalen Islands	QC005	Plages de la Martinique et de Havre-Aubert	Common Tern Piping Plover
Magdalen Islands	QC006	Les Rochers aux Oiseaux	Atlantic Puffin Black-legged Kittiwake Common Murre Northern Gannet Razorbill Thick-billed Murre
Magdalen Islands	QC007	Ile Brion	Arctic Tern Atlantic Puffin Black Guillemot Black-legged Kittiwake Common Eider Common Murre Common Tern Great Black-backed Gull Great Cormorant Herring Gull Horned Grebe Leach's Storm-Petrel Merlin Northern Gannet Piping Plover Razorbill
Magdalen Islands	QC009	Ile de l'Est	American Black Duck American Golden-Plover Arctic Tern Black-bellied Plover Blue-winged Teal Caspian Tern Common Tern Common/Arctic Tern Great Black-backed Gull Greater Scaup Greater Yellowlegs Herring Gull Horned Grebe Least Sandpiper Lesser Yellowlegs Northern Gannet Piping Plover Red-breasted Merganser Ring-necked Duck Roseate Tern Sanderling Semipalmated Sandpiper Short-billed Dowitcher Whimbrel White-rumped Sandpiper
Magdalen Islands	QC012	Plage de l'Hopital	Piping Plover
Magdalen Islands	QC013	La Pointe	Piping Plover
Magdalen Islands	QC015	Bassin aux Huitres	Piping Plover

Location	Site ID*	Important Bird Area	Bird Species
Magdalen Islands	QC017	Rocher le Corps Mort	Black Guillemot Great Black-backed Gull Great Cormorant Herring Gull
Magdalen Islands	QC022	Ile aux Paquet	Common Tern Common/Arctic Tern Great Black-backed Gull Herring Gull Roseate Tern
Magdalen Islands	QC024	Dune du Sud	Great Cormorant Northern Gannet Piping Plover
Magdalen Islands	QC026	Ilot C	Common Tern Great Black-backed Gull Herring Gull Horned Lark Northern Gannet Northern Pintail Piping Plover Roseate Tern Semipalmated Plover
Magdalen Islands	QC027	Ile aux Loup Marins	Double-crested Cormorant Great Black-backed Gull Great Blue Heron Herring Gull
Anticosti Island	QC058	Falaise aux Goelands / Pointe de l'Est	Atlantic Puffin Black-legged Kittiwake Common Murre Great Cormorant Northern Gannet

* Refer to Figure 5.56 for location.
Source: http://www.ibacanada.com

5.7.4 Tern Colonies

There are 69 known tern breeding colonies on the Gulf. Tern colonies are concentrated in several areas of the Gulf, including the north shores of New Brunswick and Prince Edward Island, the south shore of the Gaspé Peninsula, the Magdalen Island Archipelago and the Mingan Archipelago. There are also some relatively large tern colonies present along the west coast of Newfoundland. Common Tern is the most abundant nesting tern in the Gulf. Arctic Terns are present in fairly large numbers in the more northerly tern colony sites on the west coast of Newfoundland and along the north shore of Québec. Caspian Terns nest in small numbers along the north shore of Québec and western Newfoundland. The endangered Roseate Tern has been recorded only on Ile aux Paquet in the Magdalen Islands (refer to Section 5.2.2.4).

5.8 Commercial Fisheries and Other Users

5.8.1 Commercial Fisheries

The Gulf is commercially fished by fleets from Québec and all four Atlantic provinces; there has been no foreign fleet since they were excluded after the first cod collapse in the 1970s (DFO 2005e). Management of the commercial fishing activity in the Gulf by DFO is conducted through the Québec, Maritimes, Gulf and Newfoundland and Labrador Regional offices (DFO 2011l).

Many of the major species are fished according to quota systems (i.e., groundfish and crab), while others are fished according to availability (i.e., herring and mackerel) or specific season lengths (i.e., lobster and crab). Licenses and quotas are set by DFO for individual species management areas, NAFO divisions and subdivisions. The NAFO Unit Areas are illustrated in Figure 5.58. EL 1105 is located mostly in NAFO area 4Ss, but overlaps with 4Tf. The wellsite is located in 4Ss. In terms of this environmental assessment, all major fish groups including groundfish, pelagic and shellfish fished within NAFO Unit Areas 4Ss, 4Tf, 4Rd, 4Vn and 3Pn were included.

Such species consisted of mackerel, herring, spiny dogfish, American eel, skate, blue shark, shortfin mako, porbeagle, American plaice, Atlantic halibut, catfish, cod, Greenland halibut, haddock, witch flounder, winter flounder, monkfish, pollock, redfish, sculpins, tomcod, white hake, windowpane flounder, yellowtail flounder, lobster, shrimp, snow crab, rock crab, toad crab, Atlantic razor clam, scallop, soft-shell clam, squid, Stimpson's surf clam, surf clam and whelk.

5.8.1.1 Fisheries in Northwest Atlantic Fisheries Organization Unit Areas 4Ss, 4Tf, 4Rd, 4Vn and 3Pn

Landings data for NAFO Unit Areas 4Ss, 4Tf, 4Rd, 4Vn and 3Pn for 2004, 2005, 2006, 2007, 2008, 2009 and 2010 were acquired from DFO from the Québec, Gulf and the Newfoundland and Labrador regions. These data are presented in Tables 5.19 to 5.23 and represent the most up-to-date verified data at the time of writing (May 2011). The NAFO Unit Areas 4Ss, 4Tf, 4Rd, 4Vn and 3Pn cover an area substantively more expansive than EL 1105. However, general information on trends associated with the fishery for this division could provide insight and knowledge for the general region in which the Project and associated supply vessel activity will occur.

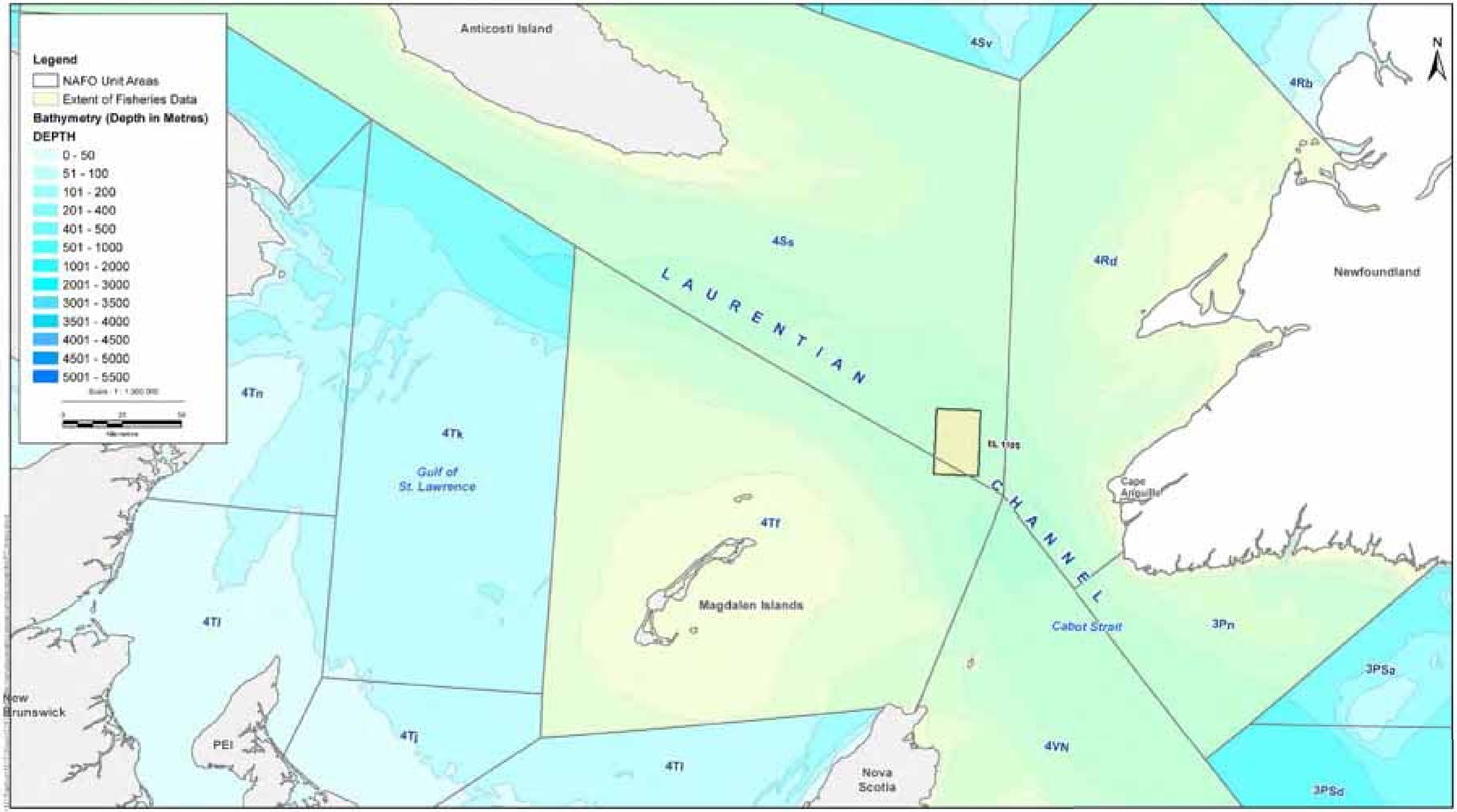


Figure 5.58 Northwest Atlantic Fisheries Organization Unit Areas

Table 5.19 Landed Value of Fisheries Harvest for Northwest Atlantic Fisheries Organization Unit Area 4Ss, 2004 to 2010

Species	2004		2005		2006		2007		2008		2009		2010	
	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)
Pelagic														
Herring	512	235	277	54	39	16	18	8	37	11	170	83	143	70
Eel					26	25								
Skate					218	55								
Spiny Dogfish	2	1	1	1										
Mackerel													250	85
Blue Shark													36	73
Groundfish														
American plaice	175	125	291	207	23	20	779	531	5,199	4,429	1,877	1,369	2,751	1,831
Atlantic halibut	23,159	137,672	19,608	110,776	10,381	60,403	36,665	210,653	27,462	155,859	28,011	155,699	9,696	56,800
Catfish	10	3	17	6									484	373
Cod	9,946	14,943	11,012	13,210	11,969	13,003	14,176	20,497	14,974	22,961	14,686	21,878	14,033	19,546
Greenland halibut	26,709	55,856	46,925	98,739	11,615	19,348	288,837	539,224	198,853	386,068	189,519	386,791	199,007	424,435
Witch Flounder					166	257	51	85					15	12
Monkfish	22	20	151	95	45	51	229	133	609	378	434	166	529	214
Redfish	15,843	10,484	53,267	44,173	49,696	40,923	19,498	17,036	4,787	3,167	10,782	7,915	45,805	30,778
White hake	163	89	189	104	163	60	179	119	114	72	457	256	613	361
Shellfish														
Lobster	68,067	993,501	94,160	1,378,438	93,650	1,206,846	109,479	1,524,675	133,555	1,520,234	140,760	1,343,132	166,188	1,509,274
Shrimp	11,449,450	14,419,491	11,016,469	14,808,063	9,246,339	2,546,569	4,031,118	5,615,584	7,017,315	7,890,467	4,912,372	5,042,714	4,557,661	4,937,273
Snow crab	153,032	975,918	172,253	569,625	146,095	325,702	184,869	703,294	190,841	742,805	205,591	628,900	167,773	510,815
Scallop	2,157	4,433												

Table 5.20 Landed Value of Fisheries Harvest for Northwest Atlantic Fisheries Organization Unit Area 4Tf, 2004 to 2010

Species	2004		2005		2006		2007		2008		2009		2010	
	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)
Pelagic														
Mackerel	976,216	392,024	729,175	417,778	1,331,365	640,537	583,131	281,310	429,494	230,658	363,494	180,631	281,487	174,653
Herring	3,016,469	785,280	1,158,558	388,073	155,913	62,877	55,065	14,925	121,413	48,703	148,907	35,016	523,926	405,019
Eel	55	17	35	37	26	26	17	34	23	28				
Skate	654	654	1,626	353	1,435	743	943	482	1,119	607			541	154
Shortfin Mako							55	111	52	104				
Portbeagle							354	709	424	849	328	656		
Spiny Dogfish	8,315	4,687	45	61	101	94	6	6	16	20	3	3		
Blue Shark			37	37	32	29			24	27				
Mako Shark	170	169	160	320	100	200	544	533	23	23	249	249		
Groundfish														
American plaice	184,104	152,466	128,167	101,569	198,205	168,997	137,328	114,177	34,481	27,056	30,253	25,534	54,449	86,232
Atlantic halibut	33,546	209,101	41,847	269,631	27,644	182,074	28,764	191,115	50,855	360,403	67,831	474,168	40,554	333,564
Catfish	16	12	43	63	244	226	126	139	44	40			4	3
Haddock	728	706	1,419	2,564	1,256	2,291	1,435	1,969	1,208	1,657	176	306	24	44
Cod	737,334	921,980	1,150,657	1,220,984	1,308,453	1,572,404	476,005	627,128	680,364	905,947	74,134	92,877	15,697	26,852
Greenland halibut	21,739	46,240	42,517	61,642	53,089	80,207	21,073	35,246	16,069	27,916	36,685	69,592	10,516	21,882
Witch Flounder	228,747	262,561	365,383	340,009	429,025	511,741	310,232	366,395	276,076	297,806	140,472	92,878	14,356	16,592
Monkfish	180	136	3,901	1,929	1,297	647	975	506	2,710	1,922	5,658	2,259	1,054	319
Polluck	502	293	2,169	1,175	10,724	10,496	3,876	2,458	736	455	14	9	81	8
Redfish	99,575	73,525	522	269	1,270,577	341,799	66,335	55,507	275,615	240,161	369,205	251,250	169,844	108,677
Sculpins	163	5	786	150	108	46	675	255	215,964	189,039	3,369	600	2,745	275
Tomcod	109	42	100	57	8	2	83	88	72	70	109	100	18	18
White hake	19,655	13,654	17,913	12,331	11,086	7,402	6,088	4,359	17,826	11,391	18,964	15,513	4,202	2,368
Windowpane flounder	23,551	17,935	51,576	42,112	22,165	23,959	104,498	104,498	67,057	87,208	85,268	126,610	134,418	201,090
Winter flounder	151,942	103,889	174,070	153,681	160,959	164,417	121,699	139,663	111,928	140,313	153,970	205,967	242,556	340,078
Yellowtail	309,383	128,792	168,450	132,820	181,366	191,872	141,824	165,177	91,350	118,799	101,476	144,166	185,829	276,475
Shellfish														
Lobster	2,486,112	2,486,112	2,453,010	34,370,076	2,459,173	31,177,933	2,481,499	33,316,778	2,625,401	29,773,860	2,669,184	23,774,569	3,033,042	25,803,902
Snow crab	7,268,029	48,002,316	8,790,766	38,383,413	6,243,323	17,432,383	2,428,454	26,516,893	5,579,765	24,596,638	4,127,544	14,860,833	782,234	3,001,827
Rock crab	678,724	530,816	781,631	596,235	766,703	636,937	802,518	657,700	644,257	566,208	621,079	546,374	610,465	537,209
Toad crab			165,354	122,388	197,078	155,583	195,776	152,133	165,368	127,603	142,992	108,094	181,379	119,710
Atlantic razor clam	11,874	26,173	26,374	58,150	10,354	22,829	21,437	47,259	11,766	25,942	18,116	21,782	24,015	40,790
Scallop	139,843	253,444	239,516	474,963	148,396	399,520	385,827	10,402,011	314,464	621,925	485,541	948,566	371,061	737,753
Soft shell clam			87	228	407	958	506	521	988	2,124	521	1,816	889	3,112
Squid					320	46			6	13				
Stimpson's surf clam	21,283	16,423	8,159	8,111	8,873	7,165	16,713	12,896	7,576	5,846			7,529	5,797
Surf clam	95,878	68,575	140,014	140,925	126,653	123,419	156,567	165,493	174,307	188,088	288,805	305,460	258,495	213,819
Whelk	367,733	334,805	441,714	446,397	394,942	415,447	381,915	404,620	352,386	388,482	23,353	15,414	150,472	132,415

Table 5.21 Landed Value of Fisheries Harvest for Northwest Atlantic Fisheries Organization Unit Area 4Rd, 2004 to 2010

Species	2004		2005		2006		2007		2008		2009		2010	
	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)
Pelagic														
Mackerel	9,533,066	9,802,555	7,012,557	7,228,536	7,110,085	7,162,036	7,935,416	8,071,914	4,423,152	4,433,815	13,817,259	13,703,505	3,852,313	3,885,715
Herring	7,565,099	7,535,150	7,646,778	7,666,599	7,537,987	7,527,922	374,913	358,480	11,058,093	10,955,138	4,134,037	4,159,051	8,508,237	8,518,377
Eel	13,800	13,800	15,288	15,288	10,406	10,406	14,825	14,825	5,531	5,531	9,790	9,790	4,975	4,975
Skate	11,209	5,627	6,202	2,171	9,607	4,875	12,074	5,003	10,169	4,465	6,918	4,369	28	8
Shortfin Mako											9	9		
Portbeagle											464	368		
Mako Shark	2,406	1,545	1,383	901	1,713	1,152	202	123	164	112	626	425		
Capelin	60,958	60,793	345,640	346,167	755,673	773,910	72,999	72,999	4,083,326	3,920,263	531,430	523,966	171,513	171,813
Groundfish														
American plaice	62,253	55,209	103,916	90,893	52,670	42,272	72,655	63,825	41,743	35,337	77,207	72,882	53,224	50,830
Atlantic halibut	35,197	27,501	52,142	58,899	39,397	31,533	22,828	68,687	32,233	87,973	22,472	34,903	30,141	24,212
Atlantic wolffish	5,909	4,917	6,894	5,871	3,387	2,129	4,536	3,137	4,319	2,914	7,783	6,263		
Catfish			223	82			17	3						
Haddock	2,831	1,988	9	2	20	11	3	2	20	8	17	10	24	9
Cod	347,362	300,006	764,692	701,328	1,166,051	1,114,206	556,121	455,169	828,966	806,554	593,498	497,897	221,510	180,402
Cusk	34	29	12	0	9	7			5	0	14	0	36	18
Greenland halibut	2,511	1,250	5,435	4,513	2,974	3,126	1,750	935	2,217	1,753	1,951	1,335	355	731
Lumpfish	26,320	26,320	21,291	21,073	29,998	29,998	1,273	1,273	179	179				
Witch Flounder	406,796	376,214	475,390	486,300	412,128	435,122	427,218	408,348	300,847	285,585	244,097	235,960	109,264	102,649
Monkfish	778	712	1,243	704	333	196	87	77	32	12	416	341	754	513
Polluck	221	171	60	31	17,407	14,360	140	112	818	670	2,326	1,769	193	90
Redfish	205,964	165,733	381,018	361,001	98,145	95,147	1,780	1,183	54,299	50,663	90,358	88,857	135,105	115,414
White hake	12,551	9,360	8,089	5,746	3,729	2,513	5,635	3,586	7,508	3,962	2,415	1,743	3,049	2,152
Winter flounder	49	45	214	214	265	262	157	143	2,619	2,404	39	39		
Shellfish														
Lobster	263,479	236,479	347,720	347,720	351,275	351,275	333,039	333,039	403,391	403,391	343,450	343,450	321,106	321,106
Snow crab	337,842	335,555	84,652	84,521	44,796	44,847	24,126	24,022	58,691	58,338	110,557	109,144	51,563	50,749
Rock crab	238	238												
Atlantic razor clam														
Scallop	12,289	1,481	1,118	135			301	36	6,777	816				
Squid	29	0												

Table 5.22 Landed Value of Fisheries Harvest for Northwest Atlantic Fisheries Organization Unit Area 4Vn. 2004 to 2010

Species	2004		2005		2006		2007		2008		2009		2010	
	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)
Pelagic														
Mackerel	10,372	4,667	125,206	77,874	221,537	177,536	367,032	164,066	110,548	90,415	51,364	37,937	6,248	0
Herring	1,483,885	328,357	650,785	267,685	218,498	86,671	72,238	24,310	201,720	39,501	4,719	2,478	1,037	0
Eel											10,571	44,935		
Elvers											45	0		
Skate			92	42	0	0	1,942	676						
Shortfin Mako														
Portbeagle	938	1,276	349	445	682	567	1,219	1,050			414	0	184	0
Spiny Dogfish			7,329	3,223							1	0		
Blue Shark	46	61	74	119	37	61	36	59						
Mako Shark	173	184	42	47	242	369					256	0	283	0
Alewives / Gaspereau					3,346	735	13,580	6,644	17,890	944	11,164	898	4,848	0
Argentine					4	0								
Smelts							41	45						
Swordfish	162	1,375							100	637			147	0
Bluefin Tuna			737	12,636	4,471	87,672	2,149	35,768	1,994	40,569			626	9,868
Capelin														
Groundfish														
American plaice	10,880	17,925	16,355	18,928	22,302	36,041	15,279	22,770	6,448	9,675	3,194	3,166	1,381	450
Atlantic halibut	37,660	325,611	43,684	384,443	40,996	381,954	45,600	455,471	55,314	524,952	78,881	811,175	66,906	127,895
Atlantic Wolffish			0	0					176	74	35	12	90	0
Catfish	485	216	181	79	94	38	87	39						
Haddock	824	866	1,263	1,580	4,105	6,211	179	245	302	468	507	832	308	26
Cod	240,086	426,627	242,889	505,969	231,590	487,485	169,983	341,985	129,088	241,867	34,693	65,873	24,200	51,698
Cusk	82	51	56	49	103	89	16	14	11	11	23	20	496	0
Greenland halibut	240,168	426,678	242,945	506,018	231,693	487,574	169,999	341,999	129,099	241,878	34,716	65,893	24,696	51,698
Lumpfish														
Hagfish (Slime Eel)					1,014	1,003	590	584	1,165	1,153			1,451	0
Witch Flounder	235,798	235,923	313,678	411,164	262,872	161,497	284,453	236,571	190,182	138,628	74,427	61,616	108,548	0
Monkfish	912	1,119	2,691	4,110	2,303	2,233	2,795	3,090	1,069	1,640	931	1,337	938	1,294
Polluck	221	90	141	77	37	33	100	89	47	34	2,096	1,850	279	0
Redfish	950,756	566,500	612,383	368,187	545,169	319,418	523,611	374,741	609,093	422,261	866,758	566,676	648,675	326,235
Scuplins					14	6								
Tomcod														
White hake	60,118	26,149	53,687	43,696	75,382	67,783	40,402	35,659	27,072	27,180	26,989	28,674	24,039	28,005
Silver Hake					8	6								
Windowpane flounder														
Winter flounder														
Yellowtail														
Shellfish														
Lobster	1,760,065	22,918,017	1,938,030	26,838,518	1,861,542	23,922,207	1,914,371	25,237,346	2,732,636	29,439,474	2,138,212	19,491,984	2,430,430	21,855,904
Snow crab	1,893,730	12,525,138	868,673	3,659,076	665,885	1,870,679	342,448	1,555,360	426,103	1,921,460	786,402	2,703,414	856,854	3,380,480
Rock crab	282,790	200,113	232,416	171,169	245,966	205,547	200,759	209,004	164,224	127,634	174,404	124,510	166,900	5,755
Toad crab	14,341	9,466	9,667	5,601	2,802	1,849	12,768	7,023						
Jonah crab	946	1,250			1,229	27	182	4	375	1	269	1	634	3
Stone crab	8	8												
Propellor crab					1,738	192								
Cockles					737	0								
American Oysters	18,981	27,914	28,291	23,764	14,187	11,915	3,254	2,735	640	544			1,661	0
Atlantic razor clam														
Scallop	35,305	61,297	18,595	25,395	26,435	35,633	33,832	45,533	42,553	61,023	34,734	58,720	46,297	1,182
Soft shell clam			58	256									2,044	3,591
Squid														
Sea Urchin	61,719	180,345	63,653	160,847	63,056	128,500	64,150	128,835	56,852	127,885	82,647	256,290	85,264	6,585
Shrimp	2,044,848	3,145,858	1,141,667	1,306,012	613,705	566,931	89,372	83,661	220,785	236,313	10,665	10,337	132,744	140,227
Stimpson's surf clam					27,143	4,872								
Surf clam														
Whelk									10	10				

Table 5.23 Landed Value of Fisheries Harvest for Northwest Atlantic Fisheries Organization Unit Area 3Pn. 2004 to 2010

Species	2004		2005		2006		2007		2008		2009		2010	
	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)	Weight (kg)	Landed Value ($)
Pelagic														
Mackerel	29,499	29,499	81,688	81,688	76,863	76,863	51,581	51,581	5,928	5,928	5,024,020	4,935,831	4,222,271	4,286,451
Herring	42,582	42,582	100,834	100,834	90,399	90,399	82,491	82,491	8,594	8,594	79,030	80,089	9,371	9,371
Eel	6,294	6,294	3,207	3,207	2,985	2,985	2,569	2,569	2,462	2,462			1,251	1,251
Skate	11,018	6,016	8,561	4,798	6,824	4,576	9,927	6,598	10,034	7,227	7,610	3,929	5,644	2,806
Shortfin Mako			10	10	9	9	15	15	19	19	6	6	67	65
Portbeagle			28	28	105	70					237	181	491	425
Mako Shark	671	465	1,413	991	527	365	1,355	914	1,406	994	1,454	989	797	528
Groundfish														
American plaice	8,908	8,713	11,254	10,901	9,285	9,005	10,455	10,294	10,014	9,845	11,472	11,177	6,307	6,190
Atlantic halibut	28,959	22,772	22,007	17,312	17,280	13,614	29,600	23,135	42,944	33,752	61,204	48,673	46,277	36,082
Atlantic wolffish	9,437	8,657	19,038	9,065	4,710	4,242	5,312	4,811	8,983	8,265	13,655	12,701		
Catfish	3	3												
Haddock	11	10	3	2			2	1	107	90	64	39	83	68
Cod	778,662	645,324	849,090	707,271	1,208,134	1,000,530	1,080,830	899,013	1,130,827	941,797	1,356,757	1,124,237	703,822	584,728
Cusk	383	283	69	57	87	30	83	61	299	220	123	84		
Greenland halibut	705	701	1,128	1,112	1,487	1,428	1,173	1,120	953	893	1,235	1,202	378	368
Lumpfish	89,075	89,075	56,001	56,001	59,361	59,361	4,403	4,403	197	197				
Witch Flounder	7	10	3	3			1	0	6	0	1	0	31	3
Monkfish	142	109	223	104	91	38	54	39	272	228	43	36	173	83
Polluck	5,717	5,088	1,795	1,488	1,648	1,226	2,546	2,093	2,776	2,331	6,015	4,734	2,104	1,602
Redfish	182,029	179,403	51,812	54,544	165,881	158,284	19,230	21,540	50,572	55,045	22,905	21,617	55,642	55,934
White hake	74,874	61,859	44,887	37,216	15,864	13,104	36,004	30,014	46,658	38,586	27,320	22,538	20,920	36,082
Winter flounder	1	1	7	6	121	110			36	33	3	3		
Yellowtail			51	51	19	17							16	16
Shellfish														
Lobster	12,932	12,932	28,808	28,808	47,954	47,954	93,954	93,954	153,264	153,264	127,342	127,342	13,844	138,438
Snow crab	1,461	1,461	520	520	2,066	2,066	2,987	2,987	1,325	1,325	649	703	1,039	957
Squid	5	0												

During this time period, the majority of the harvest for NAFO Unit Areas 4Ss and 4Tf was landed in the Québec region, for 4Rd and 3Pn it was landed in Newfoundland and for 4Vn it was landed in Nova Scotia. During this time period, no fish catch data were landed in the Gulf region for NAFO Unit Areas 4Rd and 3Pn. For the entire NAFO Unit Area 4Ss, the landings were dominated by shrimp, lobster, snow crab and Greenland halibut in 2004, 2005, 2006, 2007, 2008 and 2009 and by shrimp, snow crab, lobster, Greenland halibut and redfish in 2010. For the entire NAFO Unit Area 4Tf, the landings were dominated by snow crab, lobster and herring in 2004 and 2005, by snow crab, lobster and mackerel in 2006, by lobster, snow crab and rock crab in 2007, 2009 and 2010, and by lobster, snow crab and cod in 2008. For the entire NAFO Unit Area 4Rd, the landings were dominated by mackerel, herring and witch flounder in 2004, by mackerel, herring and cod in 2005, 2006 and 2009, by mackerel, witch flounder and cod in 2007, by herring, mackerel and capelin in 2008 and by herring, mackerel and lobster in 2010. For the entire NAFO Unit Area 4Vn the landings were dominated by redfish, lobster, snow crab and rock crab in all years between 2004 to 2010 and in addition, by: herring, cod, Greenland halibut, witch flounder and shrimp in 2004; by mackerel, herring, cod, Greenland halibut, witch flounder and shrimp in 2005, 2006 and 2008; by mackerel, cod, Greenland halibut and witch flounder 2007; and by witch flounder and shrimp in 2010. For the entire NAFO Unit Area 3Pn, the landings were dominated by cod, redfish and lumpfish in 2004, by cod, herring and mackerel in 2005, by cod, redfish and herring in 2006, by cod, lobster and herring in 2007, by cod, lobster and redfish in 2008, by mackerel, cod and lobster in 2009 and by mackerel, cod and redfish in 2010. All catch data reported have been fished between April and December of each year.

The fishing effort in NAFO Divisions 4Ss, 4Tf, 4Rd, 4Vn and 3Pn (i.e., divisions surrounding EL 1105) are presented in Figures 5.59 to 5.62 by species, geo-referenced by latitude and longitude.. Note that not all of the catch data summarized in Tables 5.19 to 5.23 included harvest locations coordinates and as such, the commercial fishery figures may not illustrate the same information as portrayed in the tables. Fisheries species of special status in the Gulf because of a moratorium or conservations status of the fish population by COSEWIC are also indicated in Figures 5.59 to 5.62, if applicable.

As is evident in Figures 5.59 to 5.62, there is minimal fishing effort within and surrounding the Project. No harvesting locations were recorded within EL 1105. The closest harvest location to the Project is located just less than 10 km to the southwest of EL 1105, and was recorded for redfish. Between 10 and 12 km from the EL 1105, a couple of harvest locations were recorded for redfish and one for each cod and white hake. However, in general, the fishing effort can be summarized in the immediate vicinity of the Project as low.

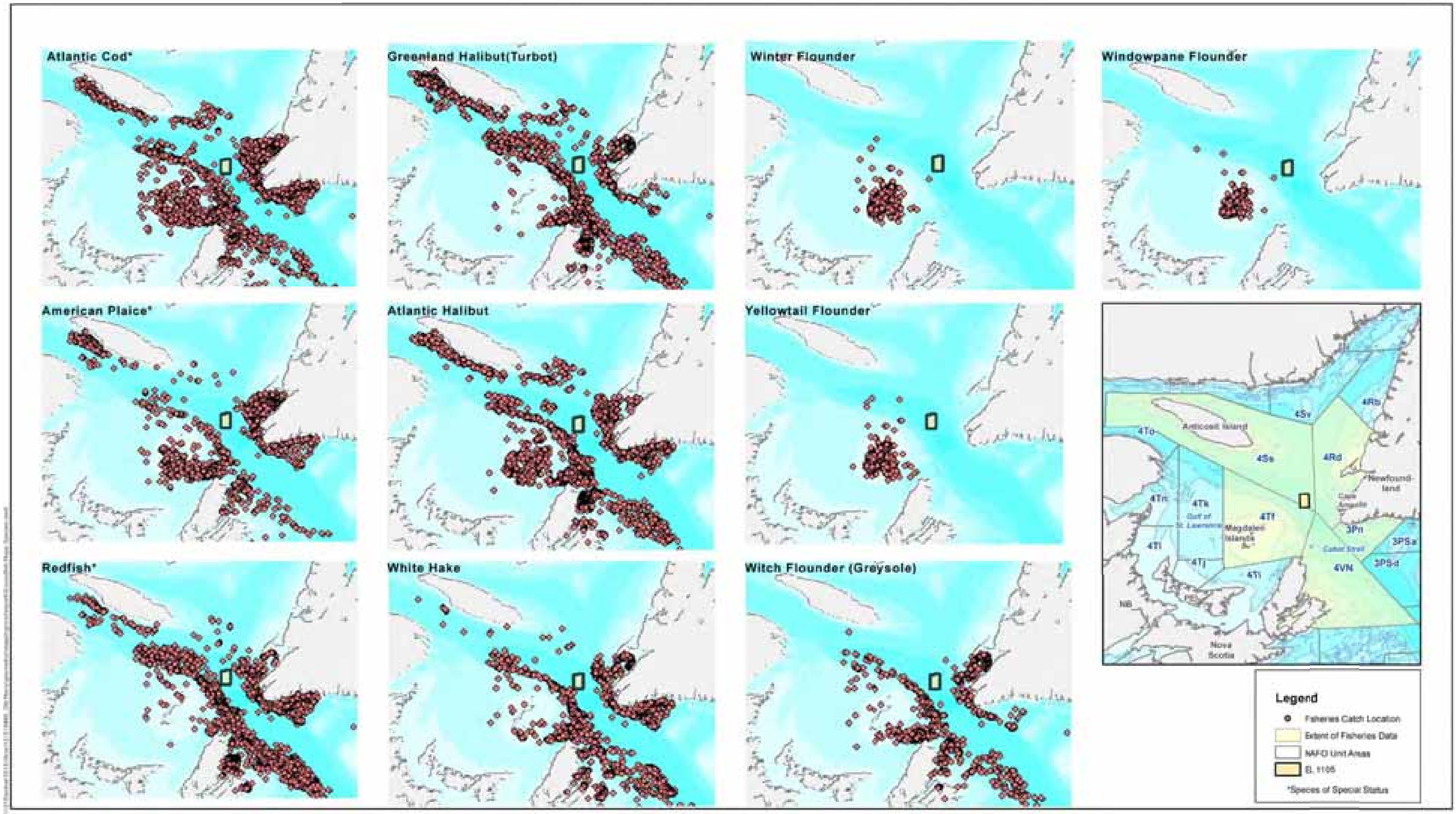


Figure 5.59 Groundfish Fisheries Effort for Major Species, 2004 to 2010

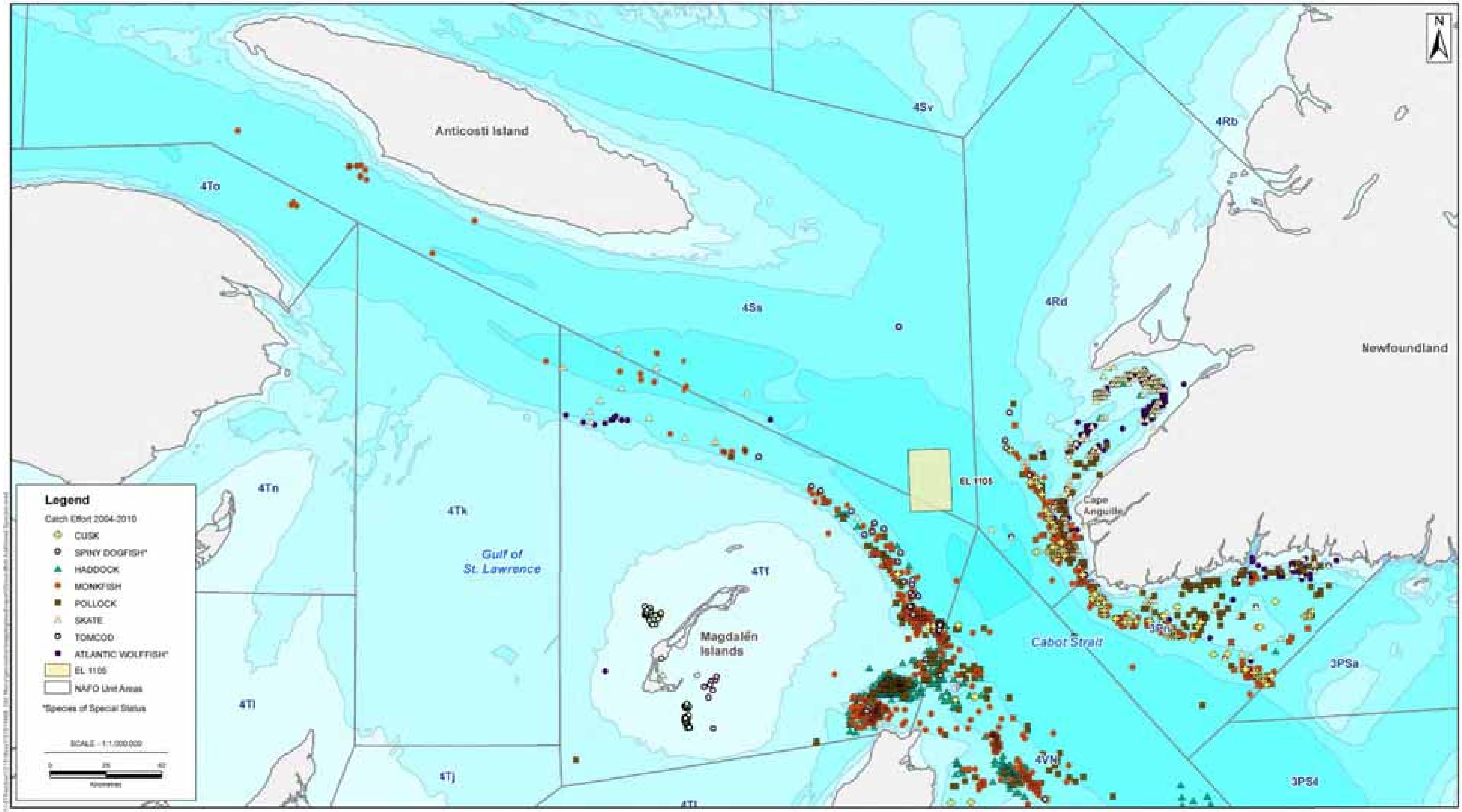


Figure 5.60 Groundfish Fisheries Effort for Additional Species, 2004 to 2010

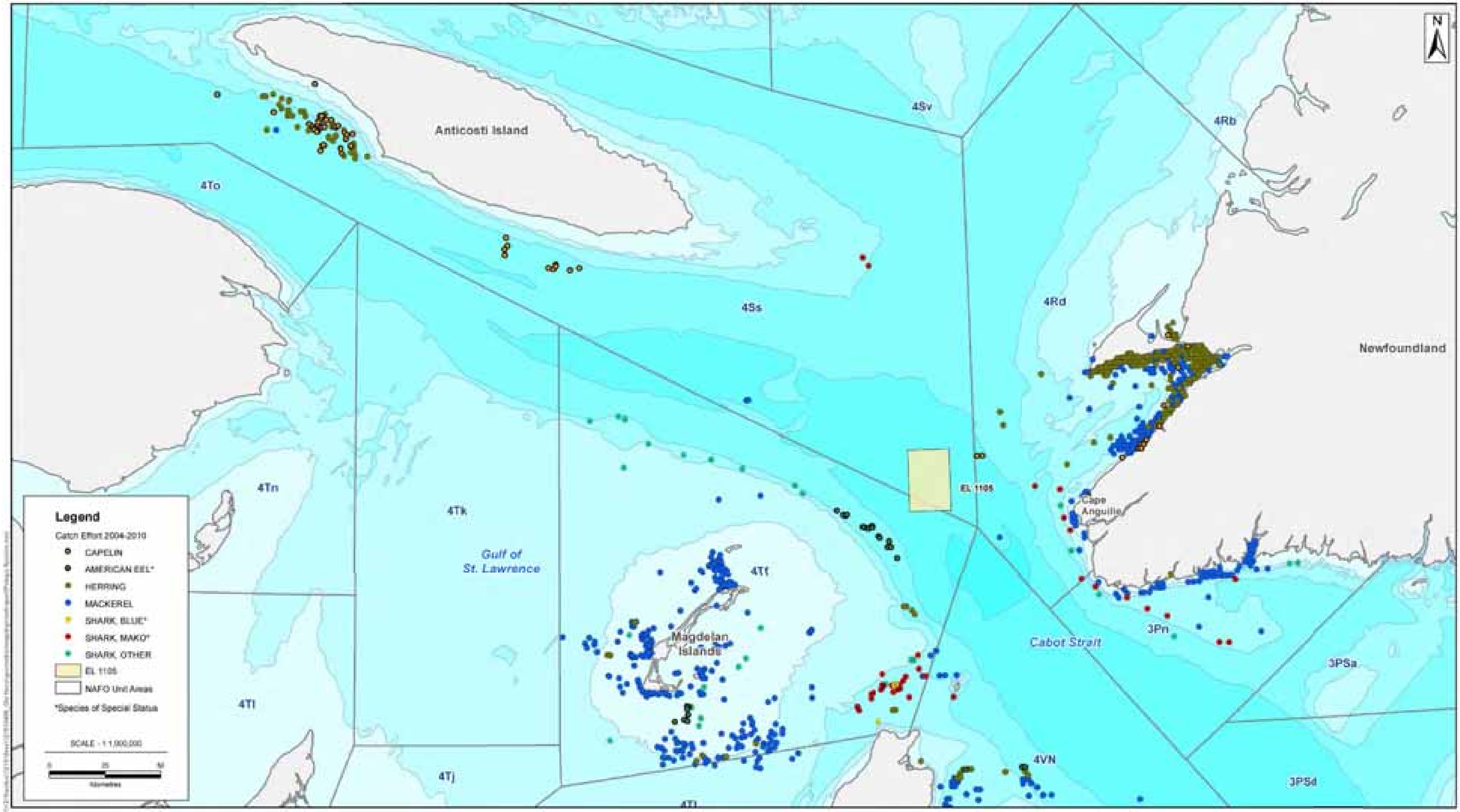


Figure 5.61 Pelagic Fisheries Effort, 2004 to 2010

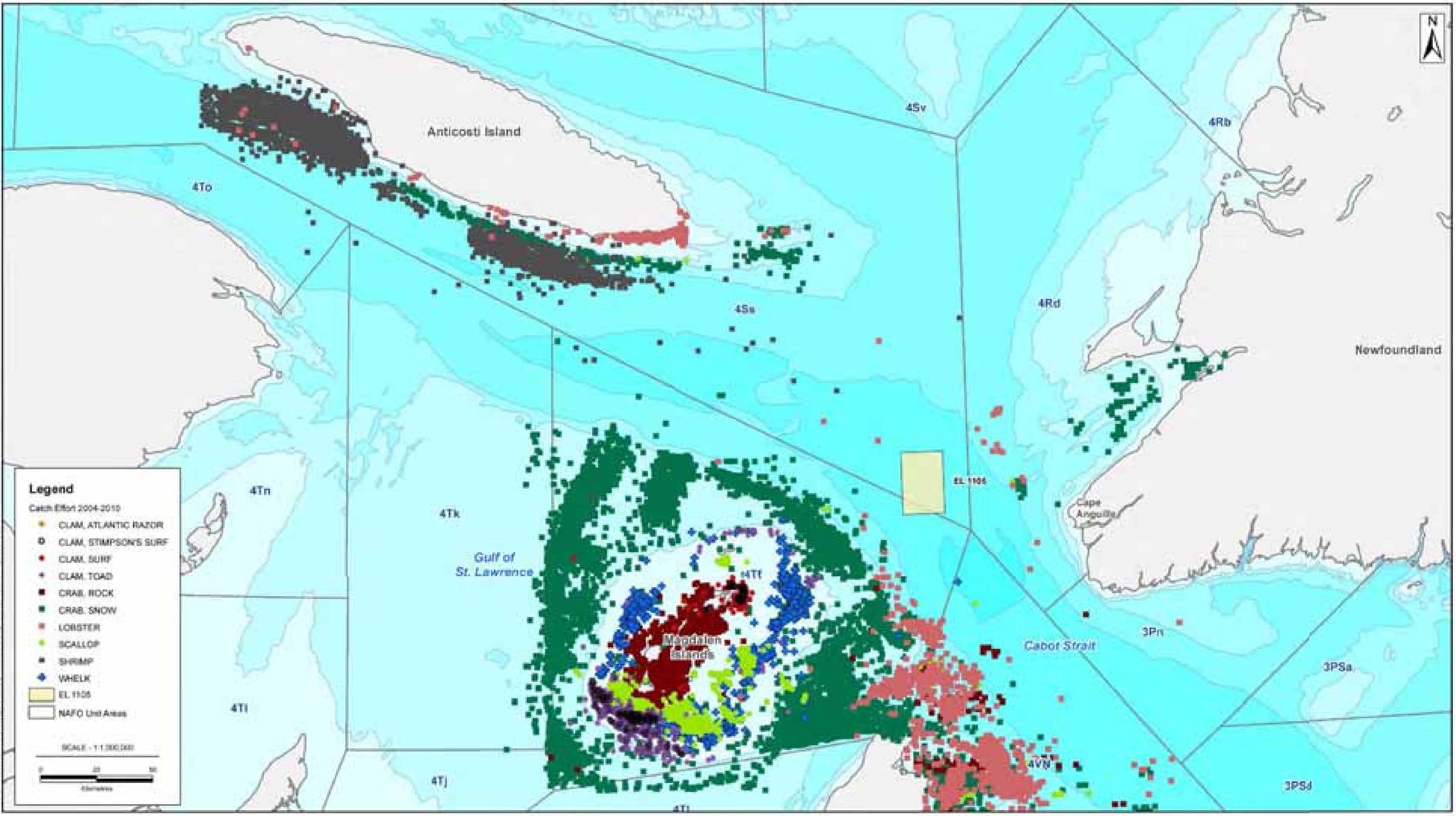


Figure 5.62 Shellfish Fisheries Effort, 2004 to 2010

5.8.1.2 Principal Commercial Fish and Shellfish Species

On the basis of the landed weight data collected and analyzed for the years 2004 to 2010 for NAFO Unit Areas 4Ss, 4Tf, 4Rd and 3Pn (Tables 5.19 to 5.23), the main fish and shellfish species commercially fished in the vicinity of EL 1105, (i.e., those that reported the highest landed weights) included mackerel, herring, cod, deepwater redfish, witch flounder, Greenland halibut, lobster, shrimp, snow crab and rock crab. There are currently only three enterprises of approximately 60 license holders participating in the redfish fishery. There are no authorized redfish fisheries in NAFO Unit area 4Ss, and Variation Order 2010-056 results in closures of the redfish fishery from June 15 to December 31, 2010, for a range of vessel types in NAFO Unit Areas 4To, 4Tn, 4Tk (Theriault 2010, L. Légère pers. comm. 2010); the closure boundaries have the potential to stretch into a portion of 4Tf. The snow crab fishing season in area 12F starts in April / May and continues into early summer (DFO 2010g).

Species descriptions for the majority of the fish and shellfish species listed above are provided in Section 5.4 and in the 2005 Western Newfoundland SEA (LGL 2005b), Sections 3.4.1 and 3.4.2.

5.8.1.3 Historical Fisheries

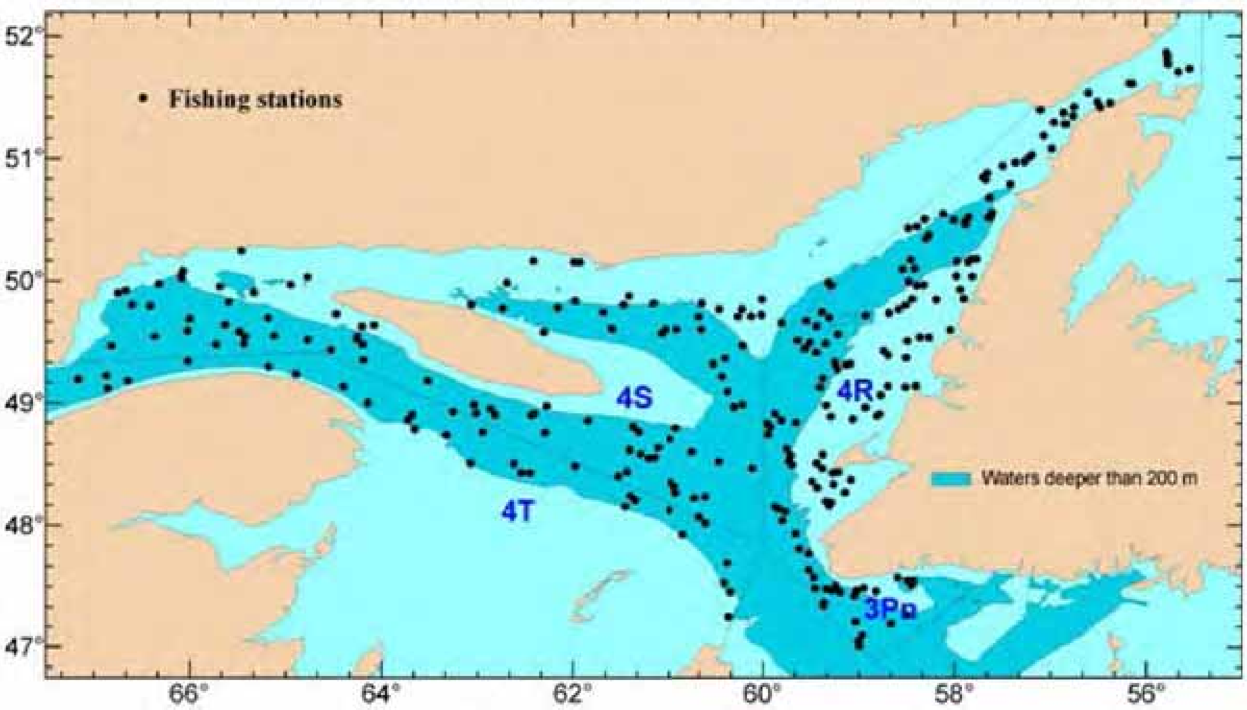
Although the fishing effort for the Atlantic cod in the vicinity of the Project is low (refer to Figure 5.59), this species has been over-exploited in offshore western Newfoundland waters in the past. The commercial cod fishery began in the 1600s or earlier. According to DFO, cod landings in Newfoundland between the 1600s and the 1800s ranged from 100,000 to 400,000 t annually. In the 1950 to 1970s, cod landings averaged 900,000 t and peaked at 2,000,000 t. In the early 1970s, all cod stocks in the Northwest Atlantic were placed under a quota regulation (DFO 2010o). In the late 1980s to early 1990s, landings of cod started to decline significantly and in 1993 a moratorium on the cod fishery was imposed. The southern Gulf cod fishery was closed from September of 1993 to May of 1998, when it re-opened with a total allowable catch (TAC) of 3,000 t. The TAC was increased to 6,000 t in 1999 to 2002. In 2003, the cod fishery closed again and re-opened in 2004 with TAC of 3,000 TAC. In 2005 and 2006, the TAC was 4,000 t, and in 2007, 2008 and 2009 it was at 2,000 t (Swain et al. 2009; DFO 2009r).

During the time period of 1960 to 1994, the commercial fishery of white hake was historically considered the third or fourth most important groundfish fishery in the southern Gulf. During this time, landing values averaged 5,675 t (DFO 2005c). However, a moratorium on the directed fishery for white hake in NAFO Unit Area 4T was established in 1995 due to a substantial decline in landing values (DFO 2005c). The only landings of white hake from this Unit Area are a result of by-catches. As of 2011, the moratorium on white hake is still in force (DFO 2010p).

Historical fisheries offshore western Newfoundland and in the Gulf have been described in further detail in the 2005 Western Newfoundland SEA (LGL 2005b) in Section 3.4.4.2 and the 2007 Western Newfoundland SEA Amendment (LGL 2007) in Section 3.3.2.1.

5.8.1.4 Sentinel Fisheries

The mobile gear Sentinel Fisheries Program (St. Lawrence Global Observatory 2010) follows a depth-stratified random survey plan. The northern Gulf is divided into depth strata because depth is known to have an influence on the distribution of fish and invertebrate species. The mobile survey generally consists of 300 stations randomly selected within those strata with all strata sampled, because results from this survey are used for multiple species with different depth preferences (Figure 5.63).



Source: SLGO 2010

Figure 5.63 Distribution of Stratified Random Tows Performed during the July 2010 Survey

Nine trawlers, five from Newfoundland and Labrador and four from Quebec, conduct the survey. At each pre-determined station, the vessel performs a standard 30 minutes tow at 2.5 knots. The boats participating in the survey use a 300 star balloon trawl mounted on a rock hopper footgear. The trawl mesh size is 145 mm, with a liner of 40 mm in the codend.

The 16th annual July sentinel survey was conducted in the northern Gulf between June 30 and July 19, 2010. A total of 280 fishing stations were successfully carried out (Figure 5.63), including 21 stations in 3Pn, 129 in 4R (including 10 tows in the 10 to 20 fathoms strata), 100 in 4S and 30 in 4T; this represented 93 percent of the sampling target.

Data collected per set of information included length, weight, sex and maturity for a certain number of fish for each species. In addition, samples of otoliths, liver, gonads and stomach may also be collected. Fish samples are also collected and frozen for diverse studies. Finally, water temperature and fishing depth data are collected using a Vemco sensor installed on the trawl.

Cod, redfish, Greenland halibut (turbot) and Atlantic halibut catches for the 280 successful tows of the 2010 July survey are presented in Table 5.24. In 2010, American plaice, thorny skate and shorthorn sculpin were the other main fish caught.

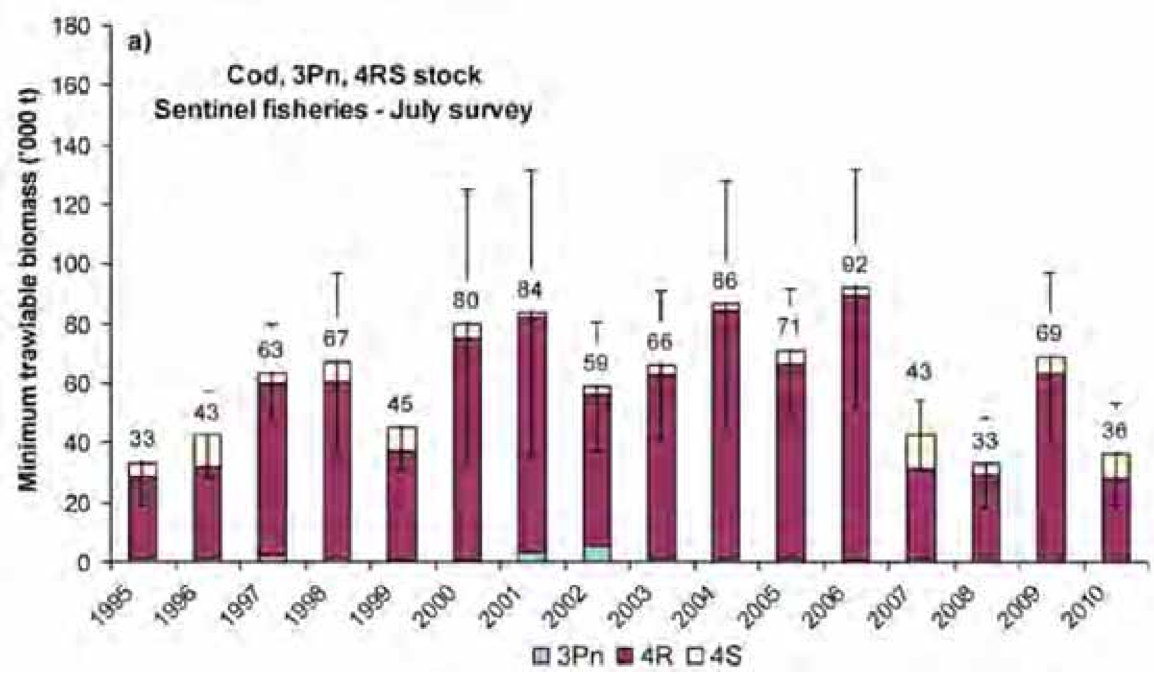
Table 5.24 Cod, Redfish, Greenland Halibut and Atlantic Halibut Catches for the July 1995 to 2010 Surveys (3Pn, 4RST)

Year	Sets Survey	Survey Catches (kg)				Sets Total	Total Catches (kg)				
		Cod	Redfish	Turbot	Halibut		Cod	Redfish	Turbot	Halibut	Other
1995	311	6,477	11,457	649	84	326	6,598	11,662	675	84	4,716
1996	272	7,254	16,921	1,300	114	332	12,108	27,169	1,502	150	8,593
1997	285	8,642	12,358	1,206	27	313	11,271	13,582	1,397	80	5,848
1998	289	7,719	16,154	1,472	17	320	12,196	36,231	1,668	113	7,198
1999	294	5,487	12,623	1,703	42	335	19,396	17,177	2,079	129	4,031
2000	291	7,893	7,574	1,583	97	324	16,963	10,486	1,932	126	5,454
2001	275	10,238	7,603	1,342	120	317	16,476	14,421	1,814	208	4,194
2002	261	7,729	8,101	1,486	113	293	18,551	8,849	3,090	160	4,155
2003	296	13,741	6,400	1,693	44	326	14,040	6,616	3,512	72	3,590
2004	280	14,072	8,245	2,015	216	317	15,655	13,295	2,567	271	6,670
2005	285	9,662	6,785	2,977	226	303	10,023	7,802	3,649	402	8,652
2006	295	13,174	5,106	2,748	335	325	15,332	5,963	3,624	577	6,647
2007[A]	291	6,431	6,797	2,976	382	297	6,435	6,836	2,977	399	3,905
2008[A]	289	9,931	4,310	2,594	456	293	9,931	4,341	2,604	456	2,743
2009[A]	282	8,939	3,605	1,701	521	285	8,940	3,605	1,716	521	3,921
2010[A]	280	7,137	4,059	1,935	395	284	7,137	4,059	1,965	395	2,689

Source: SLGO 2010
A No discretionary tows.

Cod

The July sentinel survey series for water deeper than 20 fathoms (1 fathom = 1.8 m) (1995 to 2009) suggests an increase in the minimum trawlable biomass for cod between 1995 and 2001, followed by stable period up to 2006 (Figure 5.64). Substantial decreases were observed in 2007 and 2008, followed by an increase in 2009. The estimate of 36,478 tons in 2010 is a marked decrease, bringing the index level close to the lowest values observed in the series (33,000 tons in 1995 and 2008).



Source: SLGO 2010

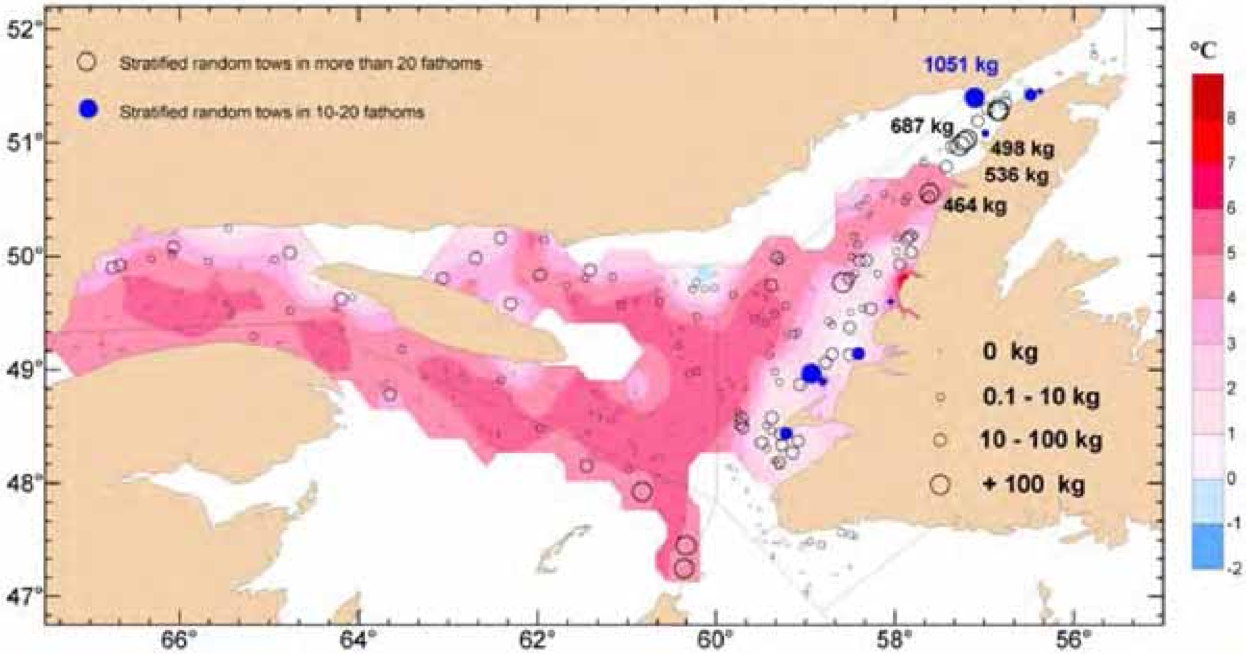
Figure 5.64 Minimum Trawlable Biomass Index for Cod (July sentinel mobile survey in Subdivision 3Pn and Divisions 4RS (1995 to 2010))

Three inshore strata with depths ranging from 10 to 20 fathoms were added in 2003 for 4R. These strata were added to examine cod outside the zone previously sampled by trawlers in the July mobile gear sentinel survey. Ten tows were done in these strata by four trawlers during the July 2010 survey. The cod catches varied between 0 and 1,051 kg for a 30-minute standard tow. Six of the ten tows reached the 30-minute duration, while the other four lasted less than 30 minutes because of bad bottom (trawl hooked at the bottom). The global biomass index (including the 10 to 20 fathoms strata) is 45,323 tons for 2010; this value is the lowest observed since sampling began in 2003.

The catch distribution shows that cod is located primarily in 4R along the west coast of Newfoundland (Figure 5.65). In 2010, the cod concentration remains low in 4S and 3Pn. Of the 280 tows performed as part of this survey in 2010, five had catches of cod of more than 400 kg and they were all located in 4R. Only one large catch occurred in the 10- to 20-fathom strata. The largest catches for 4S and 3Pn were 61 and 3 kg, respectively.

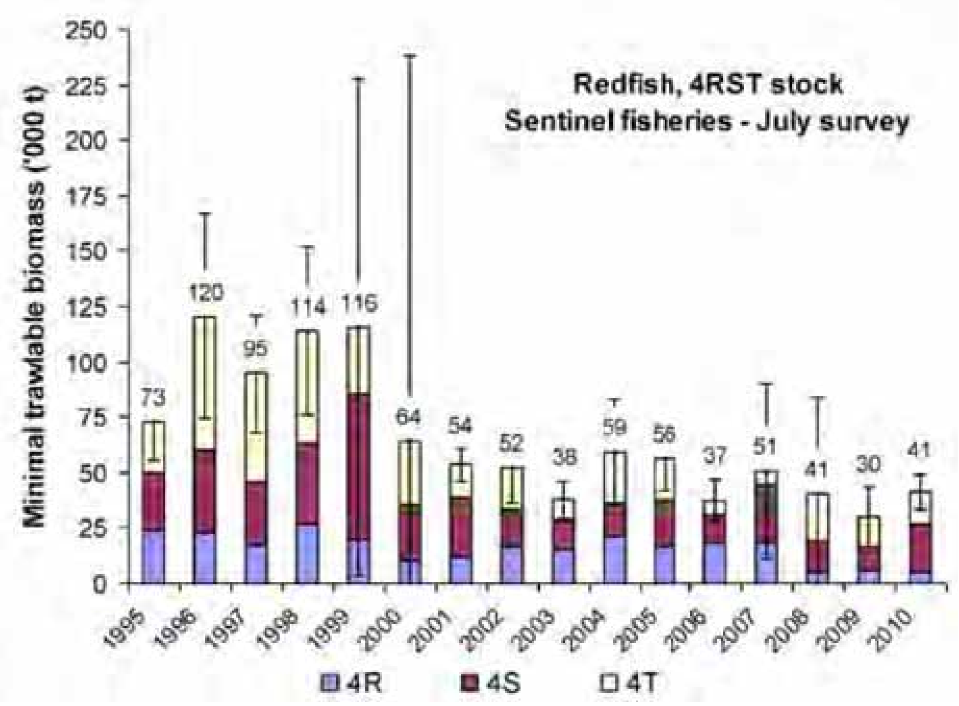
Redfish

For Unit 1 redfish stock (4RST Divisions), the July sentinel survey series (1995 to 2010) shows a higher minimum trawlable biomass between 1996 and 1999, followed by decrease biomass from 2000 until 2009 (Figure 5.66). In 2010, the minimum trawlable biomass estimate increased (primarily in 4S) to 41,283 tons but remains among the lowest values of the series.



Source: SLGO 2010
Note: Catches greater than 400 kg are noted on map.

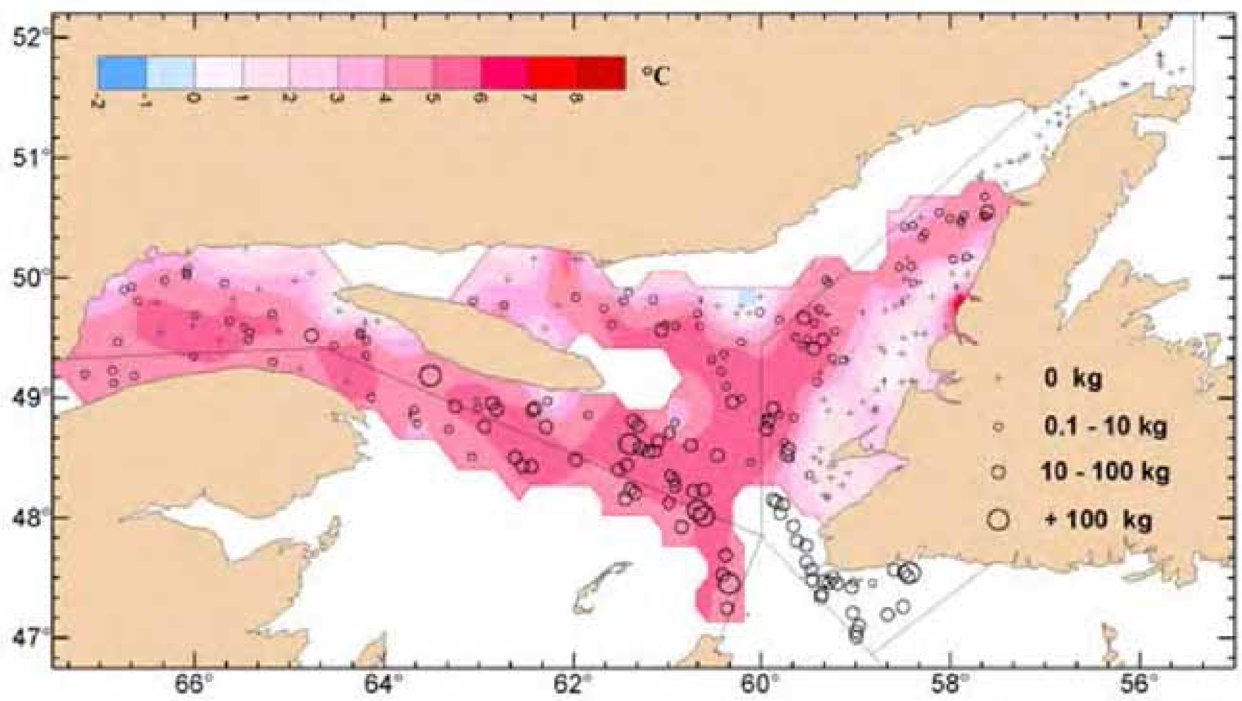
Figure 5.65 Bottom Temperature and Observed Catch Rate (kg/standard tow) Distribution of Cod for the July 2010 Stratified Random Survey in 3Pn and 4RST



Source: SLGO 2010

Figure 5.66 Minimum Trawlable Biomass Index for Redfish in 4RST Based on the July Stratified Random Survey (1995 to 2010)

Redfish were concentrated for the most part in the channels of the northern region of the Gulf (Figure 5.67). In July 2010, some concentrations of redfish were found in 3Pn. This area is not part of the redfish stock of Unit 1 management (4RST) between the months of June to December.



Source: SLGO 2010

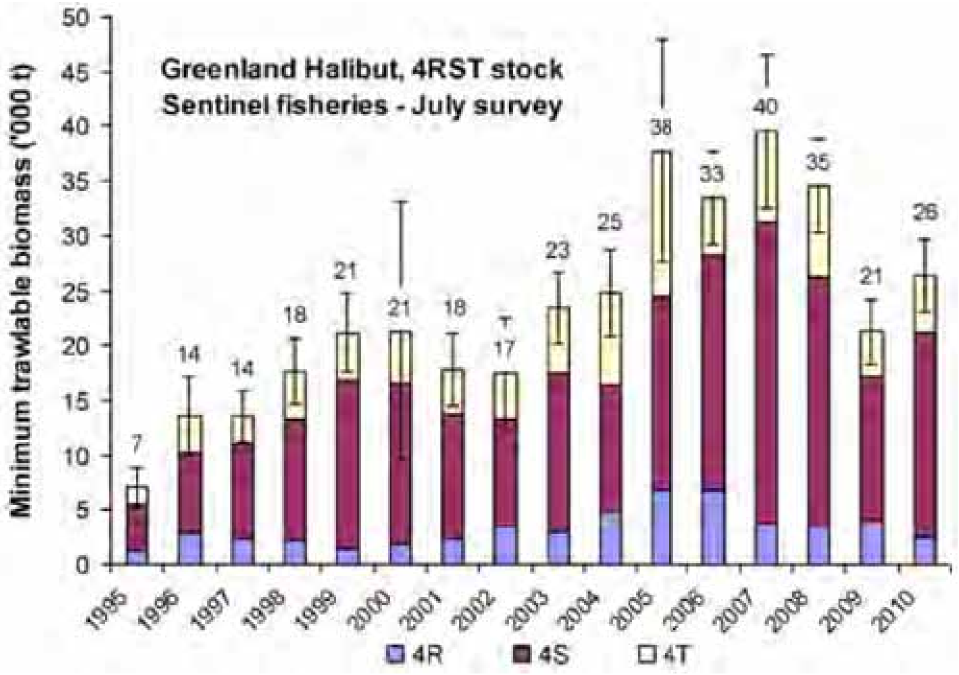
Figure 5.67 Bottom Temperature and Catch Rate (kg/standard tow) Distribution of Redfish for the July 2010 Stratified Random Survey in 3Pn and 4RST

Greenland Halibut

The July sentinel survey series (1995 to 2010) showed a general increase in turbot biomass from 1995 to 2005 that remained relatively stability up to 2008, followed by a substantial decrease in 2009 and an increase in 2010 (Figure 5.68). The 2010 value compares to those observed in 2003 and 2004. Turbot was concentrated mostly in the Estuary and in the Laurentian Channel, around Anticosti Island and in the northern portion of the Esquiman Channel (Figure 5.69). The distribution of turbot is overall similar to those of earlier years.

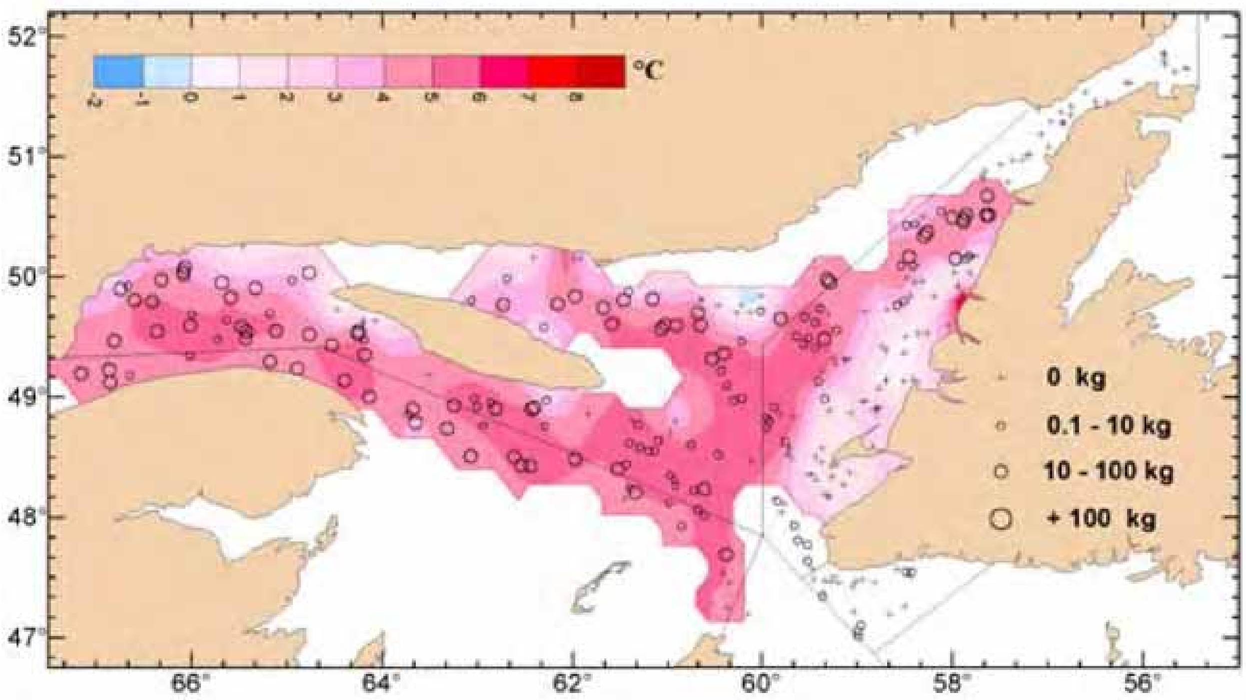
Atlantic Halibut

The July sentinel survey series (1995 to 2010) showed a substantial increase in biomass from 2004 to 2010 (Figure 5.70); biomass was low and stable between 1995 and 2003. The 2010 value compares to those observed in 2007. Atlantic halibut was concentrated mostly in the Esquiman Channel (Figure 5.71).



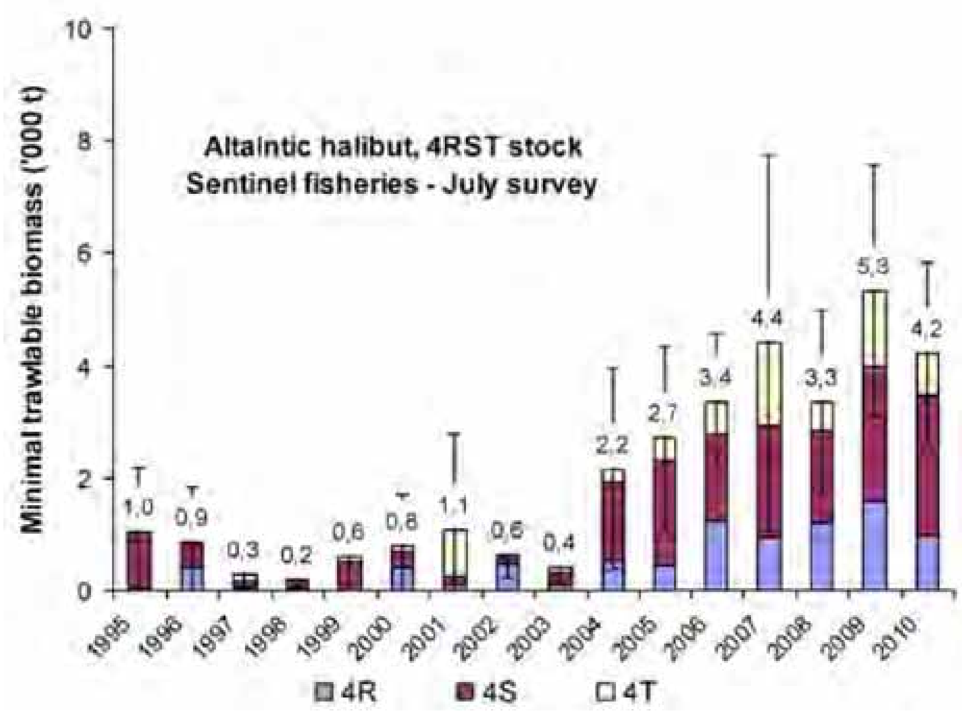
Source: SLGO 2010

Figure 5.68 Minimum Trawlable Biomass Index for Greenland Halibut Based on the July Stratified Random Survey (1995 to 2010)



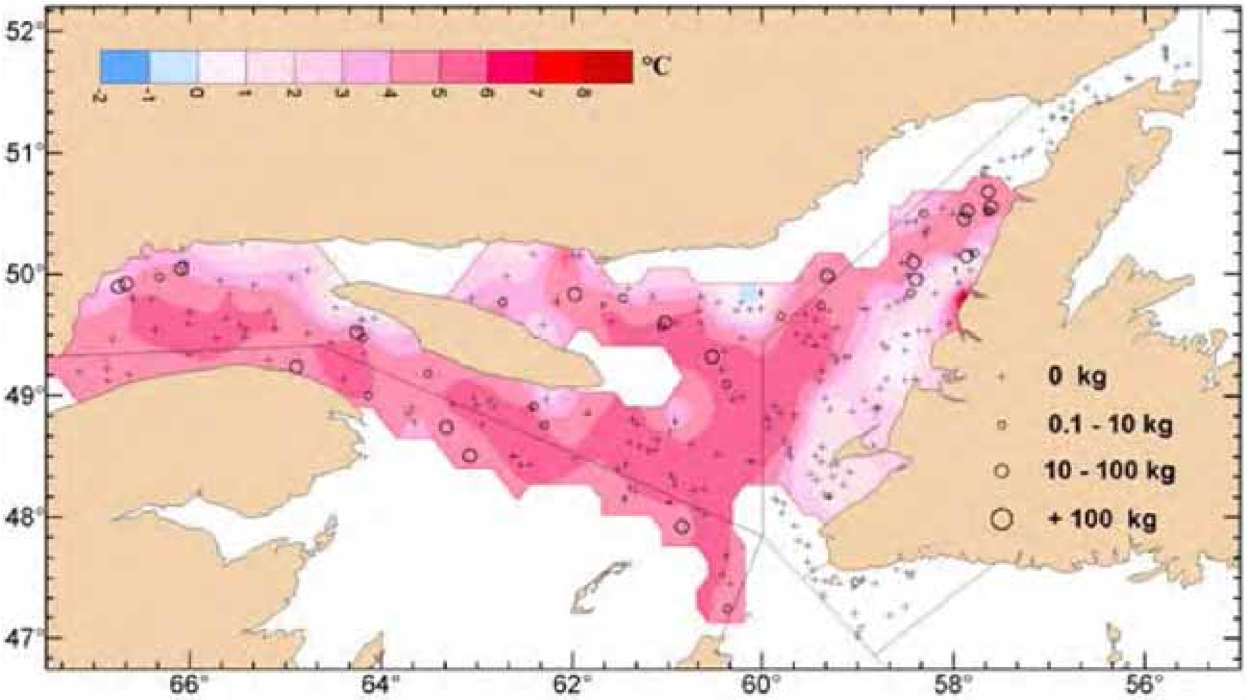
Source: SLGOy 2010

Figure 5.69 Bottom Temperature and Catch Rate (kg/standard tow) Distribution of Greenland Halibut for the July 2010 Stratified Random Survey in 3Pn and 4RST



Source: SLGO 2010

Figure 5.70 Minimum Trawlable Biomass Index for Atlantic Halibut Based on the July Stratified Random Survey (1995 to 2010)



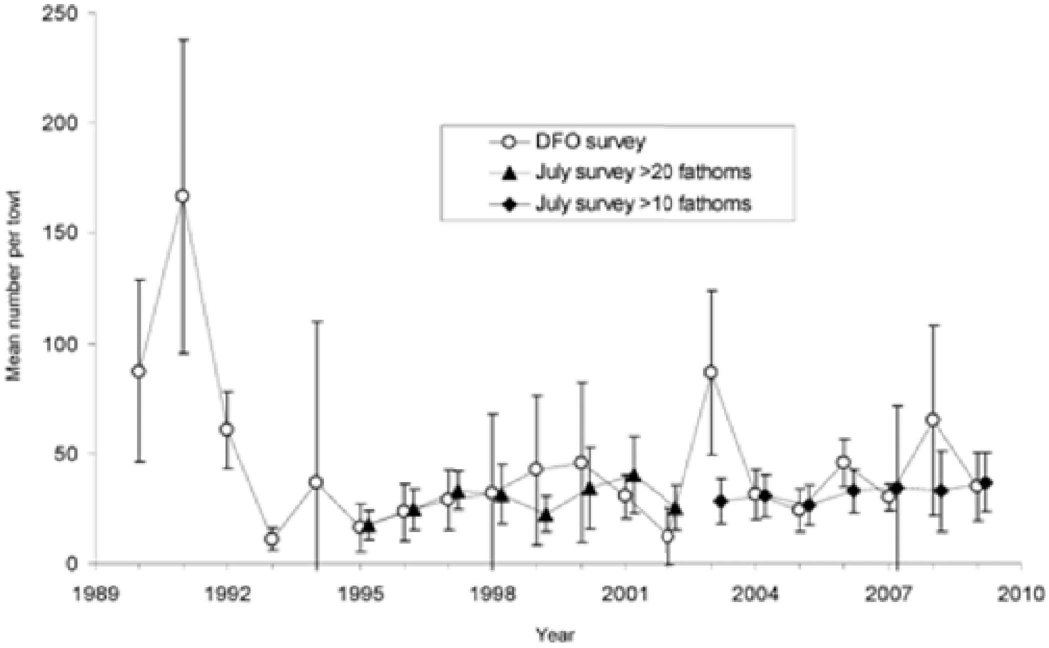
Source: SLGO 2010

Figure 5.71 Bottom Temperature and Catch Rate (kg/standard tow) Distribution of Atlantic Halibut for the July 2010 Stratified Random Survey in 3Pn and 4RST

5.8.1.5 Research Vessel Data

The trends in the main species caught in the northern Gulf DFO research vessel (RV) survey during 1990 to 2008 indicate that turbot, Atlantic halibut and shrimp increased during the last 10 years and are currently at relatively high abundance levels. Redfish remains at low abundance following intensive fishing in the 1980s and early 1990s. Herring and capelin abundance seems relatively healthy. Simulations using abundance data from RV surveys and diet data from various sources has suggested that intensive fishing during the 1980s and early 1990s removed most of the large piscivorous fish trophic level (i.e., cod and redfish), which has left marine mammals as the dominant top predators in the northern Gulf during the 2000s (DFO 2010a).

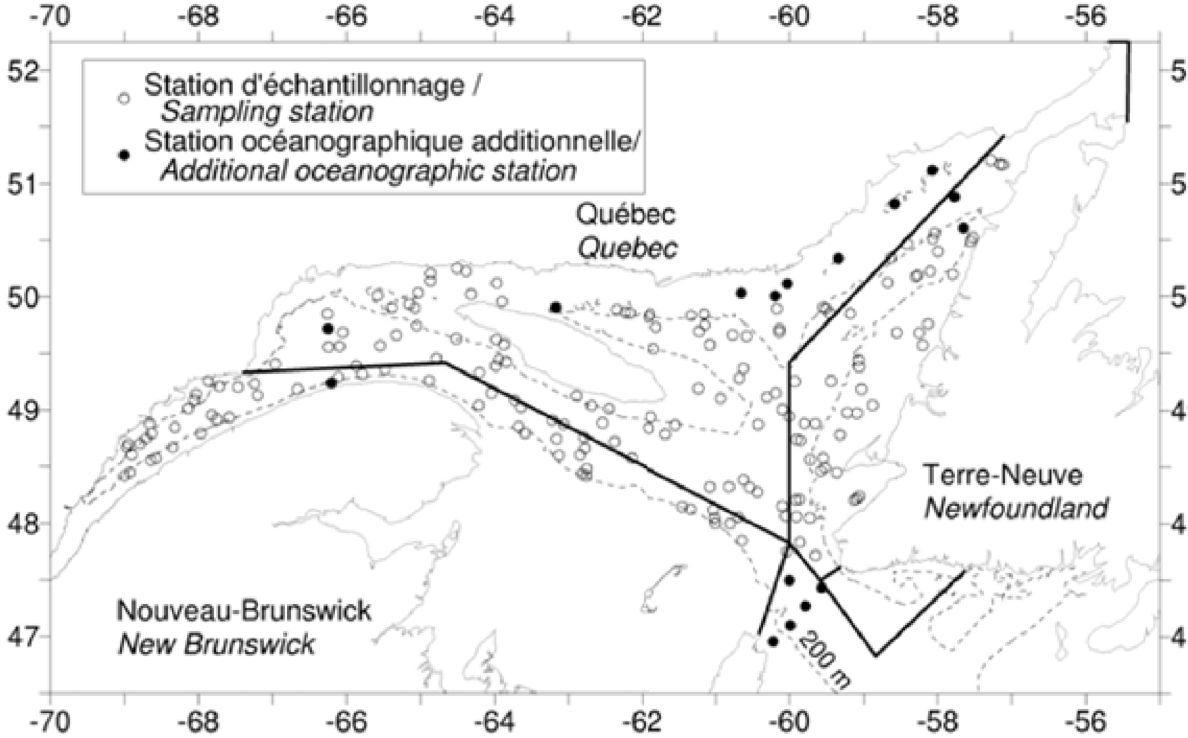
The DFO RV survey began in 1990 on the *CCGS Alfred Needler* and since 2004 has been carried out on the *CCGS Teleost* (DFO 2010a). The results of the RV survey indicate a sharp decline in cod abundance during 1991 to 1993, followed by an increase until 2000. The timing of the increase corresponded to the period of the first moratorium during 1994 to 1996 (Figure 5.72). Abundance then fluctuated with little trend from 2001 to 2009. An abnormal low value occurred in 2002 and a high value occurred in 2003.



Source DFO 2010a

Figure 5.72 Mean Number per Tow for the August DFO RV and the July Sentinel Mobile Surveys

In 2009, the annual summer survey for the assessment of abundance and distribution of groundfish and shrimp in the northern Gulf was conducted from July 31 to August 31 onboard the *CCGS Teleost* (Bordages et al. 2010) (Figure 5.73). In 2009, the abundance and biomass indices of many species have decreased as compared to the previous years. Indices for redfish, black dogfish and longfin hake are among the lowest values. Greenland halibut indices are similar to the early 2000s, a decrease of approximately 30 percent. Meanwhile, indices for other species (cod, northern shrimp, Atlantic halibut, thorny skate, white hake, American plaice, witch flounder and snow crab) in 2009 are comparable to the average of 2004 to 2008 years, even though a decrease was observed compared to 2008. The geographic distributions of catches recorded for the different species in 2009 show the same pattern as observed for the previous seven years.



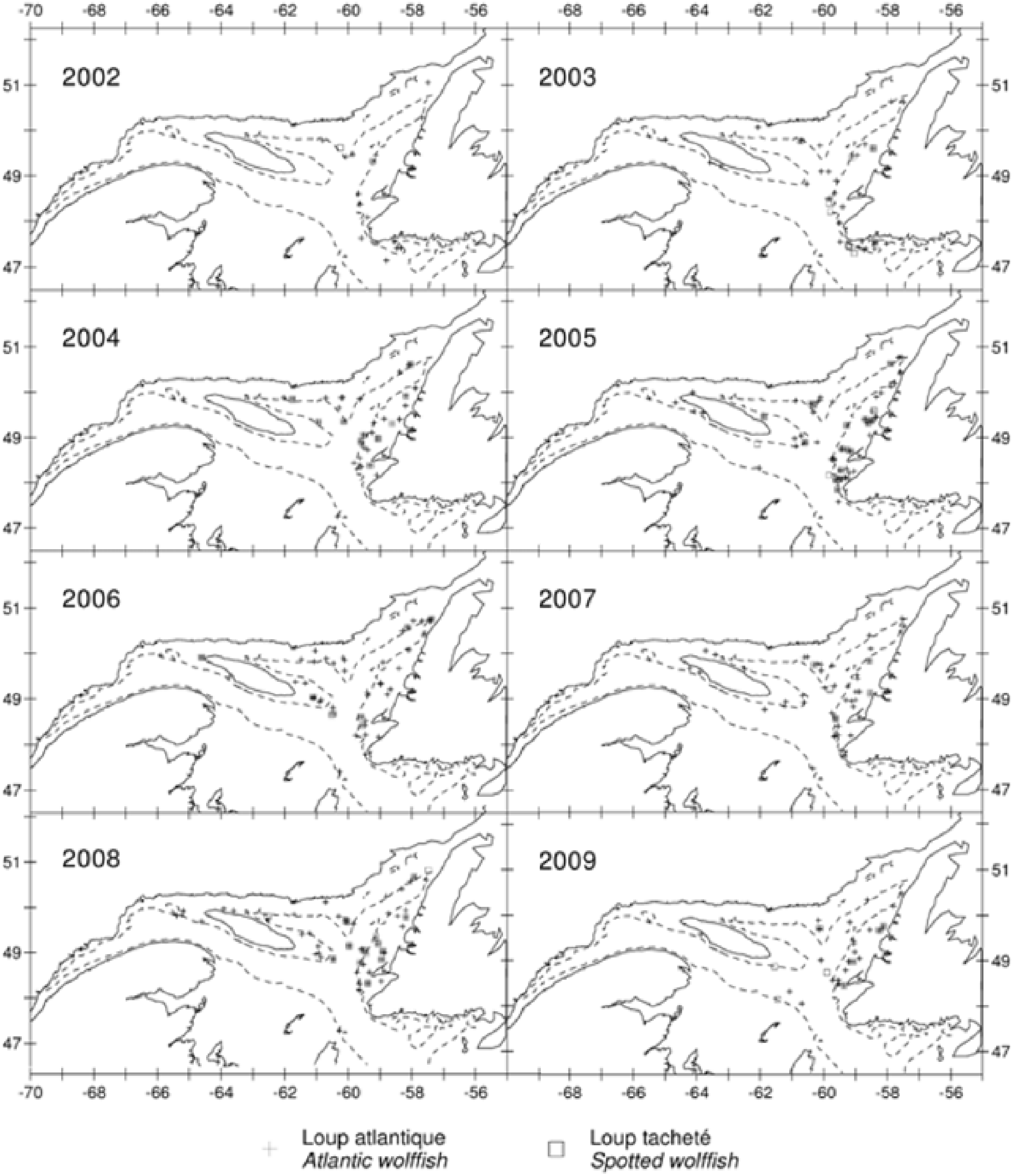
Source: Bordages et al. 2010

Figure 5.73 Locations of Sampling Stations for the 2009 Survey

Atlantic and spotted wolffish, both SARA-listed species, are caught primarily at the 200 m isobaths off western Newfoundland, Beauge Bank, near Anticosti Island and in the southern Laurentian Channel (Figure 5.74) . The number of wolffish per tow when caught was between a few individuals to a maximum of 20 (Bordages et al. 2010).

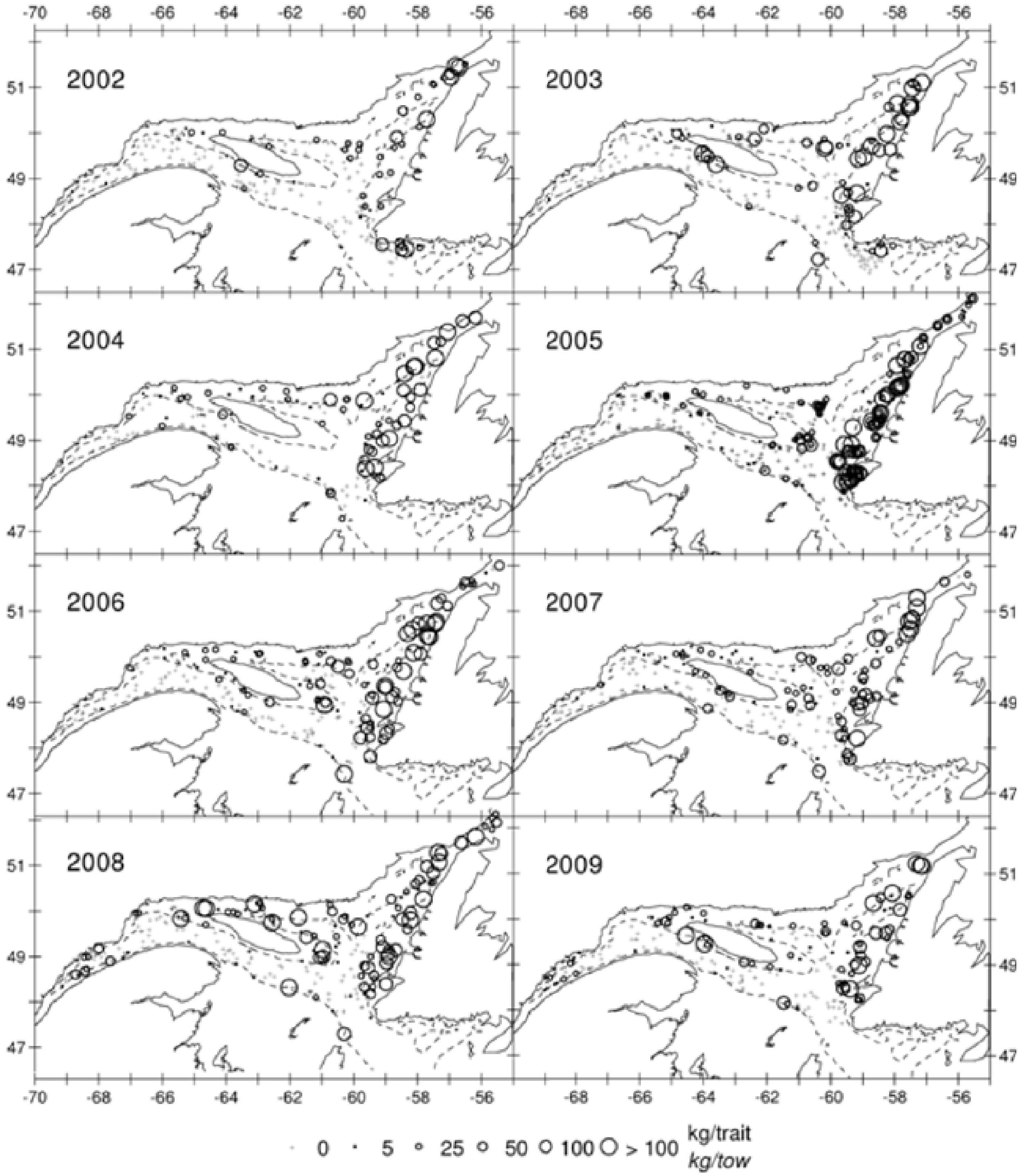
The mean number and weight of cod (a COSEWIC assessed species) per tow have remained low but stable since the fishery reopened in 1997 (Bordages et al. 2010). The most substantial cod catches in 2009 (and previous years) were mostly caught along the west coast of Newfoundland (NAFO Division 4R) (Figure 5.75).

American plaice (a COSEWIC assessed species) fluctuated without notable trends in mean numbers and weights from 1990 to 2003 (Bordages et al. 2010). Numbers remained stable from 2004 to 2008, with the mean number per tow increasing slightly in 2009 (Figure 5.76). A shift towards smaller-sized individuals has been observed since 2007. American plaice are found throughout the Estuary and Northern Gulf.



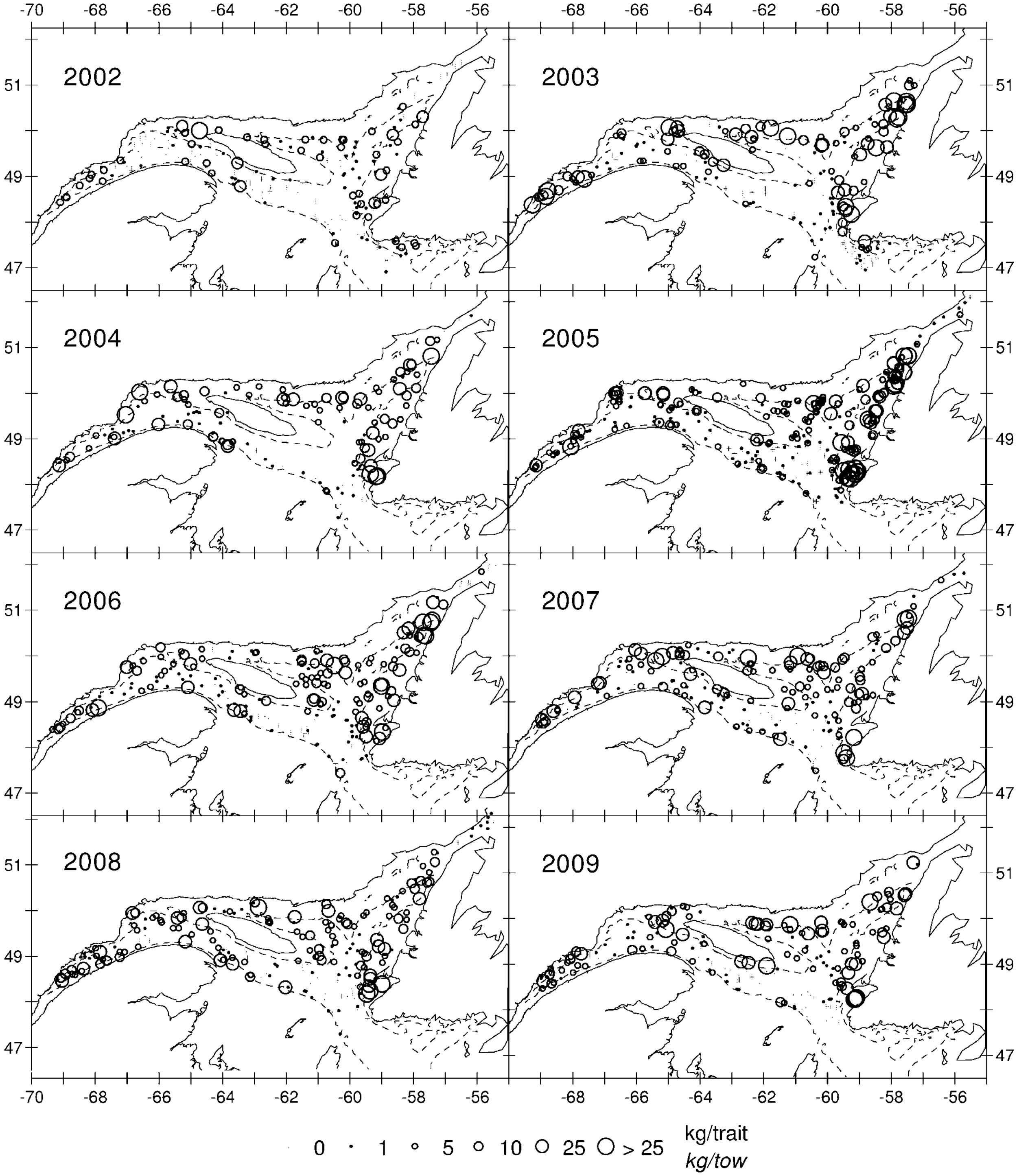
Source: Bordages et al. 2010

Figure 5.74 Atlantic Wolffish and Spotted Wolffish Catch Locations from the Survey for the 2002 to 2009 Period



Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

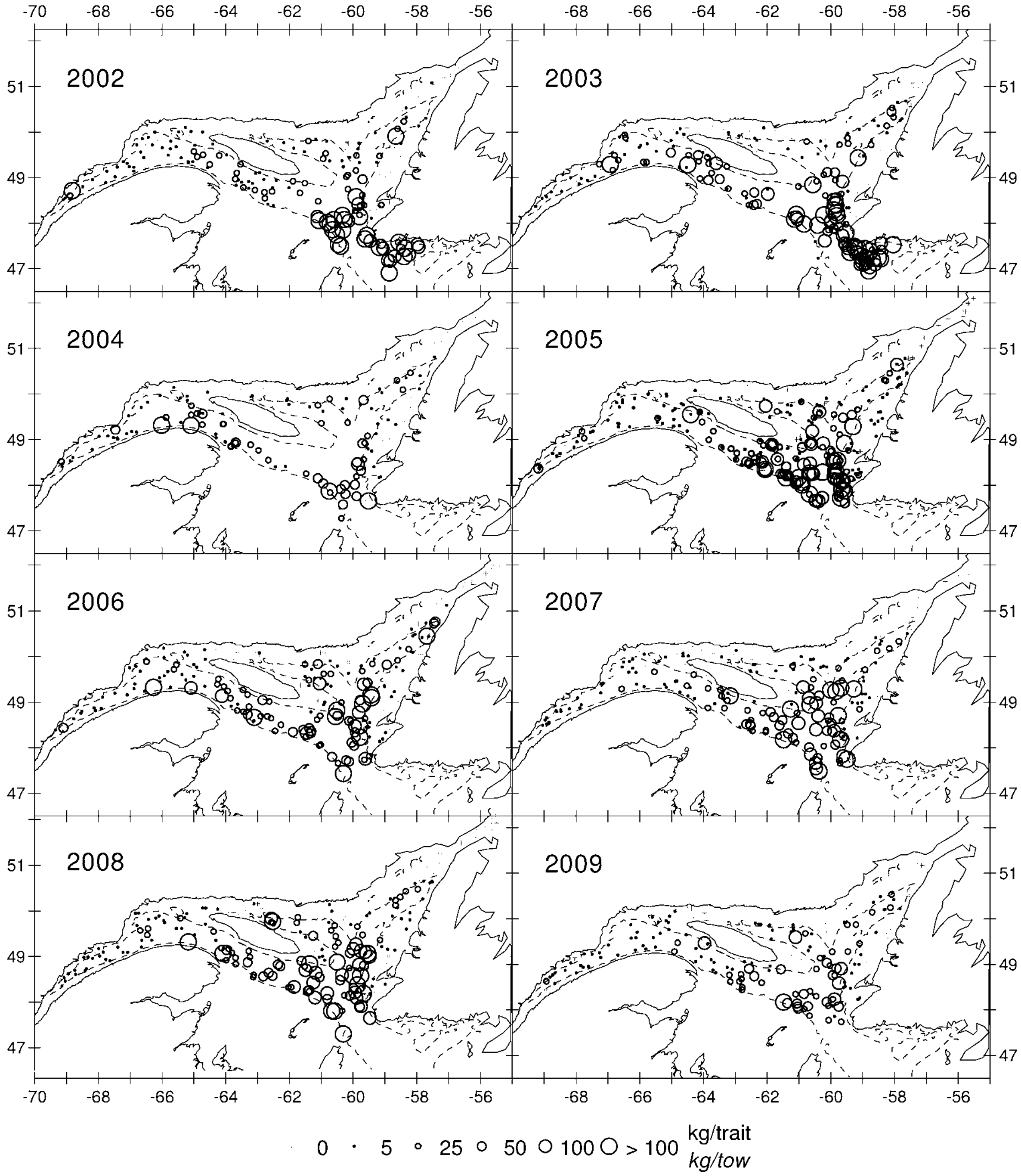
Figure 5.75 Cod Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.76 American Plaice Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009

Redfish (two COSEWIC assessed species) mean number and weight per tow dropped between 1990 to 1996, after which the values have remained steady but low until 2005, when it increased due to good recruitment from the 2003 year class (Bordages et al. 2010). The 1988 and 2003 were strong year classes that were observed in 1990 to 1992 and 2005 to 2007, after which they quickly declined. The main Gulf redfish concentrations are at the entry and north of Cabot Strait and South of Anticosti Island in the Laurentian Channel (Figure 5.77).



Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

Figure 5.77 Redfish Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009

Mean number and weight of Greenland halibut per tow has shown an upward trend in the 1990s and since the early 2000s, this increase has been less pronounced (Bordages et al. 2010). The 2009 abundance and biomass are the lowest of the last 10 years. The main concentrations of Greenland halibut were mostly observed west, south and north of Anticosti Island and were also seen in the Esquiman Channel (Figure 5.78).

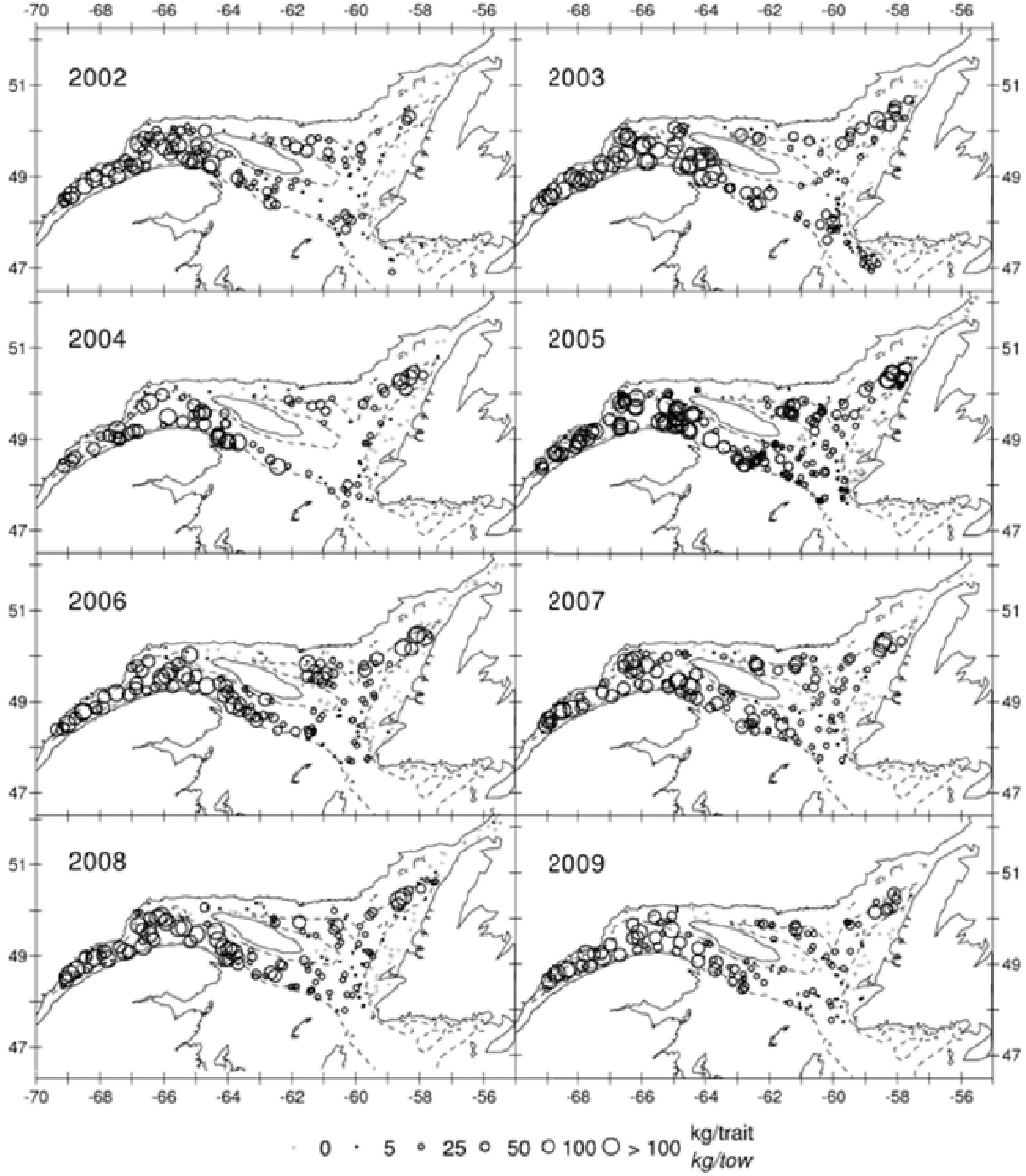
Atlantic Halibut mean weight and numbers were low during the 1990s and have steadily increased until 2008, followed by approximately 33 percent decrease in 2009 (Bordages et al. 2010). However, the Atlantic halibut abundances were the highest from 2006 to 2009. The largest catches are from the channel areas along the 200 m isobaths and in the Sept-Îles and estuary areas (Figure 5.79).

Herring caught during the survey represent two spawning stocks and are found throughout the area (Bordages et al. 2010). The highest catches are from the St. Lawrence Estuary, along the Laurentian channel, between Anticosti Island and Newfoundland as well as in the Strait of Belle Isle (Figure 5.80). In 4R, the probability of finding herring varied for 1990 to 1998 (21 to 41 percent), and increased until 2001 (73 percent), then dropped again until 2004 (26 percent). Probabilities have increased reaching 50 percent in 2007 and remained steady since. The 4s annual variations in catch probabilities were similar to 4R.

Capelin catches are the highest in the St. Lawrence estuary, around Anticosti Island and in the Strait of Belle Isle (Figure 5.81). Catch probabilities have fluctuated substantially since 1990, reaching the lowest value in 2006 (23 percent) and have risen to 51 percent (2008) and 42 percent (2009). Catch probabilities for 4S are less variable, with an increasing trend observed between 1990 and 2000, decreasing slightly until 2003 and have remained between 70 to 80 percent since 2002 (Bordages et al. 2010).

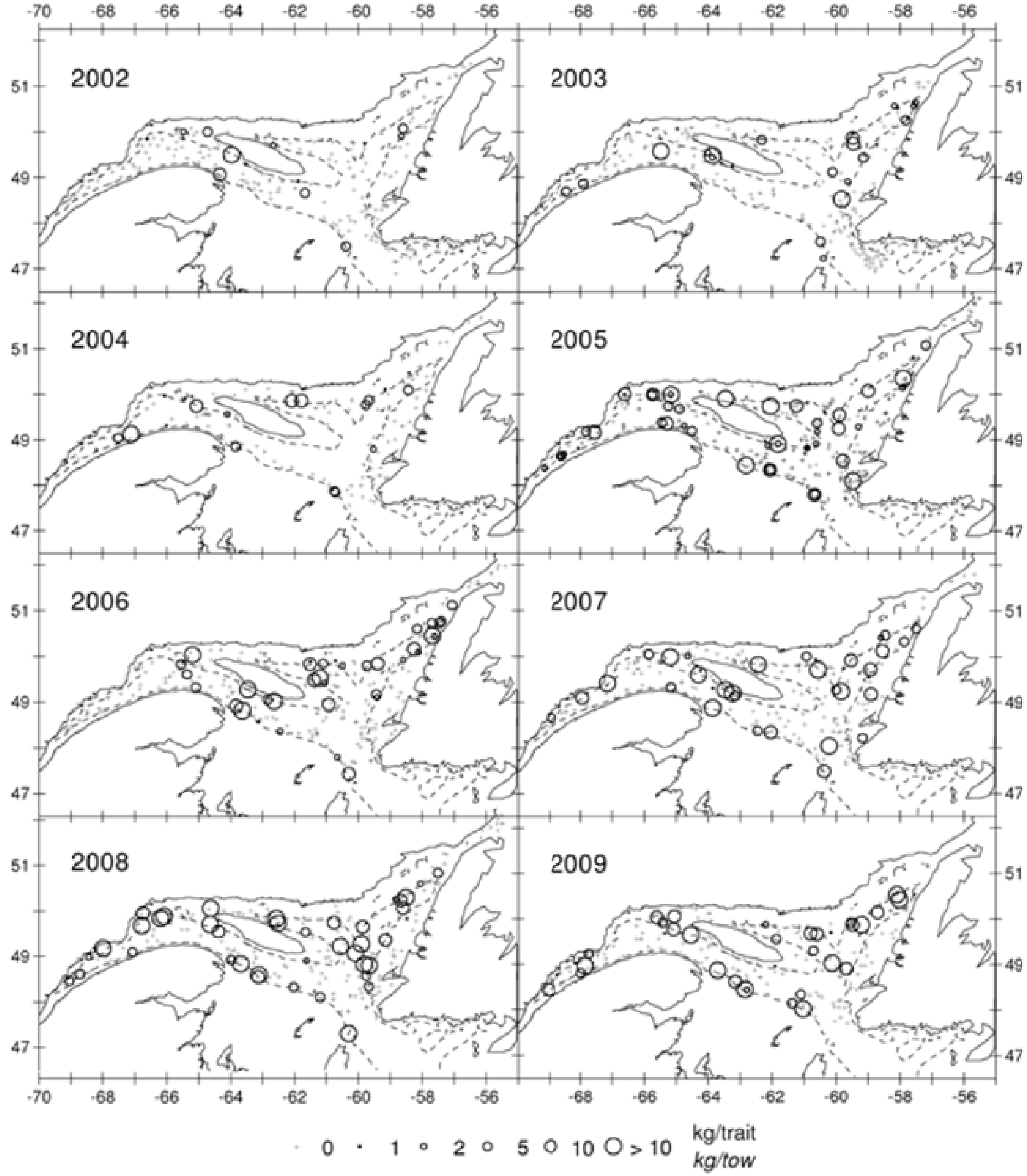
Black dogfish mean numbers and weights per tow have varied considerably over the years and large confidence intervals are often associated with the largest values as a result of the species gregarious nature and limited spatial distribution (Figure 5.82). The 2009 values are among the lowest of the data series. The largest dogfish concentrations were found in the deep upstream portion of the Laurentian Channel and in the St. Lawrence Estuary in 2002 to 2007. In 2009, the concentrations were limited to the Cabot Strait area and the southern part of the Laurentian Channel (Bordages et al. 2010).

Thorny skate mean number and weights exhibited fluctuations between 1990 to 2002, with the means numbers decreasing since 2003, but the mean weight has remained stable over the this timeframe (Figure 5.83) . Therefore, thorny skate are less abundant but larger (Bordages et al. 2010).



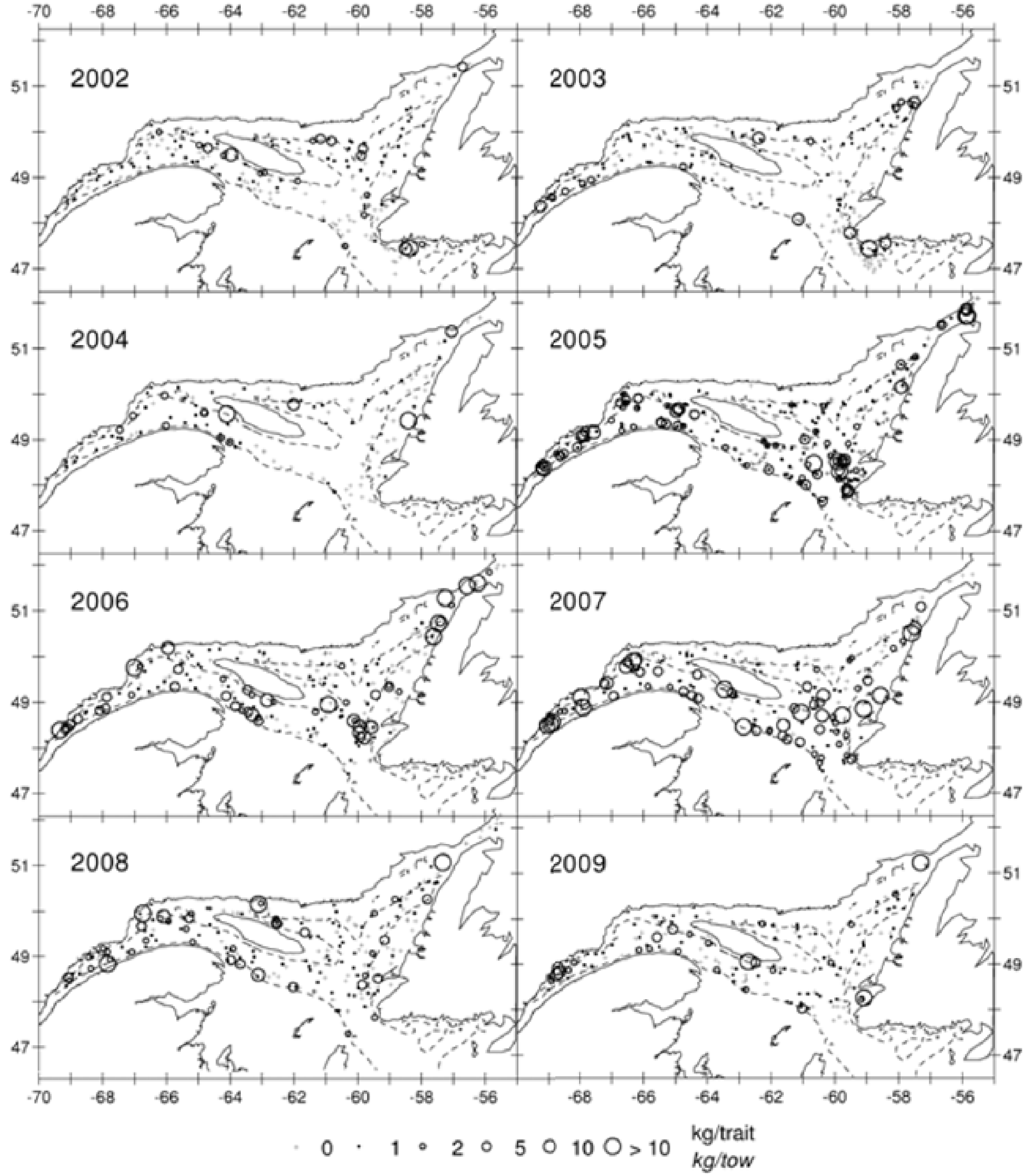
Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.78 Greenland Halibut Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



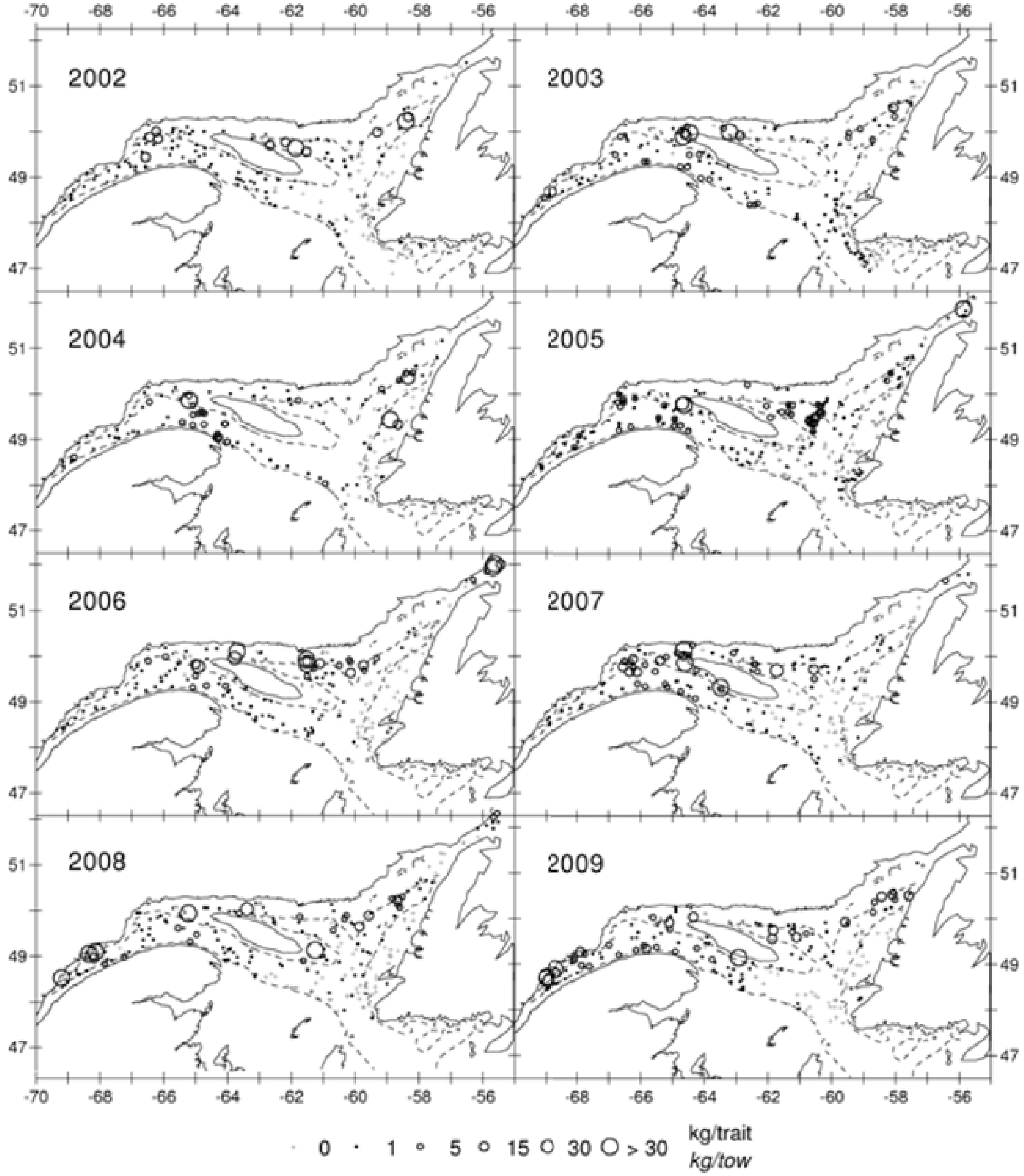
Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

Figure 5.79 Atlantic Halibut Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



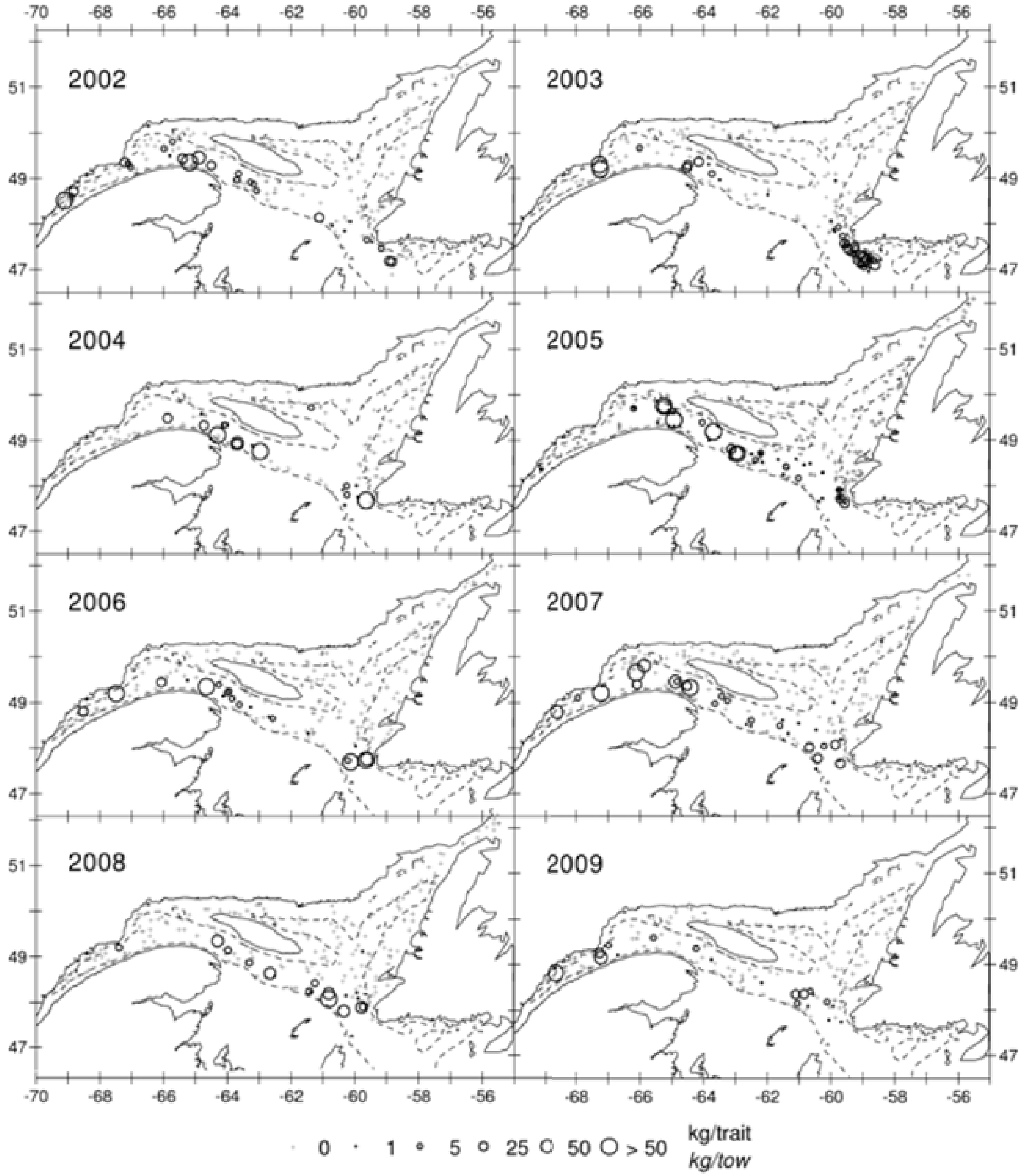
Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.80 Herring Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



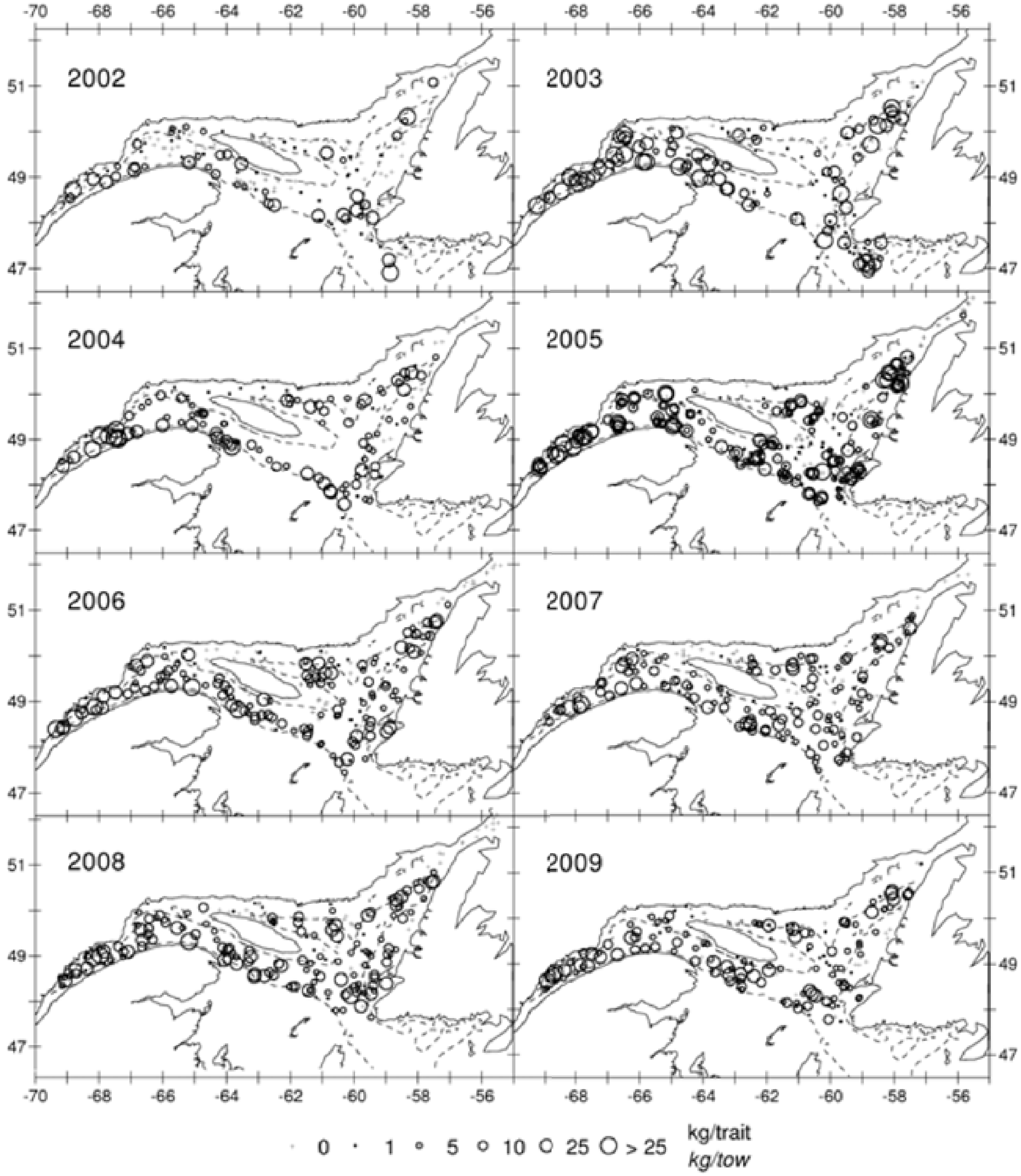
Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

Figure 5.81 Capelin Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.82 Black Dogfish Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

Figure 5.83 Thorny Skate Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009

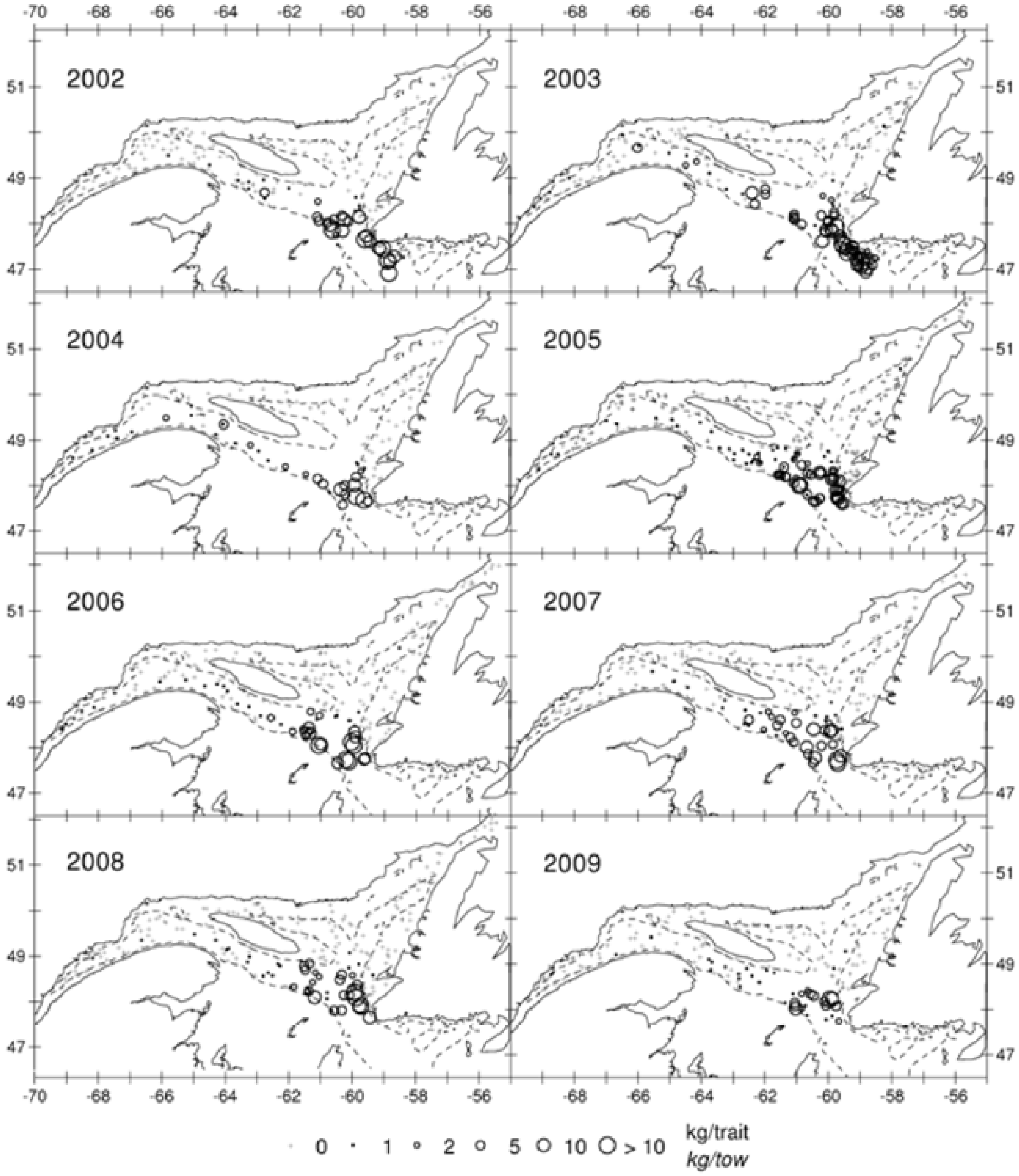
Longfin hake exhibited a sharp drop in the mean number and weight between 1990 and 1993, and has fluctuated since this period (Bordages et al. 2010). There was a slight increase in the late 1990s but numbers have subsequently dropped sharply and have remained relatively stable since 2003. The 2009 values are the lowest for this survey (Figure 5.84). Longfin hake are found primarily in the southern portion of the Gulf, with highest catches in the southern Laurentian Channel and near Cabot Strait.

White hake mean numbers and weights dropped sharply from 1990 to 1993 and have fluctuated thereafter (Bordages et al. 2010). The indices recorded between 2003 and 2009 were among the survey's lowest (Figure 5.85). Since 2003, the strongest concentrations are found along the 200 m isobaths in the southern flank of the Laurentian Channel and offshore St. Georges Bay.

Witch flounder are relatively homogenous covering the northern Gulf, with mean number and weights having decreased between 1990 and 1993. These values remained stable until 1999, followed by two upward and downward waves between 2000 and 2003 and were again stable between 2004 and 2009 (levels comparable to 1994 to 1999 levels). Values in 2009 were below the 1990 to 2008 average. The largest concentrations are along the southern slope and the head of the Laurentian Channel (Figure 5.86). In 2009, good catches were noted at the Head of the Esquiman Channel which is seldom observed (Bordages et al. 2010).

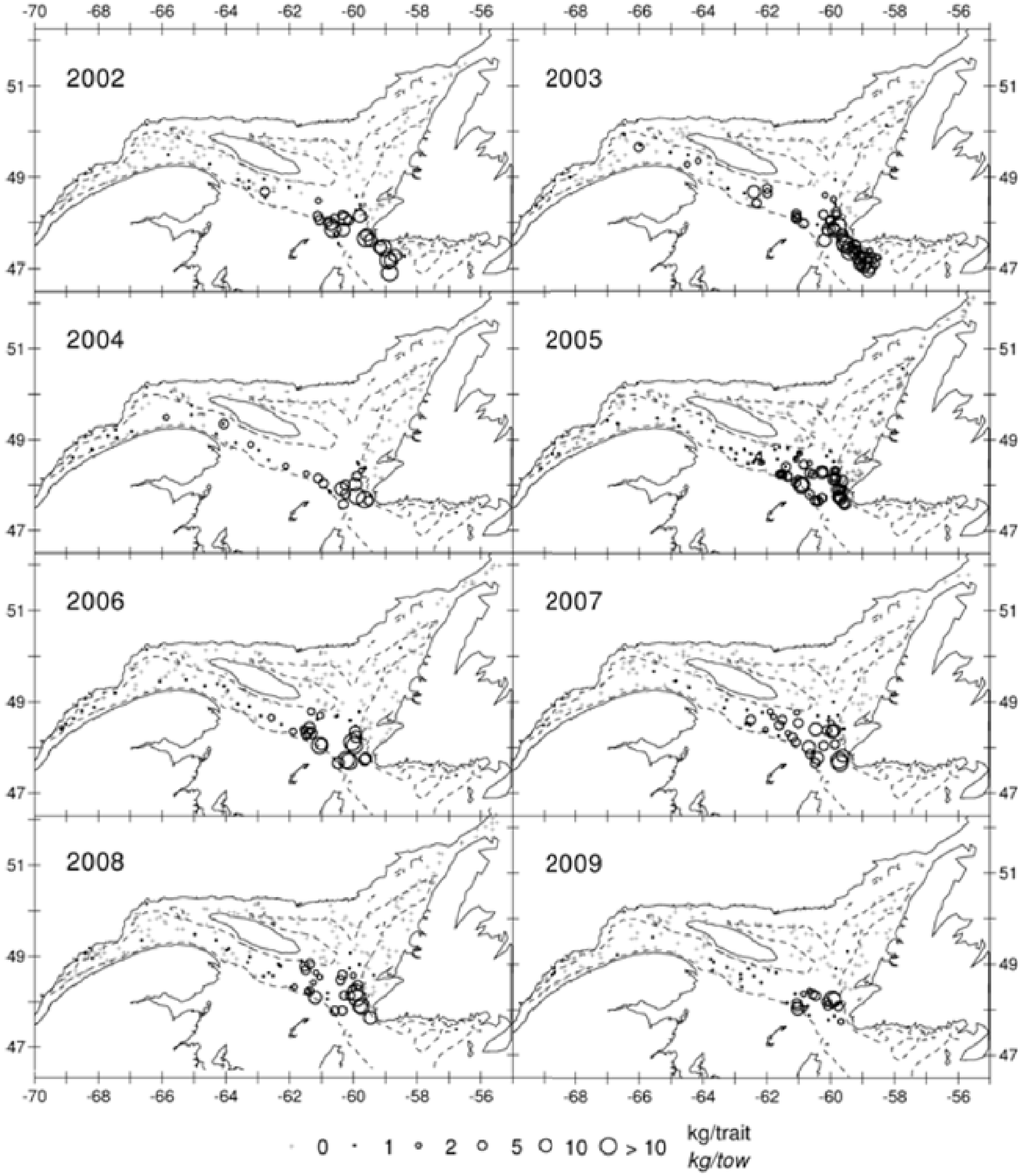
Northern shrimp mean number and weights per tow are similar to 2006 and 2008 observations, with 2009 values lower than those observed in 2003 but higher than pre-2002 values (Bordages et al. 2010). The catches were highest along the channels and west of Anticosti Island (Figure 5.87).

The 2009 RV survey data indicates the presence of a large but stable biomass of snow crab (Figure 5.88), with the 2002 to 2009 data catch distribution revealing that snow crab are not abundant at depths greater than 200 m. Catches were made for all stations less than 200 m in depth (Bordages et al. 2010).



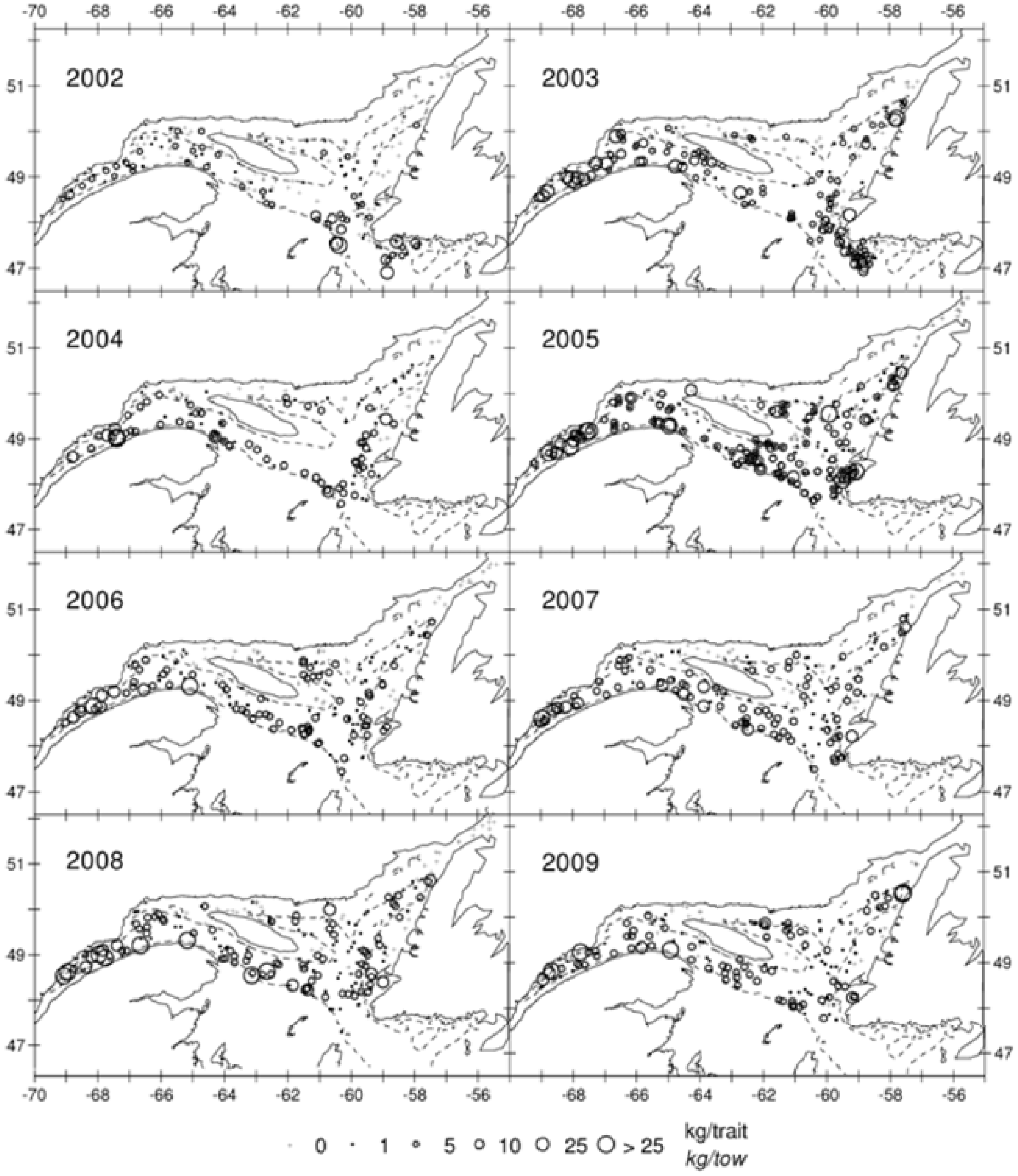
Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.84 Longfin Hake Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



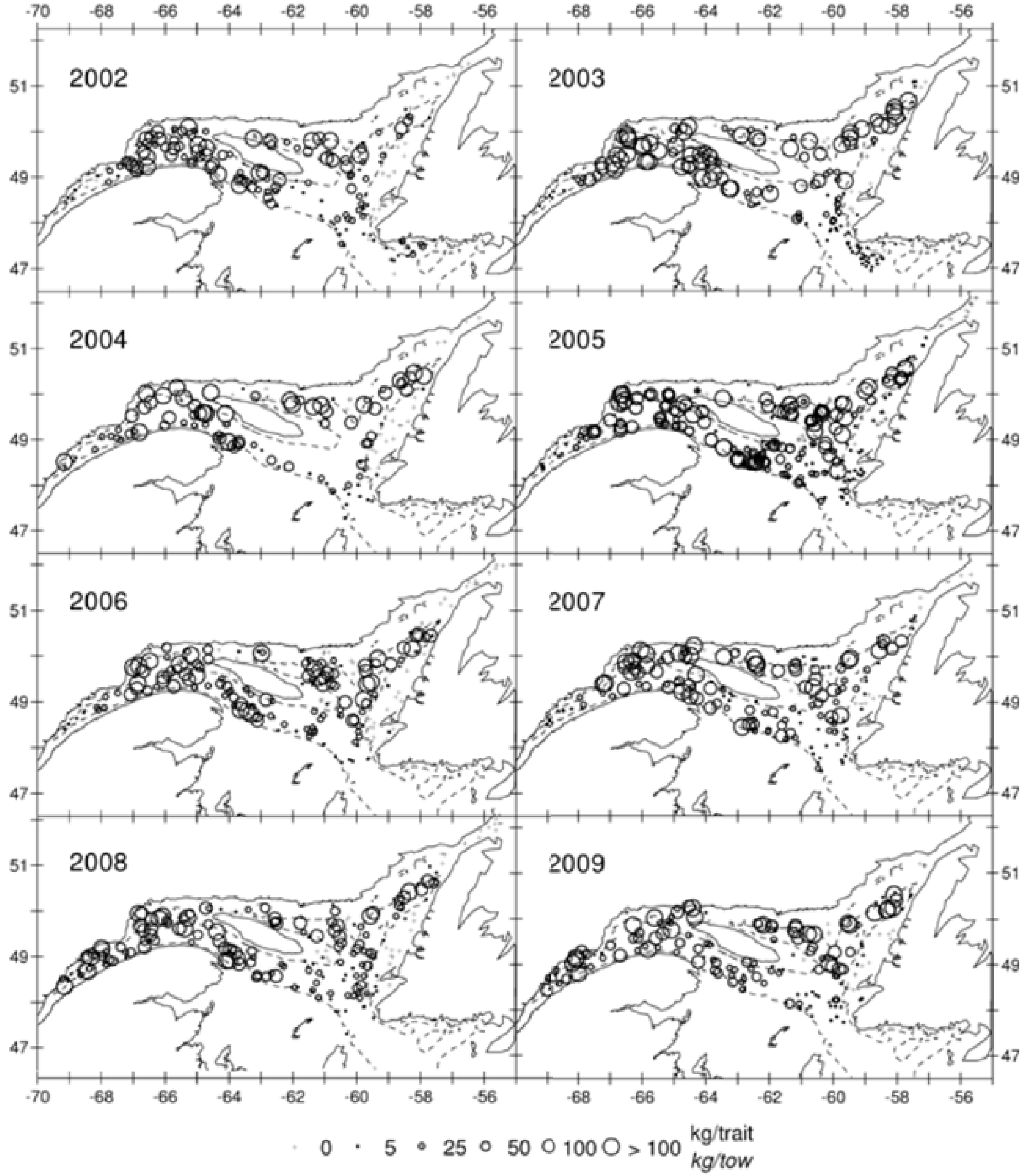
Source: Bordages et al. 2010
Note: The “+”symbol indicates a zero.

Figure 5.85 White Hake Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



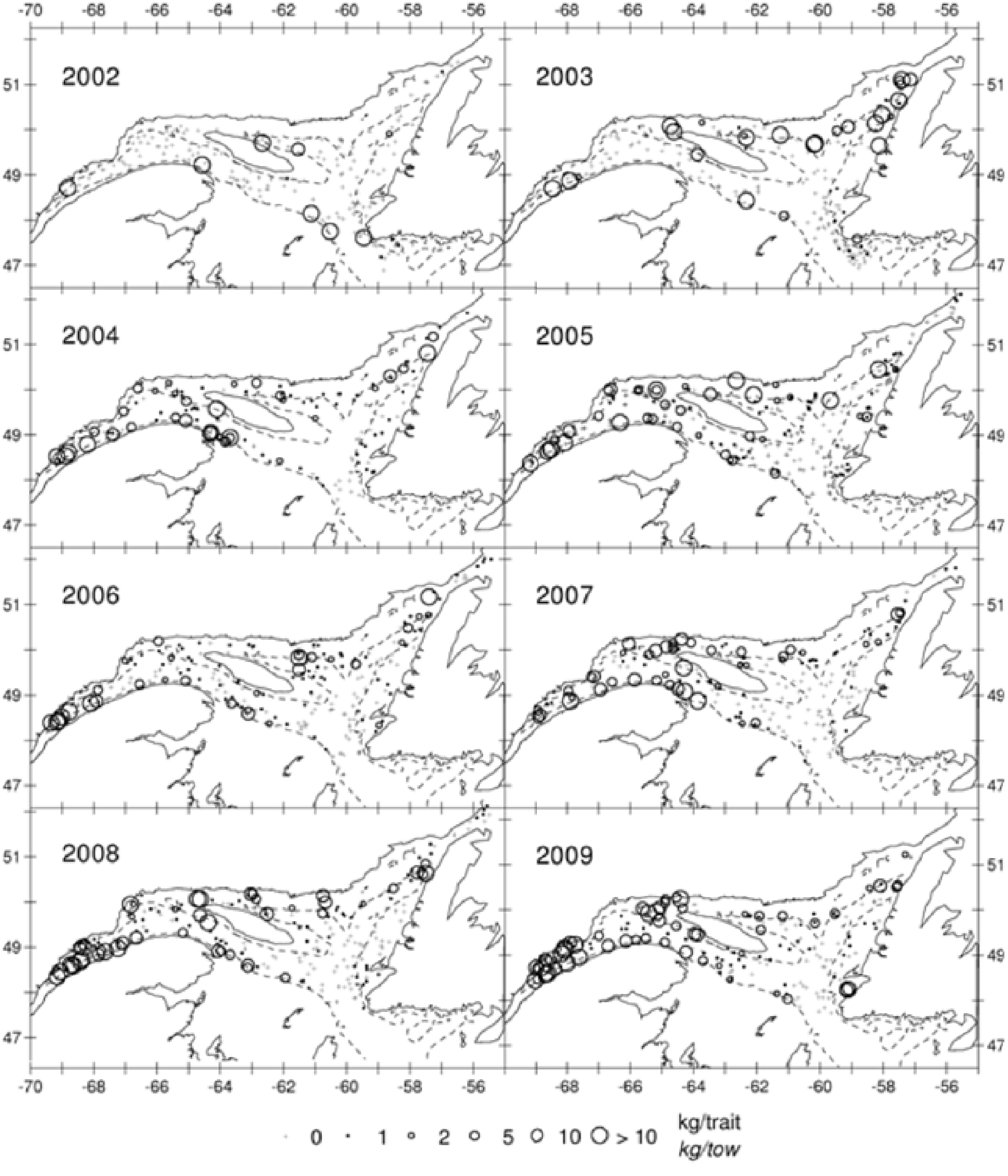
Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.86 Witch Flounder Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.87 Shrimp Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009



Source: Bordages et al. 2010
Note: The "+"symbol indicates a zero.

Figure 5.88 Snow Crab Catch Rate (kg/tow) Distribution from the Survey for 2002 to 2009

5.8.2 Other Users

Commercial fishing has long been a major focus of economic activity for the western Newfoundland and it remains the most important economic base for many of the small communities. The number of active fishers in the region has remained relatively stable from 2000 to 2007 at approximately 1,100 for Fishing Area 13 (DFO 2011m). These 1,100 fishers work with the 316 enterprises for core, non-core and recreational fish harvesters in the western Newfoundland region (based on 2006 licence numbers).

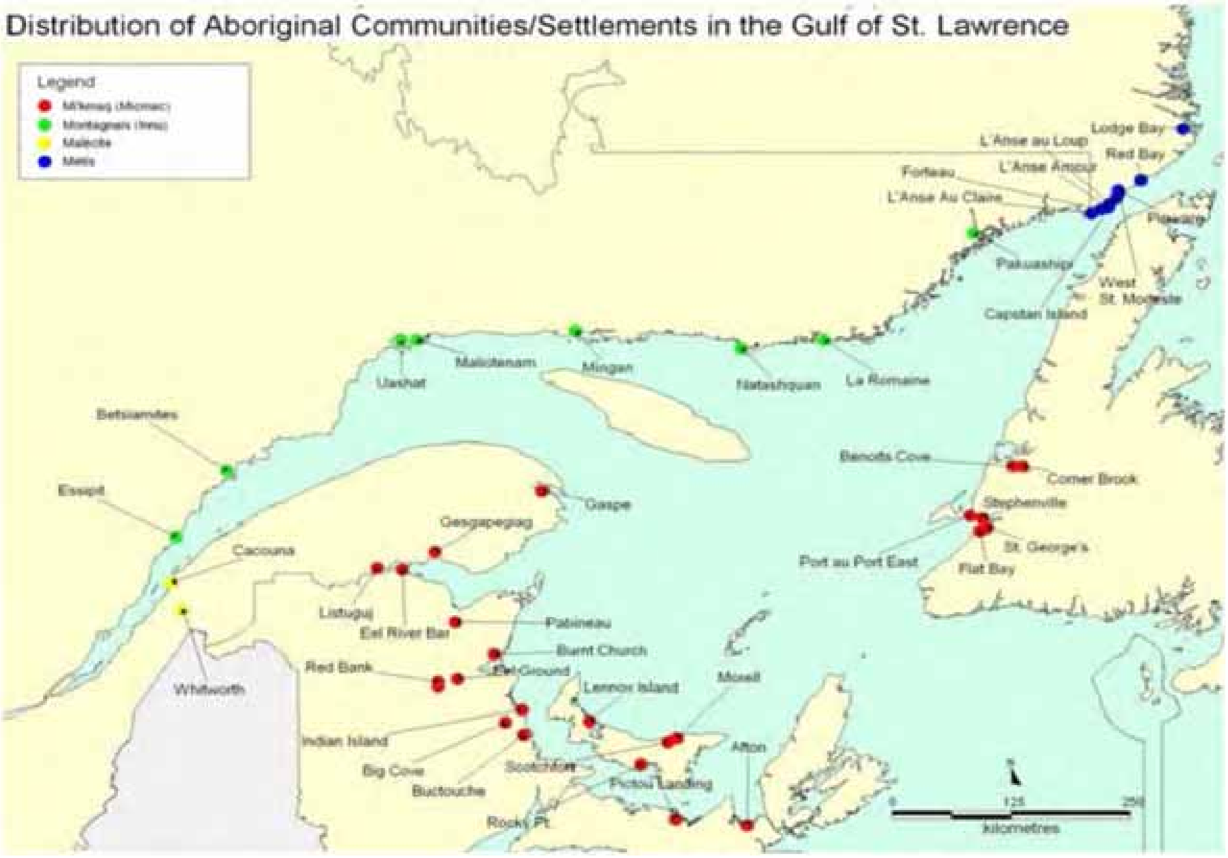
5.8.2.1 Aboriginal Fisheries Newfoundland

In 1999, the Supreme Court of Canada handed down its decision in the Marshall case, which essentially agreed that the Treaties signed in 1760 and 1761 by Mi'kmaq and Maliseet communities include a communal right to hunt, fish and gather natural resources in pursuit of a 'moderate livelihood' (DFO 2011n; Gaudet and Leger 2011). In response, DFO began to negotiate interim fishing agreements in order to provide First Nations communities with the opportunity to enter commercial fisheries (though some communities already held Communal Commercial Fishing Licenses at this time). The number of licenses held by First Nations is divided into Communal Fishing Licenses that grant permission to fish for food and social and ceremonial purposes, and Communal Commercial Fishing Licenses that allow fishers from First Nations to sell their catch. The distribution of Aboriginal communities in the Gulf is illustrated in Figure 5.89.

The Allocation Transfer Program is a process for voluntary retirement of commercial fisheries licence holders and the re-issuance of such licences to appropriate aboriginal groups. The program is therefore designed to provide aboriginal groups with employment and income while not placing additional burdens on existing resources (DFO 2011n).

The main species harvested in aboriginal fisheries in the Gulf are snow crab, lobster, rock crab, alewife / gaspereau, mackerel, shrimp and smelt. In 2007, $22 million in revenue was generated through the Communal Commercial Fishing License program in the Gulf Region, and $15 million was generated in the Quebec-Maritime Region (DFO 2011n). Snow crab and lobster are the most valuable species (Gaudet and Leger 2011).

The Federation of Newfoundland Indians (FNI) is sole owner of a company named Mi’kmaq Commercial Fisheries Inc. In NAFO Division 4R, FNI owns five core enterprises with vessels under 39’11”. All five possess a groundfish licence, with four having a lobster licence, and three possessing a crab quota. There are pelagic fixed gear licences associated with three of the enterprises as well. One of the enterprises that the FNI possesses holds a groundfish licence that is currently being used by an Aboriginal person (DFO 2011m).



Source: Alexander et al. 2010

Figure 5.89 Location of Aboriginal Communities with the Gulf of St. Lawrence Region

The Aboriginal Aquatic Resource and Oceans Management program provides funding to qualifying Aboriginal groups to establish aquatic resource and oceans management bodies. For eligible groups, funding was available to obtain access to commercial fishery opportunities (including vessels and gear) and to build the capacity of groups to take advantage of aquaculture opportunities. One such body has been set up for Western Newfoundland, whereby the FNI and Conne River Band have formed the Mi'kmaq Alsumk Mowimsikik Koqoey Association (MAMKA). MAMKA holds four enterprises with vessels less than 39’11”. All four of these enterprises hold a lobster licence, with two of them holding a groundfish and snow crab quota. There are also pelagic fixed gear licences associated with three of the enterprises (DFO 2011m).

During the Western Newfoundland SEA (LGL 2005b) public consultation process, Mi’kmaq groups from the area reiterated the province’s requirement to notify Aboriginal peoples about any land development issues. Historically, in the 16th and 17th centuries the Mi'kmaq created a "Domain of Islands" in the Gulf (Heritage NF 1997). However, there are no known active Aboriginal fishing grounds in the vicinity of EL 1105. It is anticipated that commercial fishing licenses are issued to Aboriginal peoples fishing in the 4Ss, 4Tf, 4Rd and 3Pn NAFO Unit Areas, but there is no known commercial fishing activity within the boundaries of EL 1105 (refer to Figures 5.59 to 5.62). Therefore, the only expected interaction is in relation to the Project’s supply vessel traffic.

5.8.2.2 Recreational Fisheries

Statistics from the Maritime, Gulf and Newfoundland and Labrador regions suggest that recreational fishing has declined in recent years, though the value to the provinces has increased. From 2000 to 2006, the Maritime Provinces experienced a decline (23 percent) in the total number of days anglers spent fishing; however, the total expenditures per day associated with angling increased by 22.9 percent on average (Gaudet and Leger 2011). Pinfold (2009) reported on the estimated participation of anglers and revenue in the Maritime Provinces and Quebec (Table 5.25). The most commonly fished species include Atlantic salmon in some areas (Miramichi River), striped bass, chain pickerel, gaspereau, yellow perch, Atlantic sturgeon, trout species, shad species, smelt, eel and white perch. There are specific federal and provincial regulations governing recreational fishing including licensing, catch limits, gear restrictions, size limits, fishing season and area closures.

Table 5.25 Estimated Number of Saltwater Recreational Fishing Days for All Anglers (resident and visitors), Estimated Expenditure per Day and Total Expenditure per Year (2005)

Province	Number of Participation Days	Expenditures per day ($)	Total Expenditures ($000)
Quebec	197,444	120	54,271
Nova Scotia	198,802	98	19,273
New Brunswick	40,838	114	7,013
Prince Edward Island	61,515	52	2,137
Source: Adapted from Pinfold 2009			

In Newfoundland and Labrador, recreational fishing may take place in coastal and inland waters. Coastal water fishing for Atlantic salmon is on a catch-and-release basis and may be done year-round and without a licence. Salmon Fishing Areas (SFAs) of the western Newfoundland region are SFA 13 (Cape Ray-Cape St. Gregory) and SFA 14A (Cape St. Gregory-Cape Bauld). A multi-year Atlantic Salmon Management Plan (2007 to 2011) that was developed with the collaboration of user groups and stakeholders contains elements of adaptive management strategies and river classification.

Of the 186 scheduled salmon rivers in Newfoundland and Labrador, 43 occur in the western Newfoundland and southern Labrador region. These rivers offer a great variety of angling opportunities in pristine settings. The Great Northern Peninsula coastal area tops the list with 22 scheduled salmon rivers, while the Bay St. George / Port au Port coastal area is second with 14 scheduled rivers. The salmon river catch data for 2007 are presented by coastal area in Table 5.26.

Table 5.26 Salmon River Catch Data for Western Newfoundland Coastal Areas, 2007

River	Effort (Rod Days)	Catch	Catch per Unit Area
Bay St. George / Port au Port			
Bear Cove River	10	0	0.00
Little Codroy River	151	31	0.21
Great Codroy River	3,751	1,087	0.29
Highlands River*	136	24	0.18
Crabbe's Brook*	979	270	0.28
Middle Barachois Brook*	135	44	0.33
Robinsons River*	1,464	677	0.46
Fischell's River*	610	269	0.44
Flat Bay Brook*	1,927	662	0.34
Little Barachois Brook*	302	99	0.33
Southwest and Bottom Brooks*	2,448	734	0.30
Harry's River*	2,792	730	0.26
Fox Island River	109	39	0.36
Serpentine River	849	315	0.37
Bay of Islands			
Cook's Brook	Closed to angling		
Humber River*	13,102	4,362	0.33
Hughes Brook	36	3	0.08
Goose Arm Brook	47	6	0.13
Southern Labrador			
Forteau River	177	18	0.10
L'Anse au Loup River	No Data Available		
Pinware River	1,688	971	0.58
Source: DFO 2010 * Rivers with watershed management plans in place.			

Atlantic salmon catch data for SFA 13 and SFA 14A for 1996 to 2007 are summarized in Figure 5.90. These data show a decline in catches for in the western Newfoundland.

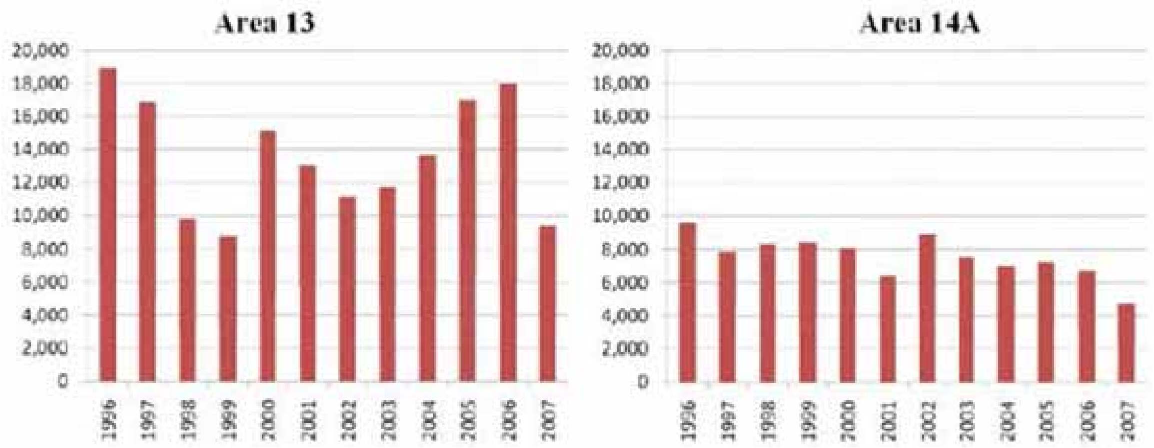


Figure 5.90 Atlantic Salmon Catch Data for Salmon Fishing Areas 13 and 14A, 1996 to 2007

5.8.2.3 Aquaculture

Marine aquaculture remains as an important industry throughout the Gulf , particularly as the number of commercial fisheries has declined. Aquaculture has experienced rapid growth in eastern Canada over the last two decades in response to a growing demand for seafood, declining wild stock fisheries and technological improvements in fish farming practices. Approximately 1,741 (2010) active aquaculture sites exist within the Gulf (Table 5.27), with the large majority concentrated in PEI and the Gulf coast of New Brunswick (Figure 5.91). In New Brunswick, most of these sites are located between Caraquet Bay and Miramichi Bay, and in Nova Scotia most of the sites occur along the north shore from Pugwash to St. Georges (Alexander et al. 2010). Shellfish account for 99 percent of aquaculture in the Gulf, with oyster and blue mussel being the most important species, though finfish are typically more valuable (Alexander et al. 2010). The majority of finfish (Atlantic salmon / rainbow trout) operations in the Gulf are land-based (hatcheries / fish-out ponds) and concentrated along the north shore of Nova Scotia, with a few seasonal marine grow-out sites distributed along western Newfoundland (Atlantic cod) and near Baie des Sept Îles (flounder and herring) on the Quebec North Shore. Other species of growing importance include quahaug, clams, scallop and sea urchin. The total value of aquaculture in the Gulf in 2001 was $292 million, over half of which is Atlantic salmon ($199 million) and the remainder is trout ($41.2 million), blue mussel ($30.5 million), oysters ($9.5 million) and 'other' ($11.4 million) (quahaug, scallop, clam, sea urchin, Arctic char, Atlantic cod, haddock) (Alexander et al. 2010; Gaudet and Leger 2011).

Table 5.27 Active Shellfish and Finfish Aquaculture Sites in the Gulf of St. Lawrence

Province	Shellfish	Finfish	Total Sites
Gulf New Brunswick	520	0	520
Gulf Nova Scotia	65	11	76
Prince Edward Island	1,095	0	1,095
Gulf Quebec	49	1	50
TOTAL	1,677	10	1,741
Source: Gaudet and Leger 2011, Alexander et al. 2010			

The main species targeted for aquaculture production in Newfoundland and Labrador are Atlantic salmon, steelhead, Atlantic cod and blue mussels. On the whole, western Newfoundland, with its shorelines exposed to heavy winds and long ice-bound seasons, is not as suitable for aquaculture as other areas of the Province, particularly the South Coast. This is particularly true for Atlantic salmon, which do not grow well in temperatures below 4°C.

Seven companies were registered for aquaculture production within the region in 2008. Only one, Cold Ocean Salmon Inc. in Daniel's Harbour, is engaged in hatchery operations for Atlantic salmon; most others are involved in shellfish production. There is one eel hatchery in Robinsons and a cod grow-out facility in Keppel Harbour. Cod grow-out operations involve post-spawn cod, which are trapped, held in established farm sites, and cared for until they are ready for harvest.

Source: Alexander et al. 2010

Figure 5.91 Distribution of Aquaculture Sites in the Gulf of St. Lawrence (2003)

There remain several conflicts and concerns associated with aquaculture in Canada, including: escapement of farmed stock and potentially invasive species; spreading of disease and parasites to wild fish stocks; eutrophication near sites; the use of chemicals and antibiotics; and benthic smothering. The industry is regulated by both federal and provincial legislation. A lease or license is required to operate any aquaculture facility. Aquaculture industry is expected to continue to grow and be a major economic contributor to local communities in Gulf, particularly as demand for seafood increases, and farming of new species (sea cucumber, sea urchin, seaweed) develops (Alexander et al. 2010).

5.8.2.4 Seal Hunting

The commercial seal hunt in Atlantic Canada dates back over 200 years. The industry grew throughout the 20th century, largely to meet the demand for fur (Alexander et al. 2010). Today the number of sealers is greatly reduced, but the hunt remains a valuable economic and cultural practice in the Gulf and Newfoundland and Labrador regions (Table 5.28). In the Gulf, two species are harvested: harp seal and grey seal. The commercial hunt occurs annually from November 15 to June 14, with the majority of sealing occurring between March and May in the Gulf, though sealing does occur along the Quebec North Shore in January and February. The estimated landed value (based on average prices paid to sealers) of harp seals (Atlantic Canada) in 2001 was $5.5 million; however, the value increased to $21 million in 2002 due to extremely favourable market conditions. In recent years, personal use sealing licenses have been issued to residents adjacent to sealing areas in Newfoundland and Labrador (south of 53°N latitude), the Quebec North Shore, the Gaspé Peninsula and the Îles-de-la-Madeleine (Alexander et al. 2010, Gaudet and Leger 2011).

Table 5.28 Number of Seal Hunting Licenses issued in 2007 for the Gulf Region

Province	Professional License	Assistant License
Gulf New Brunswick	2	5
Gulf Nova Scotia	21	21
Prince Edward Island	23	15
TOTAL	46	41
Source: Licensing Unit, DFO Gulf Region (Moncton)		

Seal hunting has represented an important source of income to residents of the western Newfoundland and southern Labrador region during a time of year when employment opportunities are extremely limited. The majority of seals taken in Newfoundland and Labrador waters are either harp or hooded seals, although ringed and bearded seals are also landed, as are harbor seals and grey seals in small numbers. Approximately 70 percent of the commercial hunt occurs on the Front (in the northwest Atlantic off the northeast coast of Newfoundland while approximately 30 percent occurs in the Gulf. The majority of sealing occurs from late March through April and may extend into May. In addition to the commercial seal hunt, residents are allowed to take up to six seals for personal consumption.

The number of seals harvested annually varies greatly from year to year. A combination of factors contributed to the relatively low turnout in 2010, most notably the poor ice conditions, which made access to seal patches extremely difficult in certain areas, especially in the Gulf. Changes in market prices, demand for fur, the Canadian dollar and trade with the European Union greatly influence the number and value of the seals hunted each year.

5.8.2.5 Bird Hunting

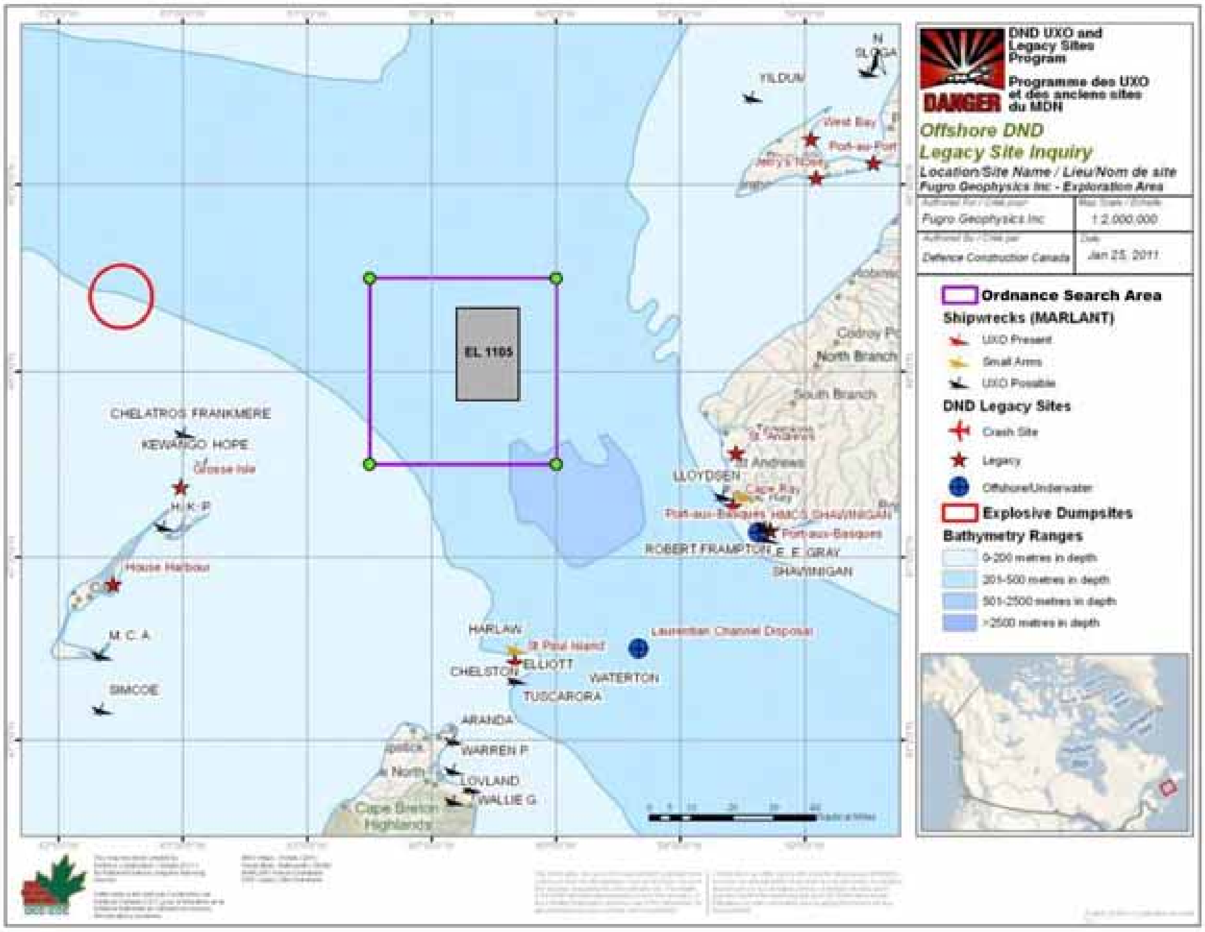
The hunted bird species and open seasons in the Western Newfoundland Migratory Game Bird Coastal Zones are posted in the provincial Hunting and Trapping Guide, published annually by the Newfoundland and Labrador Department of Environment and Conservation. The main groups of birds hunted in coastal zones are the seaducks (eiders, scoters and Long-tailed Ducks), Common and Thick-billed Murres, mergansers, geese and snipe. There is no open season for Harlequin Ducks.

Common and Thick-billed Murres (referred by residents as “turrs”) are seabirds that have been hunted in Newfoundland and Labrador since early settlement. Residents of the Province are the only people in North America, other than Aboriginal peoples, who legally can hunt turrs. The turr hunt, pursued traditionally for food, has become recognized in recent years as a recreational activity. It is generally known, and substantiated by studies conducted by Canadian Wildlife

Service, that fewer people engage in turr hunting today than 30 years ago - a trend particularly evident in the younger generation. Turr hunting is still conducted in coastal areas of western Newfoundland and southern Labrador. The hunting dates for turrs occur around early October to mid-March. depending upon the area, and are designed to take into consideration the migratory patterns of turrs along the shores of the Province.

5.8.2.6 Military Use

There is no known military use of EL 1105 (refer to Figure 5.92); however, DND is likely to be operating in the vicinity of the Project in a non-interference manner during the 2012 and 2014 timeframe (C.L. Giffin, pers. comm.). DND also confirms that there are no wrecks within EL 1105 (C.L. Giffin, pers. comm.). There is no anticipated active petroleum industry sites within the vicinity of Old Harry Prospect. While there are several exploration licenses in the coastal waters of western Newfoundland, none exist in the offshore Old Harry Prospect area other than those held by Corridor Resources. As such, marine transportation dominates other potential users of the Laurentian Channel area and further discussion of other users will focus on marine traffic.

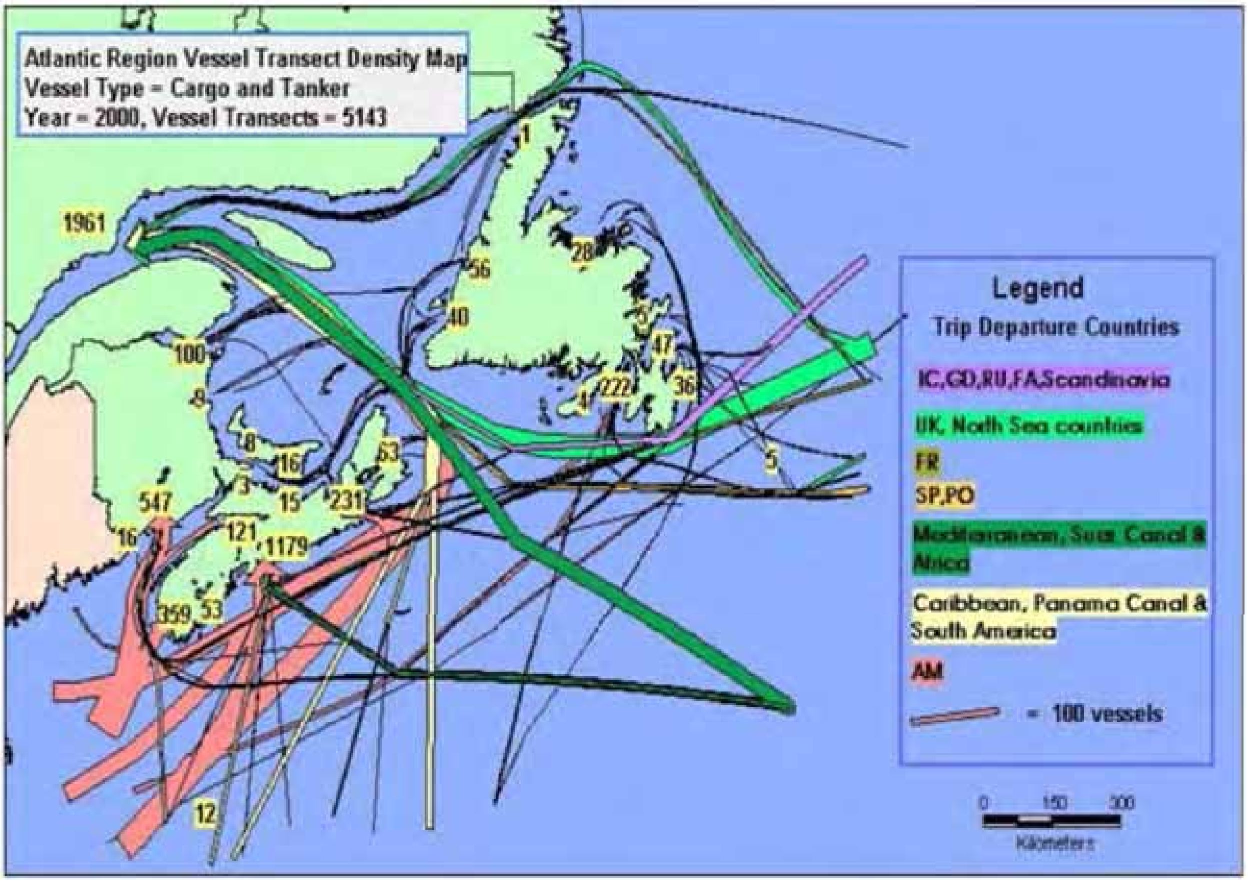


Source: Stantec 2010

Figure 5.92 Shipwrecks and DND Unexploded Explosive Ordinance Legacy Sites

5.8.2.7 Marine Traffic

The Gulf region contains one of the major seaways of the world, and the majority of ship traffic enters and exits via the Cabot Strait (or Strait of Belle Isle in summer) bound for the St. Lawrence Seaway (Figure 5.93). The Gulf accommodates approximately 6,400 commercial vessel transits annually supporting domestic and international trade and transport (Alexander et al. 2010). More than 40 ports throughout the Gulf accommodate vessel traffic; however, Charlottetown, PEI is the only major port within the Gulf. In addition, a number of major commercial ferry routes exist throughout the Gulf including: North Sydney, NS to Port aux Basques, NL; St. Barbe, NL to Blanc Sablon, QC; Caribou, NS to Wood Islands, PEI; Souris, PEI to Cap aux Meules, QC; and within Quebec, a number of coastal ferries service ports along the Quebec North Shore (Alexander et al. 2010, Gaudet and Leger 2011). Contamination of marine areas from bilge, ballast and wastewater disposal, marine safety and transport of foreign and invasive species are potential concerns within the marine transportation industry.



Source: Geocentric Mapping Consulting 2002, in Alexander et al. 2010
The arrow width represents vessel counts in the shipping corridor (traffic density); the color indicates the countries and continents of origin. Major ports are represented by a specified number of inbound transects.

Figure 5.93 Atlantic Inbound Vessel Transect Density Map: Inbound Cargo and Tanker Shipments in 2000

The Project is adjacent to the major shipping route that traverses the St. Lawrence River estuary and across the Gulf immediately south of Anticosti Island (LGL 2005b). Traffic density in this vicinity is four to eight ships per day, many of which are container vessels (LGL 2005b). DFO carries out stock assessment surveys and research activities throughout the maritime marine environment, which may overlap with proposed Project activities. The DFO Science Advisory Schedule can be accessed online to determine if there are any DFO activities scheduled to overlap with the Project. This online resource included activities scheduled through the month of May 2011, but no later, at the time of writing this report.

Vessel traffic in the area of the proposed Project is an important consideration. The main navigation lane between the Cabot Strait and the St. Lawrence River is in the vicinity of the Project. The majority of vessels enter the Gulf through the Cabot Strait. However, there may be other vessel traffic along shipping routes through the Strait of Canso and the Strait of Belle Isle. The main shipping lanes through the Gulf to Montreal overlap with the proposed work. Additional global shipping lanes exist in close proximity to EL 1105, including those routes between the Maritimes and Europe, the Maritimes and the US and within the Atlantic Provinces (GeoCommons 2010).

5.8.2.8 Tourism and Recreational Activities

Marine tourism and recreation is an industry experiencing growth throughout the Gulf, including increased cruise ship activity, offshore excursions (whale watching and marine tours), recreational boating, and recreational use of coastal areas (hiking, diving, kayaking). Owing to the climate, much of marine recreation and tourism activities occur from spring to fall.

Charlottetown, PEI, is the only major port in the Gulf. The 2011 cruise ship season was from May 2 to October 20, 2011 and during that time, 41 ships, with a total of 67,298 passengers and 28,563 crew (Charlottetown Harbour Authority Inc. No Date) arrived in port. For 2007, the average expenditure was $60.68 per passenger and $41.80 per crew member, which resulted in an estimated $3.3 million in passenger expenditures and $736,000 in crew expenditures (Gaudet and Leger 2011). Owing to the large size and capacity of modern cruise ships, these vessels are estimated to produce 400,000 gallons of wastewater per day. Similar to other large ocean vessels, cruise ships have the potential to transport non-native species and contaminate marine areas through bilge, ballast and wastewater disposal (Alexander et al. 2010).

There is a growing interest in a wide variety of marine-related recreation, with sea kayaking, in particular, growing in popularity among residents as well as visitors. Yachting is focused principally in the Bay of Islands and to a lesser extent the Gros Morne National Park area. The Bay of Islands Yacht Club has been active for many years. The waterfront at Norris Point and a new inn at Neddy’s Harbour are attracting boaters to the Bonne Bay area. There is a Humber Valley Rowing Club that uses a section of coastline near Brakes’ Cove in Humber Arm. Scuba diving as a sport has been popular in the Bay of Islands, Port au Port Bay and in Port aux Choix. Recreational boating occurs throughout much of the inshore areas of the Gulf and includes powerboats, sailboats and manually operated boats (canoes, kayaks and other rowboats). Recreational boating has the potential to adversely affect the marine environment through pollution, as well as interactions with marine mammals, sea turtles and marine birds.

There has been growth in other recreational activities in the region as well, including swimming, camping, hiking, whale and bird watching (DFO 2011e) and cottage development (Alexander et al. 2010). DFO (2011e) reports that marine-related tourist trips remained stable in the Maritimes-Gulf region between 2000 and 2006, while spending decreased overall, except in PEI, which had an increase of 3.6 percent in spending from 2003 to 2006. However, the Quebec-Gulf region experienced increases of 40 percent from 2000 to 2006, with the largest growth in Gaspé.

The dramatic coastal scenery of the western Newfoundland region and the abundant opportunities for viewing whales are some of the attractions that make the region popular for sightseeing and leisure hiking. Over decades, local communities combined have been pouring hundreds of thousands of dollars into the construction and signage for coastal trails from the Codroy Valley estuary to the headlands of the Labrador Straits. An inventory of trails would likely form a large database of information. One of the two best places for bird watching in the entire province is the Codroy Valley estuary and the municipal wetlands of Stephenville Crossing.

A network of national, provincial, municipal and private parks and historic sites as well as a number of conservation areas exist throughout the Gulf. These areas conserve and protect a number of important ecological and cultural areas, but at the same time, many of these areas attract large numbers of people. Currently there are seven national parks, seven historic sites, 59 provincial parks, 20 migratory bird sanctuaries, 13 national wildlife areas and eight ecological reserves (Alexander et al. 2010).

6.0 ENVIRONMENTAL EFFECTS ASSESSMENT METHODS

6.1 Overview

The approach and methods used for the environmental assessment are based largely on the study team's experience in conducting environmental assessments of similar projects for the C-NLOPB and their understanding of CEAA. The environmental assessment focuses on the VECs identified through issues scoping, as described in Section 6.2.

6.2 Issues Scoping and Selection of Valued Environmental Components

The Project scope encompasses those components and activities considered for the purpose of environmental assessment. The scope of the proposed exploration drilling program includes all of the components and activities described in Section 2.9.

The issues scoping exercise conducted in relation to this environmental assessment included the following:

- The final Scoping Document (Appendix A), as issued by the C-NLOPB on August 17, 2011.
- Comments from stakeholders (including regulatory agencies and the public) on the draft Scoping Document (issued by the C-NLOPB on February 25, 2011).
- Ongoing consultation with relevant regulatory agencies (including, but not limited to the C-NLOPB, DFO, Environment Canada and Transport Canada) and other stakeholders (including, but not limited to the FFAW, One Ocean, Regroupement des Pecheurs Professionnels des Iles (RPPIM), Regroupement des Palangriers et Petoncliers Unique Madelinots (RPPUM), Association des pêcheurs propriétaires des Îles-de-la-Madeleine (APPIM) and Association of Inshore Fishermen of the Magdalen Islands).
- A review of the Old Harry Prospect Geohazard Program 2010 to 2020 Scoping Document and regulatory review comments to the environmental assessment (Stantec 2010).
- A review of available information on the existing biophysical and socio-economic environments of the region in which the program will occur, and of other environmental assessments undertaken in relation to similar projects.
- A review of relevant regulations and guidelines related to offshore exploration activities.
- The professional judgment of the study team.

It is generally acknowledged that an environmental assessment must focus on those components of the environment that are valued by society and/or that can serve as indicators of environmental change and have the most relevance to the final decision regarding the environmental acceptability of a proposed undertaking. These components are known as VECs and may include biophysical and socio-economic components.

Based on the results of the issues scoping exercise described above, including the final Scoping Document (Appendix A), the following VECs are considered in this environmental assessment:

- Species at Risk;
- Marine Ecosystem;
- Marine Fish, Shellfish and Habitat;
- Marine Birds;
- Marine Mammals and Sea Turtles;
- Sensitive Areas; and
- Commercial Fisheries and Other Users.

The rationale for the selection of these VECs is provided below:

- Species at Risk: There are 15 species of marine fish, marine birds, fish, marine mammals and sea turtles that have designated status under SARA Schedule 1 and and/or 23 species designated as 'at-risk' by COSWEIC that could potentially occur in the Study Area. Species at Risk are collectively considered a VEC due to regulatory concern and in recognition of their protected status under SARA.
- Marine Ecosystem: A healthy marine ecosystem supports the biological communities and socio-economic uses of the marine environment. The marine ecosystem includes water (plankton) and benthic (coral) communities.
- Marine Fish, Shellfish and Habitat: Fish and fish habitat are considered a VEC in this assessment because of the biological and commercial significance of several fish species and associated spawning, feeding and nursery habitats within the Study Area. The commercial fishery is an important activity in the Gulf. The fish and fish habitat upon which the fishery depends is therefore an important consideration in the environmental assessment of activities that may influence the marine environment. In addition, fish and fish habitat are an important component of the marine ecosystem. Fish and their habitat are assessed as a single VEC because they are clearly interrelated. The consideration of fish and fish habitat as one VEC is in keeping with current practice in environmental assessment and provides for a more comprehensive, ecosystem-based approach. A number of species of marine fish can be found within the vicinity of the Study Area. Fish and fish habitat in the context of this environmental assessment includes finfish, shellfish, invertebrates, plankton, the water column and benthic habitats where relevant in the assessment.
- Marine Birds: The Gulf hosts a range of seabirds throughout the year. Seabirds are a key ecosystem component near the top of the food chain and are an important resource for tourism and recreational activities, as well as for scientific study. They are therefore important socially, culturally, economically, aesthetically, ecologically and scientifically. Marine birds are considered a VEC due to regulatory concern and in recognition of their protected status under the *Migratory Birds Convention Act, 1994*.
- Marine Mammals and Sea Turtles: Whales and seals are key elements in the biological and social environments in the Gulf; sea turtles are generally uncommon. There are 18 species of marine mammals and three species of Sea Turtles potentially present within the vicinity of the Study Area. Marine mammals play an important role in the offshore ecosystem. This importance is manifested in regulatory protection and scientific and public concern. As well, the whale-watching industry and the annual seal harvest are important economic considerations, as are interactions of marine mammals with the

commercial fishery. Marine turtles are occasional visitors to the Gulf and the west coast of Newfoundland and could potentially be affected by Project activities. For these reasons, marine mammals and turtles are considered a VEC. The environmental assessment focuses on marine mammal and turtle species that may live and/or migrate through the Study Area.

- Sensitive Areas: Sensitive Areas are often associated with rare or unique marine habitat features, habitat that supports sensitive life stages of valued marine resources, and/or critical habitat for species at risk. As per the Scoping Document (Appendix A), Sensitive Areas in the Study Area include any EBSAs identified within the Gulf (some consider the Gulf as a whole a sensitive area). This includes the southern fringe of the Laurentian Channel EBSA and the west coast of Newfoundland EBSA. The Project Area overlaps with a potential redfish (a COSEWIC-designated species) mating area and the Study Area overlaps with a potential redfish larvae extrusion area and a cod (a COSEWIC-designated species) spawning area. Sensitive areas were selected as a VEC due to their importance as unique or critical habitat for various species or species assemblages. Sensitive areas are important socially, culturally, aesthetically, ecologically and scientifically.
- Commercial Fisheries and other Users: Commercial fisheries and Other Users were selected as a VEC because historically, the fishery has played an important role in the Gulf and has helped to define much of the Atlantic provinces' character. Other marine users of the area include marine transportation, research surveys and military exercises, and therefore are also considered. The commercial fishery remains an integral component of the economy of the Newfoundland and Labrador as well as communities of the Gulf and for this reason is considered a VEC.

These seven VECs represent the key environmental components that are assessed in this document. This environmental assessment provides detailed effects analyses for each of these VECs.

6.3 Environmental Effects Assessment Organization

The specific steps involved in the assessment for each VEC are as follows:

- determining boundaries (see Section 6.3.1);
- describing the existing conditions for each VEC in the vicinity of the Study Area and within the Gulf as a whole (see Chapter 5);
- identifying potential interactions between VECs and the project's components / activities and outlining existing knowledge regarding these potential interactions (see Section 7.1);
- proposed mitigation (see sections 7.X.3);
- establishing significance criteria for evaluating residual environmental effects (see sections 7.X.1);
- assessing environmental effects and mitigation (see sections 7.X.2);
- assessing accidental events (see Chapter 8);
- assessing cumulative environmental effects (see Chapter 9);
- providing a summary of the environmental effects assessment (see sections 7.X.4 and Chapter 10); and
- identifying the need, if any, for follow-up and monitoring requirements(see Chapter 11).

Each of these is described in more detail in Sections 6.3.1 to 6.3.10.

6.3.1 Boundaries

Boundaries provide a meaningful focus for an environmental assessment. The Project boundaries are described generally below, as part of the effects analysis for each of the VECs. Establishing the spatial and temporal scope of the environmental assessment for each VEC included consideration of project, ecological/socio-economic and administrative boundaries.

The Project boundaries are also illustrated in Figure 6.1 and have been categorized as follows:

- Project Area: The approximately upper two-thirds of EL 1105; an approximately 304 km^2 area bounded by 48°10'59.740"N, 60°23'56.094"W (northwest corner), 48°10'0.084"N, 60°8'57.480"W (northeast corner), 48°04'45.681"N, 60°8'57.515"W (southeast corner) and 47°58'22.285"N, 60°23'55.732"W (southwest corner). The proposed well coordinates are in the vicinity of Latitude 48°03'05.294" and Longitude 60°23'39.385" (NAD83 datum, geographic coordinates).
- Study Area (note this is the same as the Affected Area as per the Scoping Document): The area that could potentially be affected by Project activities beyond the Project Area (i.e., drill cuttings deposition or an accidental event). The 27,602 km² Study Area has been defined by the furthest extent of the drill cutting deposition modelling (AMEC 2011) results (see Figure 2.7) and oil spill trajectory modelling (SL Ross 2011) results (see Figure 2.20). Note that the area is much larger than the modelling results; the coastal areas are identified as part of the Study Area only in recognition of the supply vessel / helicopter activity. Environmental assessment predictions will be based on this area.
- Regional Area: The northern and southern Gulf.

Project boundaries are defined by the spatial and temporal extent of project components and activities and are determined primarily by project-specific characteristics. Spatial project boundaries are sometimes defined by project "footprints" and may vary between project components and activities. Temporal project boundaries are defined by the timing and duration of project activities, as described in Section 2.5. Administrative boundaries refer to the spatial and temporal dimensions imposed on the environmental assessment for political, socio-cultural or economic reasons. Administrative boundaries can include such elements as the manner in which natural and/or socio-economic systems are managed.

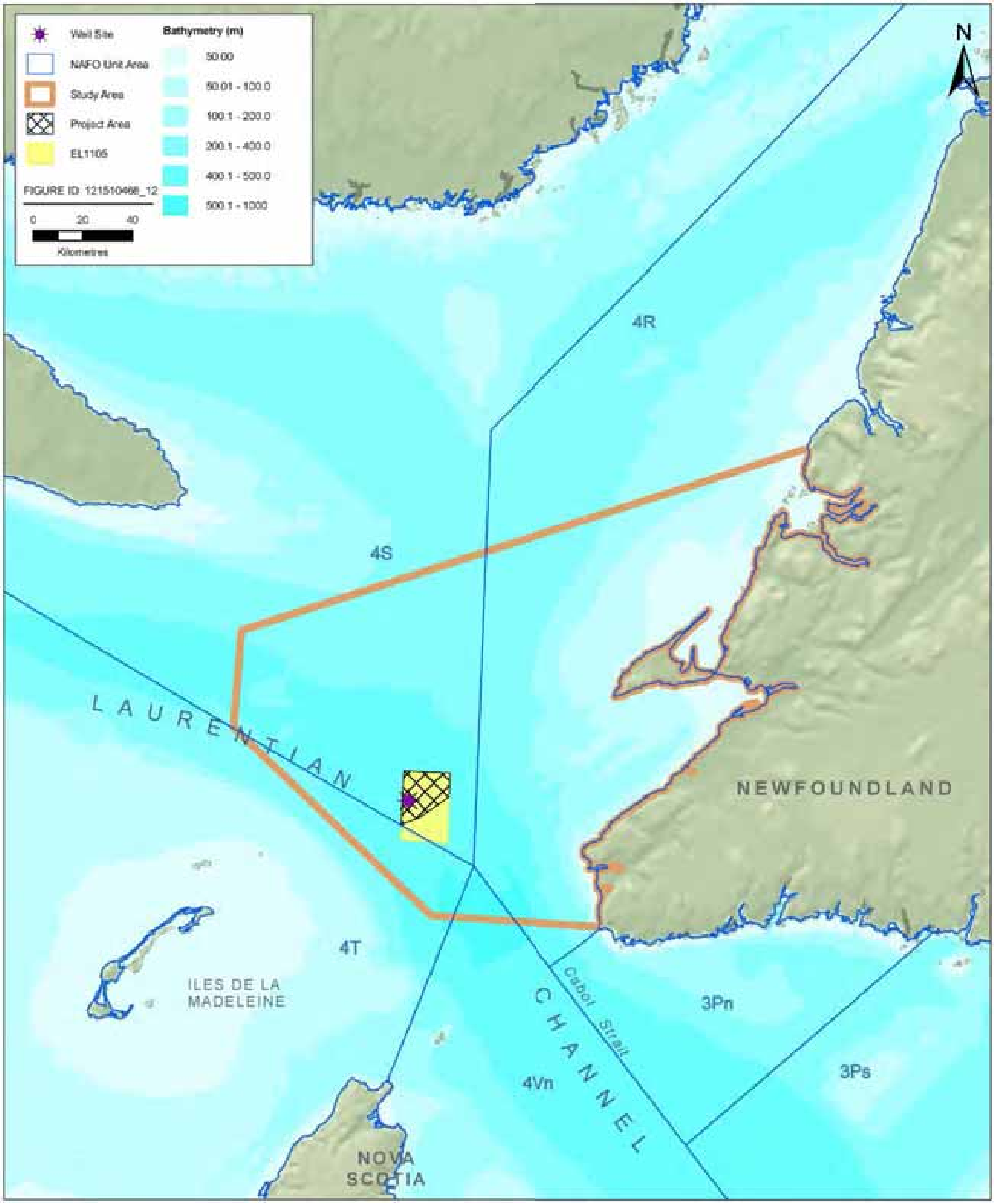


Figure 6.1 Project Boundaries

The spatial and administrative boundaries identified for each VEC in this assessment are described in Table 6.1. The temporal boundaries for each VEC are the same and are defined to include the 20 to 50 days to drill an exploration well between 2013 and 2014, during the open water (i.e., ice-free) period of the Laurentian Channel. Although the Project Description indicates a drilling start date as potentially mid-2012, this date is no longer achievable due to the implementation of the Independent Review process by the C-NLOPB for this screening-level environmental assessment.

Table 6.1 Project Boundaries by Valued Environmental Component

VEC	Spatial Boundaries	Administrative Boundaries
Species at Risk	Includes the area within and around the Study Area.	Species at risk are protected under SARA, administered by Environment Canada, Parks Canada and DFO. SARA is intended to protect species at risk in Canada and their critical habitat (as defined by SARA). Only species on Schedule 1 of SARA are subject to the permit and enforcement provisions of the Act. However, species designated as at risk by COSEWIC are also included in this VEC.
Marine Ecosystem	Includes the area within and around the Study Area.	The marine ecosystem is protected by the *Canada Oceans Act*
Marine Fish, Shellfish and Habitat	Includes the area within and around the Study Area.	Marine fish and fish habitat are protected by federal legislation. Fish habitat is protected under the federal *Fisheries Act* and by DFO's Policy for the Management of Fish Habitat. This policy applies to all projects and activities in or near the water that could alter or destroy fish habitat by chemical, physical or biological means.
Marine Birds	Includes the area in and around the Study Area.	Marine birds are protected federally under the *Migratory Birds Convention Act*, which is administered by Environment Canada.
Marine Mammals and Sea Turtles	Includes the area within and around the Study Area.	Marine Mammals and Sea Turtles not at risk are protected by federal legislation under the *Fisheries Act*.
Sensitive Areas	Includes the area within and around the Study Area.	This includes the southern fringe of the Laurentian Channel EBSA and the west coast of Newfoundland EBSA. The Project Area overlaps with a potential redfish (a COSEWIC-designated species) mating area and the Study Area overlaps with a potential redfish larvae extrusion area and a cod (a COSEWIC-designated species) spawning area.
Commercial Fisheries and Other Users	Includes the area within and around the Study Area, as well as NAFO Divisions 3Pn, 4RST and 4Vn.	DFO manages the fisheries resources in the area and is primarily responsible for scientific surveys. Scientific surveys conducted outside of DFO (i.e., private surveys) come under the jurisdiction of the Coast Guard, C-NLOPB, Quebec and CNSOPB. Boundaries for commercial fisheries have also been defined by NAFO.

6.3.2 Existing Conditions

The existing conditions in the vicinity of the Project (primarily within the Gulf, but also within the North Atlantic Ocean) will be described for Species at Risk, Fish and Fish Habitat, Marine Birds, Marine Mammals and Sea Turtles, Sensitive Areas and Commercial Fisheries and Other Users.

6.3.3 Potential Interactions and Existing Knowledge

The assessment focuses on identifying and evaluating potential interactions between program components and activities and each of the VECs under consideration. As a first step in the effects analysis, potential program-VEC interactions are identified and discussed. Existing knowledge concerning these potential interactions is also reviewed and summarized.

6.3.4 Mitigation

Based on the potential interactions identified above and existing knowledge regarding these interactions, technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects are identified.

Where possible, a proactive approach to mitigating potential environmental effects has been taken by incorporating environmental considerations directly into program design and planning. Where required and feasible, additional measures are identified in the environmental assessment to further mitigate potential adverse effects. These mitigation measures are identified and discussed within the appropriate effects analysis section(s). Residual environmental effects predictions are made taking into consideration these identified mitigation measures.

6.3.5 Residual Environmental Effects Significance Criteria

Evaluating the significance of predicted residual environmental effects is one of the critical stages in an environmental assessment. Significant environmental effects are those adverse environmental effects that will cause a change that will alter the status or integrity of a VEC beyond an acceptable level. In this environmental assessment, environmental effects are evaluated as significant, not significant or positive, based on definitions of significance developed and used for each VEC.

The definitions for significant adverse environmental effects integrate key factors such as magnitude (i.e., the portion of the VEC population affected), potential changes in VEC distribution and abundance, effect duration (i.e., the time required for the VEC to return to pre-project levels), frequency and geographic extent. They also include other important considerations such as interrelationships between populations and species, as well as any potential for changes in the overall integrity of affected populations. For each VEC, an adverse environmental effect that does not meet the criteria for a significant environmental effect (developed by the proponent in accordance with CEAA guidelines (CEA Agency 1994) and accepted / standard practice) is evaluated as not significant. A positive effect is one that may enhance a population or resource use activity.

6.3.6 Environmental Effects Assessment

This stage entails the assessment of the potential environmental effects associated with the project's components / activities for each of the VECs under consideration. Environmental effects were analyzed qualitatively using the professional judgment of the Study Team and where possible, quantitatively using existing knowledge and appropriate analytical tools.

The evaluation of environmental effects takes into consideration:

- the potential interaction between Project activities for each of the Project phases and their environmental effects in combination with those of other past, present and likely future projects;
- the mitigation strategies applicable to each of the interactions; and
- the CEA Agency's evaluation criteria for determining significance (CEA Agency 1994) and any other evaluation criteria established by the Study Team to further characterize the nature and extent of the environmental effects, where required.

Environmental effects are classified by determining whether they are adverse or positive. This is indicated in Table 6.2 by the use of a bracketed ("A") or ("P").

The following includes some of the key factors that can be considered for determining adverse environmental effects, as per the CEA Agency guidelines (CEA Agency 1994):

- loss of rare or endangered species;
- loss or avoidance of critical / productive habitat;
- negative environmental effects on the health of biota;
- reductions in biological diversity;
- fragmentation of habitat or interruption of movement corridors and migration routes;
- transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- loss of, or detrimental change in, current use of lands and resources for traditional purposes; and
- foreclosure of future resource use or production.

The environmental effects assessment also includes summary tables for each VEC that summarize the potential effect of each project activity / component using the following criteria (see Table 6.2 as an example):

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

Magnitude describes the nature and degree of the predicted environmental effect. For the biophysical VECs (Species at Risk, Marine Fish and Fish Habitat, Marine Birds, Marine Mammals and Sea Turtles), ratings for magnitudes were defined as follows (effects include mortality, sub-lethal effects or exclusion due to disturbance):

- Low: Affects 0 to 10 percent of individuals in the Study Area;
- Medium: Affects 10 to 25 percent of individuals in the Study Area; and
- High: Affects greater than 25 percent of individuals in the Study Area.

Table 6.2 Potential Environmental Effects Assessment Summary: VEC

Project Components/ Activities	Potential Interactions / Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-economic Context
Presence of Drilling Platform (including safety zones, flights, flaring)								
Drill Mud / Cuttings								
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)								
Support Vessels (supply boat and helicopter)								
VSP Survey / Drilling Noise								
Routine Atmospheric Emissions								
Well Abandonment / Suspension								
Accidental Event (oil spill)								

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

Geographic extent refers to the area where the particular effect in question will occur. Frequency and duration describe how often and for how long a disturbance will occur. Quantitative values are provided for geographic extent, frequency and duration (see Table 6.2).

Reversibility refers to the ability of a VEC to return to an equal or improved condition once the activity has ended (e.g., reclaiming habitat area equal or superior to that lost). Predicted environmental effects are rated as reversible or irreversible based on previous research and/or experience. Ecological, socio-cultural and economic context describes the current status of the VEC in the area affected by the Project due to past and/or existing human activities or natural factors.

These criteria are used to provide a common basis for summarizing the potential effects of each project activity for each VEC.

As described in Section 2.5 (Project Scheduling), an exploration well is anticipated to be spudded between 2013 to 2014, dependent upon the completion of the C-NLOPB Independent Review process for this undertaking, regulatory approvals and rig availability. It will take between 20 and 50 days to drill the well, which will take place during the ice-free season.

It is important to realize that the proposed Project represents one exploration well. As such, some of the discussion presented in this report regarding potential environmental effects may be more applicable to large-scale exploration or production programs, as not all literature distinguishes between the type and scale of the programs being conducted.

6.3.7 Accidental Events

This section entails the assessment of the potential accidental events resulting in an oil spill, including probabilities and trajectory, as modelled by SL Ross (2011).

6.3.8 Cumulative Environmental Effects Assessment

Individual environmental effects are not necessarily mutually exclusive of each other but can accumulate and interact to result in cumulative environmental effects. This environmental assessment includes consideration of cumulative environmental effects for each VEC immediately following the discussion of the environment effects analysis.

Within-project cumulative environmental effects (i.e., those due to the accumulation and/or interaction of each project's own environmental effects) are considered as part of the project-specific environmental effects analyses described above (i.e., the overall effect of each project on a VEC). This section focuses on the cumulative environmental effects of drilling one exploration well in combination with other relevant projects and activities.

The region's natural and human environments have been affected by past and ongoing human activities. The description of the existing (baseline) environment reflects the effects of these other actions. The evaluation of cumulative environmental effects considers the nature and degree of change from these baseline environmental conditions as a result of the proposed program in combination with other ongoing and planned projects and activities.

An important step in undertaking a cumulative environmental effects assessment is the identification of other actions whose environmental effects will likely act in combination with those of the project under review to bring about cumulative environmental effects. CEAA requires that only the following type of projects and activities be considered, including:

- those that are certain (those that will proceed or there is a high probability of proceeding); and
- reasonably foreseeable (those that may proceed).

The degree of certainty that the project will proceed must therefore be considered (CEA Agency 2008). The other projects and activities considered in this assessment, therefore, include those that are ongoing or likely to proceed and have been issued permits, licences, leases or other forms of approval. The cumulative effects assessment considers the cumulative environmental effects of the proposed single exploration well in combination with:

- marine transportation;
- fishing activities;
- research surveys;
- military exercises; and
- other oil and gas exploration programs (including seismic and geohazard programs).

There are a number of exploration licences offshore western Newfoundland. However, due to the distance from the location of these licences to the location of the proposed Project, it is unlikely that potential projects in that area could cumulatively interact with the proposed Project to result in an adverse environmental effect.

6.3.9 Summary of Residual Environmental Effects Assessment

Significance ratings for the predicted residual environmental effects of each project phase and for the Project as a whole are provided in a summary table following the environmental effects analysis (see Table 6.3 as an example).

Table 6.3 Residual Environmental Effects Summary: VEC

<table>
<tr><th>Phase</th><th>Residual Environmental Effect Rating[A]</th><th>Level of Confidence</th><th>Probability of Occurrence (Likelihood)</th></tr>
<tr><td>Installation / Operation</td><td></td><td></td><td>NA[B]</td></tr>
<tr><td>Well Abandonment / Suspension</td><td></td><td></td><td>NA</td></tr>
<tr><td>Accidental Event</td><td></td><td></td><td>NA</td></tr>
<tr><td>Cumulative Environmental Effect</td><td></td><td></td><td>NA</td></tr>
<tr><td colspan="4">KEY</td></tr>
<tr><td>Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect</td><td colspan="2">Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence</td><td>Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence</td></tr>
<tr><td colspan="4">[A] As determined in consideration of established residual environmental effects rating criteria.
[B] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA.</td></tr>
</table>

The evaluation of the significance of the predicted residual environmental effects is based on a review of relevant literature and professional judgment. Ratings are provided to indicate the level of confidence in each prediction. The level of confidence ratings provide a general indication of the confidence within which each environmental effects prediction was made based on professional judgment and the effects from similar existing projects. The likelihood of the occurrence of any predicted significant adverse effect is also indicated, based on previous scientific research and experience.

Data gaps with respect to our current scientific knowledge regarding biological, physical and scientific processes can and do occur. The data gaps are considered when conducting the environmental effects assessment and will influence the level of confidence applied to an assessment. The means by which the data gaps are incorporated into the assessment is to consider the effect that the activity can potentially have on the environment (such as the duration, extent, seasonality, vector), consider the level or degree of effect on the environment (lethal, chronic, minimal, no effect, short term, long term) and the available scientific knowledge about the effects of the activity (such as can cause smothering of benthos in 500 m of discharge, results in potential bioaccumulation of metals to a harmful level in an organism, cause mortality from toxic response). Once these types of information have been considered, then the level of confidence of the environmental effects assessment can be assigned. Ultimately the assignment of the level of confidence incorporates professional judgment and experience of both the assessor and from similar undertakings while considering the data gaps.

6.3.10 Follow-up and Monitoring

Consideration of a follow-up program is required for a screening-level environmental assessment. The purpose of the follow-up program is to:

- verify the accuracy of the environmental assessment; and
- determine the effectiveness of mitigation measures.

Follow-up and monitoring will be considered where there are important Project-VEC interactions, where there is a high level of uncertainty, where significant environmental effects are predicted, or in areas of particular sensitivity.

Follow-up and monitoring programs should be well-defined and focused to allow for efficient use of time and resources. Follow-up and monitoring programs are typically associated with longer-term, larger projects, but are considered in this assessment.

7.0 ENVIRONMENTAL EFFECTS ASSESSMENT

This section focuses on the assessment of the potential environmental effects of routine Project activities on the VECs. An accidental event is not a routine activity and is discussed in detail in Chapter 8.

This section discusses the potential effects of routine activities associated with exploration drilling activities on the various VECs. The primary potential environmental effects related to routine activities associated with exploration drilling activities include (but are not limited to):

- disturbance to marine animals from underwater sound associated with exploration drilling activities including VSP profiling;
- displacement or smothering of benthos by accumulation of drill mud and cuttings;
- conflicts with commercial fisheries (especially fixed gear fisheries) from safety zones, vessel traffic and exploration drilling activities; and
- seabird (especially storm-petrels) attraction and stranding on marine vessels and the drilling platform.

A general discussion of these effects is contained in Section 7.1. A detailed list of the potential interactions between the Project and the identified VECs, including Species at Risk is provided in Table 7.1. The potential for residual effects on each of the VECs is assessed in Sections 7.2 to 7.8. Environments effects associated with accidental events is discussed in detail in Chapter 8.

Table 7.1 Routine Project Activity Interactions with Valued Ecosystem Components

Project Activities and Physical Works	VEC								
	Species at Risk			Marine Ecosystem	Fish and Fish Habitat	Marine Birds	Marine Mammal and Sea Turtle	Sensitive Areas	Commercial Fisheries
	Marine Mammal and Sea Turtle	Marine Bird	Marine Fish						
Presence of Drilling Platform (including safety zone, lights, flaring)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Drill Mud and Cuttings			✓	✓	✓				
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Support Vessels (supply boat and helicopter)	✓	✓	✓		✓	✓	✓	✓	✓
VSP Survey / Drilling Noise	✓	✓	✓	✓	✓	✓	✓	✓	✓
Routine Air Emissions		✓				✓			
Well Abandonment / Suspension			✓	✓	✓	✓	✓		✓

7.1 Overview of Project Interactions and Potential Effects

7.1.1 Presence of the Drill Platform

The Project could use a semi-submersible or a drillship as a drilling platform. The proposed safety zone could extend as far as 2 km from the semi-submersible rig (i.e., 50 m beyond the anchor locations of a new type of semi-submersible with a larger anchorage area). The maximum areas of the semi-submersible drill platform safety zones would be approximately 10 km^2 No one other than operational or C-NLOPB personnel will be allowed within the zone without the express permission of the Offshore Installation Manager. A 'Notice to Shipping' regarding the safety zone will be issued for each exploration well drilled during the program.

The presence of the drill platform may result in either a reef effect or an avoidance effect as a result of noise from drilling activities. Some fish species may be attracted to the drill platform due to lights and the artificial reef effect. An artificial reef effect may be created shortly after the presence of the drill platform in the area with the structure becoming a potential shelter for several species of fish and shellfish, especially juveniles. The creation of an artificial reef effect could alter the local abundance and distribution of fish (in the short-term), thereby concentrating food sources that may attract marine mammals, sea turtles and marine birds to the drill platform. The fisheries exclusion zone (FEZ) (1 to 5 km^2) may also serve as a refuge for some fish species, including commercially fished species.

A drilling rig may create an artificial reef effect that could alter the local abundance and distribution of fish, thus concentrating a food source that may attract marine birds to platforms. There has been little quantification of associations of seabirds with offshore installations, although such associations have been regularly noted (Wiese et al. 2001). Galley and sewage discharges further attract seabirds to these artificial habitats and in fact may attract birds directly in much the same way as sewer outlets (Wiese et al. 2001). Tasker et al. (1986) observed that bird density (birds/km^2) was seven times greater within a 500-m radius of a platform than in the surrounding area. Similarly, seabird concentrations around platforms on the Grand Banks were 19 to 38 times higher than on survey transects leading to the platforms (Wiese and Montevecchi 1999).

The drilling unit emits some noise continuously during operation. Marine mammals will avoid an area of noise, especially sudden changes in frequency or intensity. Depending on the circumstance, the response to noise is highly variable between species and even within a species. Between species, a response to noise can be in the form of changes in swimming direction and speed, breathing rate and vocalization (Richardson et al. 1995).

During exploration drilling, vessel traffic and the drill rig may affect seabirds by attracting them to lighting. Seabirds primarily navigate by sight, and lights can be an eye-catching visual cue (Wiese et al. 2001). Marine birds that are attracted to offshore installations may experience mortality through strikes against infrastructure or may become disoriented by lights. Drizzle and fog tend to increase the problem since during these periods light is refracted by moisture droplets that increase the illuminated area and enhance the attraction (Wiese et al. 2001). Attraction could also result in continuous circling around the lights, using energy and delaying foraging or migration, and can result in starvation (Bourne 1979). As well, during shipboard studies conducted in 1999, Leach's storm-petrels were observed being attacked by great black-backed gulls after the petrels appeared confused by the lights of vessels and platforms, adding predation as an additional potential problem for species such as Leach's storm-petrels (Wiese and Montevecchi 2000). The greatest period of risk of attraction to offshore lights is in September when birds are moving to offshore wintering grounds. Storm Petrels and other *Procellariformes* (tube-nosed seabirds) are nocturnal foragers on bioluminescent prey and are, therefore, naturally pre-disposed to attraction to light of any kind (Imber 1975). Young-of-the year birds appear to be more susceptible to light attraction than adults although further research is required (LGL Limited 2005b).

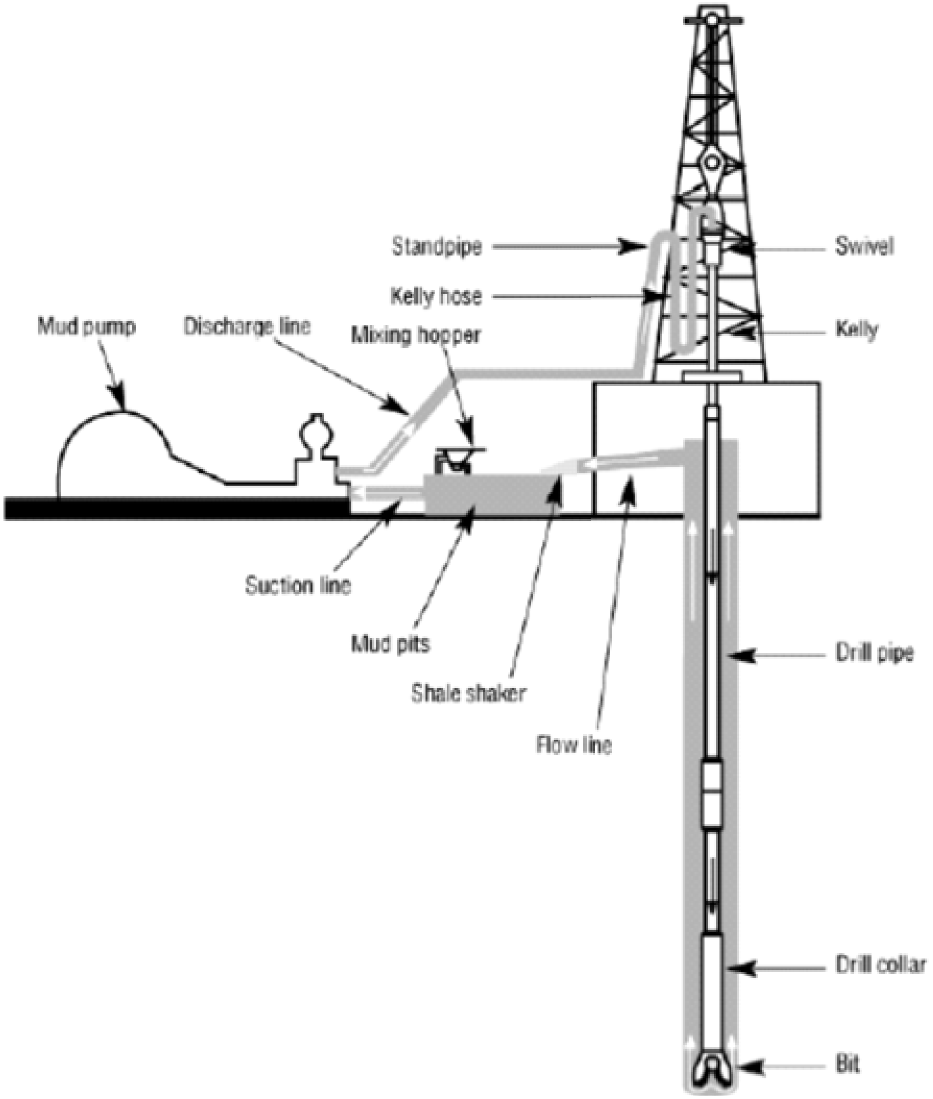
Light attraction's primary effect for fish is that the light / dark cycle may be interrupted and fish and invertebrates in the area may not react in their normal manner. This has the potential to result in physiological stress, as light resulting in 24-hour light regime affects their normal circadian rhythm. The response of fish to changes in their circadian rhythm varies among species. Examples of the effects of a 24-hour light regime on fish species are provided to demonstrate the potential for physiological stresses.

Nighttime rest deprivation in zebra fish was found to result in a significant decline in daytime locomotor activity and in a heightened arousal threshold, compared to basal recordings (Zhdanova and Reebs 2006). Leonardi and Klempau (2003) demonstrated that the application of 24-hour light period for 60 days induced an increase of cortisol in trout that lasted up to two months after return to normal light regimes. The changes observed in fish towards the end of the two-month illumination period (increased haematocrit values and erythrocyte numbers) can be explained as a consequence of acute stress or, alternatively, as a stimulation of erythropoiesis by increased light exposure. Hemre et al. (2002) found that a 24-hour light regime for Atlantic cod resulted in a delay in gonadal maturation and evident anaemia.

There may be some short-duration flaring by the drill rig during testing, if it occurs. While gas flaring will also produce light that may attract birds, heat and noise generated by the flare may actually deter birds from the immediate area. There are no study results from the Grand Banks concerning the effects of lights and flares on marine birds. However, 52 Leach's storm petrels were recovered and released with no mortality observed during monitoring on board a Terra Nova vessel over a three-week period during the summer of 1998 (Husky Oil 2000).

7.1.2 Drill Muds and Cuttings

Drilling is accomplished by a rotating drill bit attached to the end of a hollow drill pipe, referred to as the drill string (Figure 7.1). The drilling mud is pumped from the mud pit through the surface equipment and down the centre of the drill pipe. It exits through holes in the drill bit, where it picks up drill cuttings and lubricates the drill bit. Rotation of the drill bit at the bottom of the hole breaks off small chips of rock, deepening the hole. The fluid exiting the drill bit suspends these rock chips, called cuttings, and carries them up the annulus to the surface where they are removed from the fluid and disposed. The fluid, the drilling mud, usually is recycled down-hole. It passes up the annulus (the space between the drill string and the borehole wall) to the mud return line, through the shale shakers and other mud/cuttings separation devices, and back to the mud pit (Neff 2005).



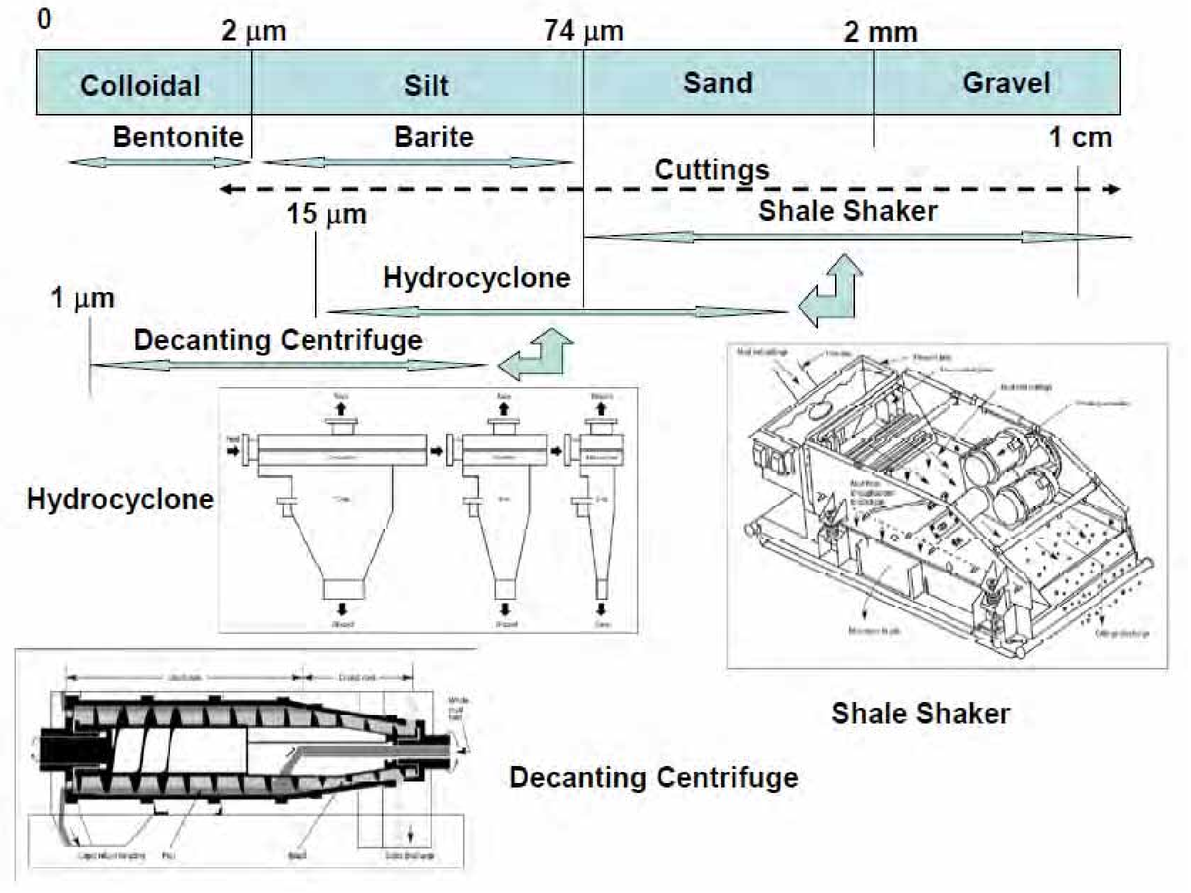
Source: CAPP 2001

Figure 7.1 Drilling Circuit on an Offshore Platform

A wide variety of fluids has been used for drilling, including water, or a mud-in-water slurry, oil, synthetic organic fluids, brine-in-oil or synthetic emulsions, mists, and foams (OGP 2003). Most modern drilling muds are mixtures of fine-grained solids, inorganic salts, and organic compounds in water or an organic liquid. There are two primary types of drilling muds in use today: WBMs and SBMs (Neff et al. 2000; OGP 2003).

Drilling muds are needed to convey the drill cuttings out of the hole and keep formation fluids from entering the well. Drill cuttings are particles of crushed rock produced by the grinding action of the drill bit as it penetrates into the earth (Neff et al. 1987). Drill cuttings range in size from clay-sized particles (approximately 2 µm) to coarse gravel (>30 mm) and have an angular configuration. Their chemistry and mineralogy reflect that of the sedimentary strata being penetrated by the drill.

During the drilling of the top hole sections, the riser is not in place and drilling mud and cuttings (or sediments) from the top part of the hole are discharged from the hole to the seabed. Once the riser is in place, the mud and cuttings are brought to the surface for cleaning and recycling. Once on board the rig, the drill cuttings are removed from the mud in successive separation stages and discharged (Figure 7.2). Separation of WBMs and cuttings commences with the coarser, sand/gravel-sized cuttings particles removed by the shale shakers. The solids that pass through the shale shaker screens may also be passed to hydrocyclones and, occasionally, decanting centrifuges, where finer particles are removed.



Source: Neff 2005.

Figure 7.2 Separation of Drilling Fluid and Cuttings

Some mud remains with the discharged cuttings. The treated cuttings are discharged via a chute to just below the water's surface. The mud and cuttings are dispersed in the water column and settle on the sea floor with the heavier particles near the hole and the fines at increasing distances from the rig.

All drilling in eastern Canadian waters is conducted using either WBMs or SBMs. A physical and chemical description of the discharge of mud and cuttings can be found in Section 2.11.1. While the drill plan is not to use SBMs unless technical challenges determine that the use of SBMs is required to safely complete the planned drill program, information on SBMs is included and assessed as their use is a possibility.

Drilling mud is a solution of suspended solids and dissolved materials in a carrier liquid. There is debate regarding which type of mud is the most “environmentally friendly”. It has been argued that WBMs are better environmentally because they consist of mostly water and cannot form sheens on the surface whereas SBMs may form sheens under certain operational and/or sea state conditions. On the other hand, SBMs generally do not disperse as widely as WBMs and, therefore, accumulate closer to the wellsite then WBMs. Compared to SBMs, WBMs remain suspended in the water column longer and therefore have greater potential to affect filter feeding organisms (Cranford et al. 2005).

Drill cuttings contain, in addition to formation solids, small amounts of liquid and solid drilling mud components (Neff 2005). The amounts of drilling fluid solids that remain attached to cuttings vary, depending on the grain size of the crushed rock from the strata being drilled. Clay sized cuttings are more difficult than larger cuttings to separate from drilling mud. A typical cuttings discharge during drilling with WBM usually contains 5 to 25 percent drilling fluid solids after passage through the solids control equipment on the drill platform. Cuttings from the fossil fuel-bearing intervals in a well also may contain crude oil or gas condensate.

The chemical composition of drill cuttings reflects the geochemistry of the formation being drilled and the amount of drilling mud ingredients adhering to the cuttings at the time of disposal. Barium is more abundant in drilling mud than cuttings, as expected because of its abundance in drilling muds. Most of the metals associated with cuttings are in immobile forms in minerals from the geologic formations (Neff 2005). Cuttings produced during drilling with WBM may contain small amounts of petroleum hydrocarbons. The hydrocarbons in cuttings generated with WBM may come from spotting fluids and lubricants added to the mud, or from the geologic strata being penetrated by the drill.

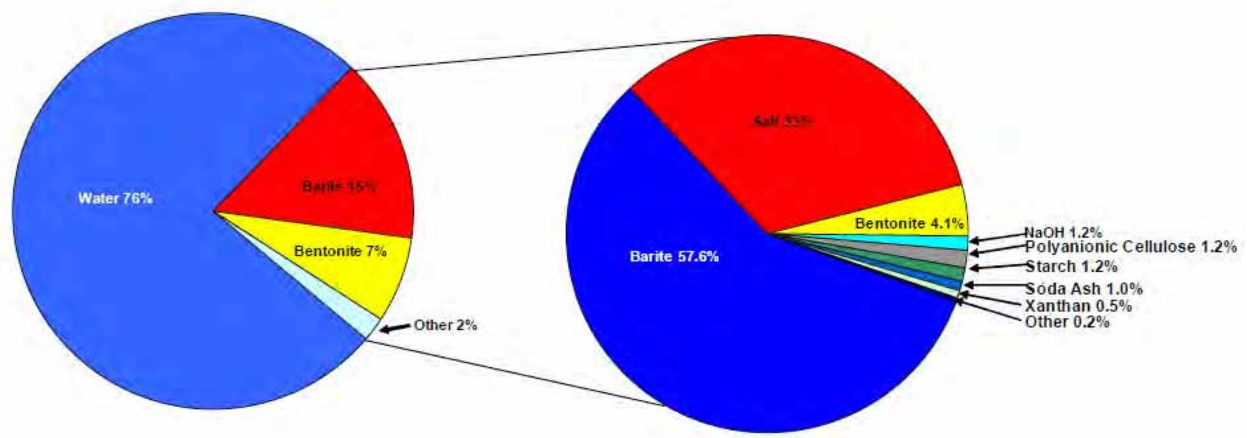
7.1.2.1 Water-based Muds

The carrier liquid for WBM’s is water (either salt or fresh). WBMs are generally used on wells in the earliest sections of drilling. WBMs are essentially non-toxic, with the main component of WBMs being seawater and the primary additives are bentonite (clay), barite and potassium chloride. Chemicals (see Table 7.2) such as caustic soda, soda ash, viscosifiers, inorganic salts, surfactants, corrosion inhibitors, lubricants and shale inhibitors are added to control mud properties and unique drilling problems (Thomas et al. 1984; GESAMP 1993; Neff 2005). All constituents used for drilling utility or production chemicals that have the potential to reach the environment are screened using the Offshore Chemical Selection Guidelines (NEB et al. 1999). The screening assesses the potential toxicity. Where chemicals are deemed to have unacceptable toxicity ratings, a substitution for that chemical is sought. Discharge of WBM and associated cuttings is regulated by the C-NLOPB. WBMs may be discharged without treatment (NEB et al. 2010).

Table 7.2 Functional Categories of Materials Used in Water-based Mud, their Functions and Examples of Typical Chemicals in Each Category

Functional Category	Function	Typical Chemicals
Weighting Materials	Increase density (weight) of mud, balancing formation pressure, preventing a blowout	Barite, hematite, calcite, ilmenite
Viscosifiers	Increase viscosity of mud to suspend cuttings and weighting agent in mud	Bentonite or attapulgite clay, carboxymethyl cellulose and other polymers
Thinners, Dispersants and Temperature Stability Agents	Deflocculate clays to optimize viscosity and gel strength of mud	Tannins, polyphosphates, lignite, ligrosulfonates
Flocculants	Increase viscosity and gel strength of clays or clarify or de-water low-solids muds	Inorganic salts, hydrated lime, gypsum, sodium carbonate and bicarbonate, sodium tetraphosphate, acrylamide-based polymers
Filtrate Reducers	Decrease fluid loss to the formation through the filter cake on the wellbore wall	Bentonite clay, lignite, Na-carboxymethyl cellulose, polyacrylate, pregelatinized starch
Alkalinity, pH control additives	Optimize pH and alkalinity of mud, controlling mud properties	Lime (CaO), caustic soda (NaOH), soda ash (Na_2CO_3), sodium bicarbonate ($NaHCO_3$) and other acids and bases
Lost Circulation Materials	Plug leaks in the wellbore wall, preventing loss of whole drilling mud to the formation	Nut shells, natural fibrous materials, inorganic solids, and other inert insoluble solids
Lubricants	Reduce torque and drag on the drill string	Oils, synthetic liquids, graphite, surfactants, glycols, glycerin
Shale Control Materials	Control hydration of shales that causes swelling and dispersion of shale, collapsing the wellbore wall	Soluble calcium and potassium salts, other inorganic salts, and organics such as glycols
Emulsifiers and Surfactants	Facilitate formation of stable dispersion of insoluble liquids in water phase of mud	Anionic, cationic, or nonionic detergents, soaps, organic acids, and water-based detergents
Bactericides	Prevent biodegradation of organic additives	Glutaraldehyde and other aldehydes
Defoamers	Reduce mud foaming	Alcohols, silicones, aluminum stearate (C54H105AlO6), alkyl phosphates
Pipe-freeing Agents	Prevent pipe from sticking to wellbore wall or free stuck pipe	Detergents, soaps, oils, surfactants
Calcium Reducers	Counteract effects of calcium from seawater, cement, formation anhydrites, and gypsum on mud properties	Sodium carbonate and bicarbonate (Na_2CO_3 and $NaHCO_3$) , sodium hydroxide (NaOH), polyphosphates
Corrosion Inhibitors	Prevent corrosion of drill string by formation acids and acid gases	Amines, phosphates, specialty mixtures
Temperature Stability Agents	Increase stability of mud dispersions, emulsions and rheological properties at high temperatures	Acrylic or sulfonated polymers or copolymers, lignite, lignosulfonate, tannins
Source: Boehm et al. 2001, in Neff 2005		

The most abundant ingredients (other than water) in most WBM (Neff 2005) are barite weighting material, salts (in several functional categories), and bentonite viscosifier (Figure 7.3).

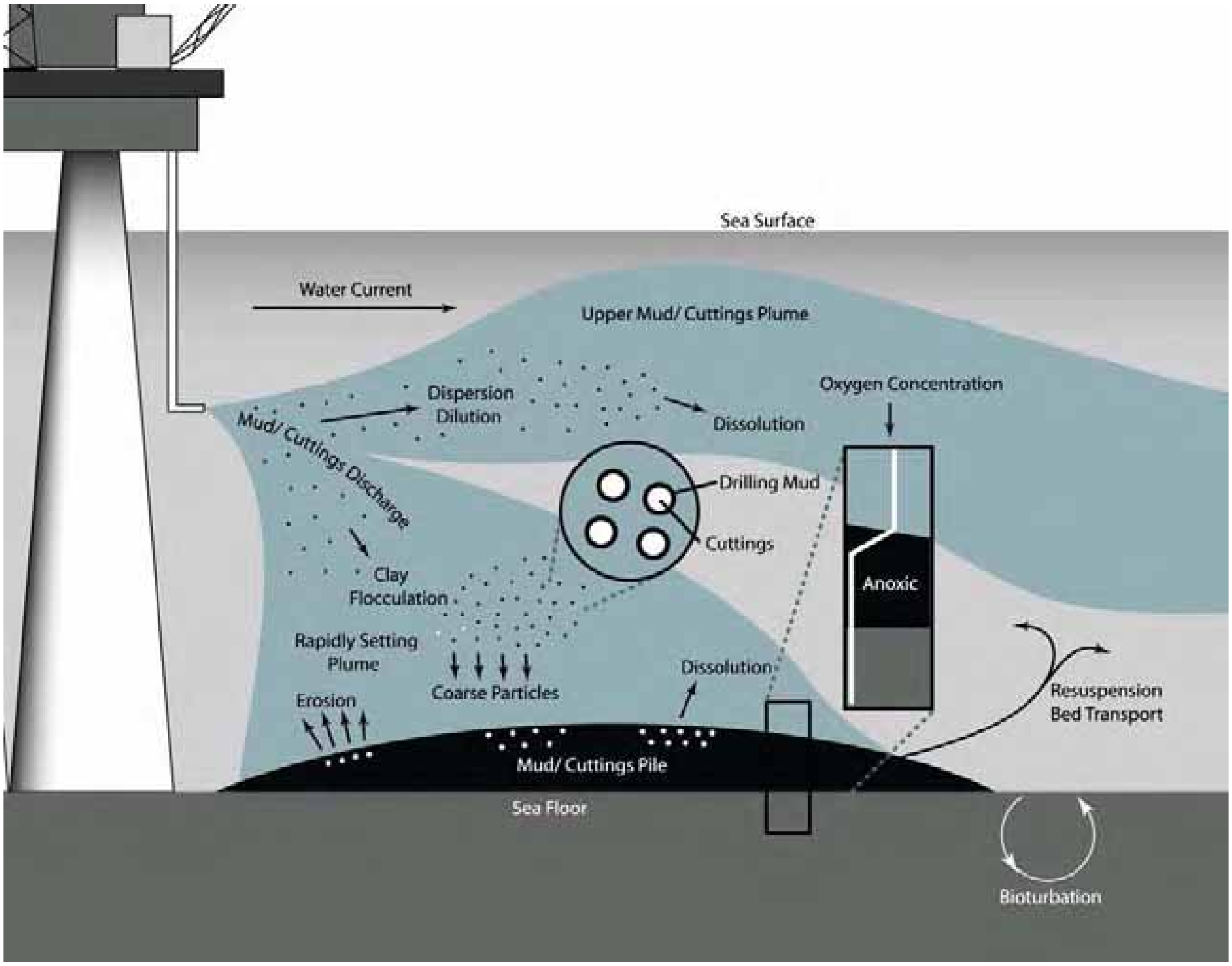


Source: Neff 2005.

Figure 7.3 Composition of a Typical Water-based Mud and of the Additives to a Typical Water-based Mud

WBM and cuttings are composed of a slurry of particles with a wide range of grain sizes and densities in water. Clay, silt, and most cuttings solids have densities of about 2.3 to 2.65 g/cm^3; drilling mud barite has a density of about 4.3 g/cm^3 (Nedwed 2004). Silts and clays, as well as drilling mud barite, have diameters of less than approximately 74 µm. Particle diameter has a greater influence than density on the rate of settling of WBM and cuttings particles. Bentonite clay in a WBM usually flocculates upon dilution in seawater (Muschenheim and Milligan 1996; Curran et al. 2002). The clay flocculate is a loose aggregate of clay particles that may include barite particles. These aggregates settle more rapidly than unflocculated silt and clay (Neff 2005, 2010).

A conceptual schematic of WBM and cuttings discharge is presented in Figure 7.4 showing that the larger particles associated with drill muds and cuttings discharge (representing approximately 90 percent of the mass of the cuttings discharge) settles to the bottom near the drill platform (Neff 2010). The remaining mass of the mud solids consisting of fine-grained unflocculated clay-sized particles (approximately 10 percent of the drill muds and cuttings discharge) along with a portion of the soluble components of the drill mud form a plume in the water column that drifts with prevailing currents away from the platform rapidly diluting in the receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; National Research Council 1983). The fine-grained solids associated with the plume settle slowly over a large area of the sea floor.



Source: Neff 2005.

Figure 7.4 Dispersion and Fate of Water-based Drilling Mud following Discharge

Based on modelling results (AMEC 2011), drilling operations will result in:

- sea floor discharge of 196 m^3 of cuttings;
- surface discharge of 211 m^3 of cuttings;
- sea floor discharge of 1,210 m^3 of WBM of various density and composition; and
- surface discharge of 400 m^3 of WBM combined with 50 m^3 of brine.

Sea floor discharge of cuttings is expected to result in a mound extending approximately 30 m from the well site, with cuttings thicknesses greatest immediately adjacent the well site. Average thickness is approximately 22 cm out to approximately 20 m from the well site; maximum thickness is approximately 4.7 m. From 20 to 50 m out from the well site, the average thickness is less than 1 mm.

Surface release of cuttings is expected to produce a deposit with thickness greatest near the drill origin, due to the most rapid fall of the heavier pebble and sand cuttings particles, and is as thick as 15 mm directly below the point of origin. Out to approximately 100 m from the origin, thicknesses are approximately 2 mm on average with a maximum of approximately 6 mm. From 100 to 200 m, thicknesses average from approximately 0.5 to 1 mm, with a maximum of approximately 6 mm.

Bioavailability and Accessibility

Bioavailability is the extent to which a chemical can be absorbed (bioaccumulated) by a living organism by active (biological) or passive (physical or chemical) processes (Neff 2002a). Thus a chemical is bioavailable if it can move through or bind to a permeable surface coating (such as skin, gill epithelium, gut lining, cell membrane) of an organism (Newman and Jagoe 1994). Metal bioavailability from sediments (cuttings piles) can be divided into two components: environmental accessibility and environmental bioavailability.

Environmental accessibility is a measure of the fraction of the total chemical that is in a form or location in the environment that is accessible for bioaccumulation by organisms. Metals of all forms in cuttings have a low accessibility to marine organisms as the metals in cuttings piles are present primarily as insoluble inclusions in barite, clay, and cuttings particles. These solid metals are not bioaccessible. A small portion of the metal component may be in solution in the pore water of the cuttings pile (Shimmield et al. 2000). If the cuttings pore water is accessible to marine organisms, or is mixed up into the overlying water column by sediment disturbance, some of the dissolved and colloidal metals in it may be in bioavailable forms and may be bioaccumulated by marine organisms (Neff 2005).

Environmental bioavailability is dependent on the interactions between a marine organism and its environment. Exposure occurs at the interface between environmental media (water, sediment, and food) and permeable biological membranes of the marine organism. Environmental bioavailability is controlled by the relative amount of permeable epithelia in contact with the environmental media, the duration of contact, and the physical form of the chemical in the environmental medium. Dissolved, free ionic forms, some metal-organic colloid complexes, and low molecular weight organo-metal compounds of metals are the most bioavailable forms of most metals to marine organisms (Neff 2002). The most bioavailable fraction of metals associated with WBM and cuttings is that dissolved in the pore water or loosely complexed with particles. The majority of metals associated with WBMs and cuttings are associated with sulphide mineral inclusions in the barite and are not soluble in anoxic marine sediment pore waters (Trefry et al. 1986; Neff 2002). The distribution of metals in different geochemical fractions of North Sea cuttings pile sediments found that approximately 17 percent of the lead and 36 percent of the nickel in North Sea cuttings piles are in potentially bioavailable forms (Westerlund et al. 2001, 2002).

Barium and Chromium

The most abundant metal in most WBM is barium. Nearly all the barium in drilling mud is from barite ($BaSO_4$) added to the mud to increase its density (Neff 2005). Using barium as a tracer, the zone of detection for both single and multiple wells found that background levels for barium were achieved at 1,000 to 3,000 m from the drill source. Barite in drilling muds and sediments has a low solubility in seawater (because of the high natural concentration of sulfate in the ocean), and because it is insoluble in seawater, it has a low bioavailability and toxicity to marine organisms (Neff 2005). The extent of barium contamination has been confirmed by the Grand Banks EEM programs. Drill cuttings releases at White Rose and Terra Nova are a mixture of WBMs and SBMs, both of which contain barium as tracers. Background barium concentrations have been achieved at Terra Nova within 1,000 to 2,000 m from drill source (Suncor Energy 2010) and within 2,400 m at White Rose (Husky Energy 2009). Hibernia has been discharging only WBMs since 2002, although prior to Q3 2002 a mixture of SBMs and WBMs was released. Barium concentrations remain elevated out to 500 m from the Hibernia discharge point and the results beyond 500 m are comparable to baseline levels (Stantec 2009).

Dissolved barium concentrations in the North Sea cuttings pile pore water were found to increase with depth in the mud and cuttings accumulation (Shimmield and Breuer 2000; Shimmield et al. 2000; Breuer et al. 2004). The solubility of barium in seawater and marine sediments is controlled by the concentration of reactive sulphate, which is high in seawater (Neff 2002). Sulphate reducing bacteria in suboxic layers of the cuttings pile use dissolved sulphate as an electron acceptor for organic matter biodegradation and, in the process, convert sulphate to sulphide (Neff 2005). As the sulphate concentration in cuttings pile pore water decreases, barite becomes more soluble, releasing small amounts of barium into the pore waters. This reaction is thought to be self-limiting because dissolution of barite results in the release of sulphate.

High barite concentrations can serve as a source of reducible sulfate for sulfate reducing bacteria (Ulrich et al. 2003), releasing dissolved barium into the pore water (Phillips et al. 2001). Much of the barium in pore water diffuses upward to the oxic layers of the sediment or into the overlying water column, where it precipitates with sulfate in the oxygenated water phase (Paytan et al. 2002). Thus, barite is highly persistent in marine sediments containing WBM and cuttings. Most other metals present in barite are primarily associated with insoluble sulfide salts (Leuterman et al. 1997; Trefry 1998; Trefry and Smith 2003). These metal sulfides have an extremely low solubility and mobility, even in anoxic, sulfidic sediments where some of the barite dissolves (Shimmield and Breuer 2000; Trefry and Smith 2003).

Neff et al. (1989a), Leuterman et al. (1997) and Schaanning et al. (2002) conducted studies on the bioavailability of several metals in different grades (purities) of drilling mud barite in sediments to marine organisms. There was some accumulation of small amounts of one or more metals (arsenic, cadmium, copper, lead, mercury, nickel and zinc) during chronic exposure to the high concentrations of the barites containing the highest concentrations of metals. It is probable that some of the metals that apparently bioaccumulated were actually still associated with fine particulate barite or other sediment particles in the gut and gills (Jenkins et al. 1989). Marine invertebrates can take up fine particles into epithelial cells by pynocytosis. The metals associated with the particles remain in the particles and are not actually assimilated by the animal. These sorbed, particulate metals are toxicologically inert (Nott and Nicolaidou 1989, 1990, 1993, 1994). Neff et al. (1989a) and Leuterman et al. (1997) concluded that metals associated with drilling mud barite have a low bioavailability to marine organisms that might come in contact with discharged drilling fluid solids.

Drilling mud chromium is derived primarily from chrome- or ferrochrome-lignosulfonates or chromate salts added intentionally to the mud for viscosity control; as well barite and bentonite clay may also contain traces of chromium (Neff 2005). The chromium in a drilling mud, even that added as chromate, is in the trivalent, chromic valency state. Trivalent chromium salts have low solubilities and limited mobility in the environment. They usually have a low toxicity to plants and animals (Neff 2005).

Neff et al. (1989a) exposed lobsters and flounder for up to 99 days in mesocosm tanks to sediments containing solids from a WBM. In addition, some of the test organisms were fed polychaete worms that had been exposed to WBM solids. Concentrations of barium and chromium, the two most abundant metals in most WBMs, were measured at different times during the study. Lobster and flounder accumulated small amounts of barium, but not chromium. Flounder, but not lobsters, exposed simultaneously to WBMs sediments and food accumulated slightly more barium than those exposed to WBMs alone. Neither species accumulated chromium from the food source. It is hypothesized that some of the barium apparently bioaccumulated by the lobsters and flounder was present as unassimilated barite particles in the digestive system. Chromium, mostly from chrome lignosulfonate, was probably in the low solubility trivalent state and was not very bioavailable. These experiments show that there was very little food chain transfer and no biomagnification of barium and chromium from drilling muds in marine organisms.

The results of a joint URS, Dames and Moore, and TNO team (URS 2002) study found similar findings as those of Neff et al. (1989a, 1989b), Leuterman et al. (1997), and Schaanning et al. (2002) indicating that the metals associated with drilling mud ingredients and cuttings have a low bioavailability to marine animals. During the exposure, turbot were fed on the polychaetes in the mesocosm tanks (URS 2002). The biomagnification factor of the metals by turbot was estimated as the ratio of the concentration in the turbot tissues to the concentration in the food. Biomagnification factors ranged from <0.01 to 0.42, indicating that biomagnification was not taking place. These results confirm those of Neff et al. (1989a) that there is little trophic transfer and no biomagnification of metals from drilling mud and cuttings in benthic environments.

There have been several surveys of the concentrations of metals in tissues of marine animals from the vicinity of offshore platforms (Neff et al. 2000; Neff 1987c, 2002b). These surveys have shown that metals concentrations in tissues of marine organisms near platforms are similar to concentrations in tissues of the same or similar species from reference areas. Thus, the metals discharged from platforms in drilling muds and cuttings are diluted rapidly to natural background concentrations or are in forms that are not bioavailable to marine animals (Neff 2005).

Concentrations of barium and chromium were slightly elevated in sediments near exploratory drilling operations on Georges Bank after drilling (Neff et al. 1989b). However, metals concentrations in sea clams (*Arctica islandica)* collected from surface sediments near the drilling rigs were in the normal range for bivalve mollusks (Phillips et al. 1987). There was no correlation between concentrations of barium in sediments and bivalve tissues.

Thus, while the discharge of WBMs may increase metals in sediments such as barium, arsenic, cadmium, copper, mercury, lead and zinc, these increases are generally limited to within 250 to 500 m of the drill site. Occasionally increases may be observed farther depending upon mud volumes and environmental conditions. The metals most frequently present in drilling muds at concentrations substantially (>100-fold) greater than natural concentrations in soils and sediments are barium, chromium, lead, and zinc (Neff 2005). There have been few if any biological effects have been associated with these increases in metals due to drill rig discharges (CAPP 2001b; Neff 2005).

Hydrocarbons

There is limited information available regarding the bioavailability of organic compounds from WBMs. Payne et al. (1984) and Phillips et al. (1987) examined saturated and aromatic hydrocarbons by UV fluorescence and gas chromatography / flame ionization detection in sediments, sea clams (*Arctica islandica*) and flounder (*Paralichthys oblongus*) from the vicinity of exploratory wells on Georges Bank off the New England coast. One of the exploratory rigs had added diesel fuel to the WBMs to assist in freeing a stuck pipe. When the WBMs were discharged, they contained approximately 100 L of petroleum hydrocarbons. Concentrations of saturated and aromatic hydrocarbons were low in sediments, clams, and fish. Sediments near the rigs contained less than 1 µg/g total aromatic hydrocarbons (mainly PAH), consistent with background concentrations in this region (Boehm and Farrington 1984). There was no evidence that the two benthic/demersal marine animals bioaccumulated any hydrocarbons.

Sjøgren et al. (1989) measured concentrations of petroleum hydrocarbon in livers of Atlantic cod from the immediate vicinity of North Sea platforms discharging WBM cuttings or oil-based mud cuttings, and compared concentrations to those in cod collected more than 10,000 m from the nearest discharge. TPH concentration was similar in livers of fish from all three locations. However, PAH and decalins concentrations were higher in livers of fish from the vicinity of the WBM- and oil-based mud-discharging platforms. Livers of fish from the vicinity of the WBM-discharging platforms contained lower concentrations of PAH and decalins than livers of fish from the vicinity of the oil-based mud-discharging platforms. Alkylcyclohexane concentrations were similar in livers of fish from the WBM-discharging and reference platforms. These results indicate that PAH and decalins (two-ring saturated hydrocarbons), probably from petroleum, are bioavailable from WBM and oil-based mud cuttings accumulations. It is possible that some of the hydrocarbons (particularly decalins) could have been derived from produced water and other discharges from the platforms, as decalins are abundant in many North Sea produced waters (Durell et al. 2005).

Toxicity of Water-based Muds

Several marine toxicity tests have been performed with dispersions of barite particles in seawater. Particulate barite is nearly insoluble and is essentially inert toxicologically to marine organisms. Most bioassays with marine organisms have produced median lethal concentrations greater than 7,000 mg/L suspended barite (National Research Council 1983). Barium (as barite) is toxic to embryos of the crab (*Cancer anthonyi*) at concentrations greater than 1,000 mg/L (Macdonald et al. 1988). This concentration is 20,000 times higher than the aqueous solubility of barium in seawater, so any adverse effects probably are caused by physical effects of fine-grained barite particles.

In chronic studies with shrimp (*Palaemonetes pugio*) and substrates containing solid barite; barium, as barite, accumulated in the exoskeleton, hepatopancreas, and muscle tissue. The ingestion of barite caused damage to epithelial tissue of the gut. Barite mixed with sediments or as a layer on the sediment surface interfered with but did not prevent recruitment of several planktonic larvae of polychaetes and mussels to sediments (Tagatz and Tobia 1978). No adverse effects were observed in the polychaete worm (*Mediomastus ambiseta*) on fecal production, growth, and tube production of adults living in barite-covered sediments (Starczak et al. 1992). Tagatz and Tobia (1978) found that fewer individuals and species colonized sediments covered by a thin layer of barite as compared to control sediments.

Cranford et al. (1999) exposed juvenile sea scallops (*Placopecten magellanicus*) to barite suspensions of 0.5 and 2.5 mg/L (ppm) for 28 days. Survival at both doses was similar to that among controls. However, scallops exposed to the barite concentrations had lower gonad growth than control scallops did and, at the higher dose, digestive gland weight was significantly different from control.

Acute and chronic exposure of scallops to 100 mg/L water based drilling mud had no significant effect on survivorship or growth (Cranford et al. 1998). It is probable that concentrations of suspended barite, clay, or drilling mud particles increased in the exposure water during the chronic flow-through toxicity tests, so the scallops were actually exposed to higher than the nominal suspended solids concentration late in the test when most effects were observed. The effects of barite were similar to those of bentonite clay and probably were caused by physical damage to delicate gill epithelial membranes and interference of the suspended particles with feeding efficiency in this active filter-feeding mollusk. Research has demonstrated that suspended WBMs at concentrations less than 10 mg/L may affect sea scallop feeding, growth and reproduction (Cranford et al. 2005).

Clams (*Cerastoderma edule*) that were exposed to 1 to 3 mm of a barite mud mixture for 12 days experienced coagulated and shortened cilia. In some extreme cases the gill structure disintegrated, probably caused by clogging and abrasion by the fine barite particles. There was 100% mortality within 12 days (Barlow and Kingston 2001).

The mysid (*Mysidopsis bahia*) was identified as one of the most sensitive species to WBMs (Neff et al. 1980). Bioassays performed by the US EPA (1985a, 1985b) with the suspended particulate phase of eight generic WBMs and mysids (Table 7.3) resulted in 96-h LC50s ranging from 3,300 to >100,000 mg/L WBM (Duke et al. 1984).

Table 7.3 96-hour LC_{50} Mysid Toxicity Test Results

Drill Mud Type	Mysid 96-hour LC50 Result
KCl Polymer Mud	3,300
Seawater Lignosulfonate Mud	62,100
Lime Mud	20,300
Non-dispersed Mud	>100,000
Seawater Spud Mud	>100,000
Seawater / Freshwater Gel Mud	>100,000
Lightly Treated Lignosulfonate Mud	68,200
Freshwater Lignosulfonate Mud	30,000

Field Studies

In summary, most microcosm and field studies (Neff 2010) on the effects of WBM cuttings (from studies conducted in North Sea, Barents Sea, Off Sakhalin Island, Beaufort Sea) have shown that:

- no or minimal short term effects on zooplankton communities;
- effects on benthic macro- and mega-faunal communities are minimal and restricted to approximately 100 m;
- no evidence of ecological significant bioaccumulation of metals and petroleum hydrocarbons by marine organisms residing or deployed in cages near WBMs discharges;
- no evidence of toxicity effects associated with WBMs constituents;
- ecological effects are due to physical disturbances of water column and benthic environment;
- ecological effects associated with WBMs are similar to physical disturbances associated with natural process, as ice scour, river floods and storms; and
- benthic communities recover quicker with WBM releases than SBM releases.

Most laboratory and field studies to date have shown low acute and chronic toxicities to marine organisms. This is due primarily to the expected and observed rates of dilution and dispersal of drilling muds in the ocean after discharge. WBM effects are restricted primarily to the ocean floor in the immediate vicinity and for a short distance down current from the discharge. The bioaccumulation of metals from drilling fluids appears to be restricted to barium and chromium and is observed to be small in the field. This was demonstrated by Daan and Mulder (1993, 1996) who studied the effects of WBM discharges from a platform in the Dutch Sector of the North Sea where surveys were performed two months and one year after completion of drilling. These surveys revealed no measurable adverse effects on the benthic community, even at stations as close as 25 m from the discharge (the transect studies ranged from 25 to 5,000 m down-current from the WBM discharge). Only small amounts of mud and cuttings solids were detected in sediments near the platform, suggesting that the discharged solids were transported away from the site and diluted to non-detectable concentrations within two months after completion of drilling.

All studies discussed above as well as other studies (and references cited in summary reviews such as Neff 2005, 2010) have demonstrated that significant effects of drilling waste discharges on benthic ecosystems occur only when large amounts of solids accumulate on the bottom near the discharge site or the solids accumulations associated with the cuttings pile contain a high concentration of biodegradable organic matter. Effects of cuttings piles on bottom living biological communities are caused mainly by burial and hypoxia caused by organic enrichment. Toxic effects, when they occur, probably are caused by sulfide and ammonia by-products of organic enrichment. Ecological recovery of benthic communities from burial and organic enrichment occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. Recovery begins as soon as discharge of drilling wastes is completed and often is well advanced within a year. However, it may be delayed until concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment become anoxic (Hartely et al. 2003).

Water Column Modelling Results

When drill muds and cuttings are discharged to the ocean, the larger particles and flocculated solids and this represents approximately 90 percent of the mass of the mud solids, form a plume that settles quickly to the bottom. The remaining 10 percent of the mass of the mud solids consisting of fine-grained unflocculated clay-sized particles and a portion of the soluble components of the mud that forms another plume in the upper water column that drifts with prevailing currents away from the platform and is diluted rapidly in the receiving waters. In well-mixed ocean waters, drilling muds and cuttings are diluted by 100-fold within 10 m of the discharge and by 1,000-fold after a transport time of about 10 minutes at a distance of approximately 100 m from the platform. Because of the rapid dilution of the drilling mud and cuttings plume in the water column, harm to communities of water column plants and animals is unlikely and has never been demonstrated (Neff 2005).

In the high-settling velocity scenario model for the Old Harry exploration drilling program, the final WBM plume size is on the order of 2 to 3 km long and less than 1 km wide. As a result of the high settling value and low currents on the order of a few cm/s, all the material stays within the first metre of the water column (above seabed). Concentrations are in the range between 250 mg/l and 1 g/l. The highest concentrations are at the centre of the plume, two to three orders of magnitude higher than at the margins (see Figure 2.8). Overall, the averaged plume concentration time shows a stabilization of the concentration near approximately 250 mg/l after approximately 20 to 25 days of the 30 -day modelling exercise (AMEC 2010).

In the low settling velocity scenario, the final plume size is on the order of 40 km long and a few kilometres wide (see Figure 2.8). Due to this low settling value, the concentration profile extends higher in the water column and material is present within zones 5 and 10 m above the seabed. Overall, the plume is much more diluted than for the high settling rate scenario but concentrations exhibit large frequency variations of about one order of magnitude. Initially, concentrations vary between 1 and 10 mg/l, with an average value of approximately 3 mg/l. After approximately 15 days, plume concentration stabilizes around an average of 1 mg/l, with variations between about 0.3 and 2 mg/l. Concentrations within the 5 m zone are only approximately 20 to 50 percent higher than at 1 0m. Concentrations at 5 and 10 m are approximately one order of magnitude lower than at 1 m and stabilize after 15 days at approximately 0.1 mg/l (AMEC 2010).

The sediment concentrations at the plume centres at the end of each phase indicate that minimum dilution factors between 20 and 30 were achieved within half an hour from release time, and minimum dilution factors between 60 and 80 were achieved within one hour from release time for all scenarios. The reduced concentration of both the barite and clay results in further reduced settling velocities. Therefore, they are expected to reach the bottom boundary layer within a period on the order of days (AMEC 2010).

The sediment concentration in the plumes varied with the plume dimensions and distance from the source, with levels generally falling as the plume dispersed and was advected horizontally.

The concentrations, averaged over a zone 1 m above the bottom, ranged from a maximum of approximately 1 g/L for the high settling rate scenario a few kilometres away from the site, down to approximately 1 mg/L for the low settling rate scenario a few tens of kilometres away from the drilling site. It was noted as well that the concentration varies greatly (one order of magnitude or more) within the plumes due to suspension / deposition patterns induced by variations of current strength over the tidal cycle (AMEC 2010).

Although the total volumes of WBM and cuttings discharged to the ocean during drilling maybe large (substantially smaller amounts are discharged during exploration drilling), the effects in the water column environment are minimal, because discharges of small amounts of materials are intermittent and take place only during drilling operations spaced over a few to several months. Several field studies have shown that drilling muds discharged to the ocean are diluted rapidly to very low concentrations, usually within 1,000 to 2,000 m down-current from the discharge and in less than an hour after the discharge (Neff 2005). Water column communities apparently are not harmed by drilling mud and cuttings discharges, because discharges are intermittent and of short duration during drilling and dispersion and dilution is rapid of dissolved and particulate components of the discharge. Aldredge et al. (1986) could not detect statistically significant biological effects of WBM and WBM chemicals on phytoplankton communities from the Santa Barbara Channel, California.

The depth of the euphotic zone is variable, depending on ambient conditions and the amount of particles suspended in the seawater; its lower limit corresponds to the depth where 1 percent of the surface light remains. In the Gulf, the euphotic zone usually includes the top 20 to 30 m of water (SLGO 2011). The remaining drilling particles (bartonite and barium) in plume (AMEC 2010) will be trapped at depths of approximately 460 to 469 m (based on 470-m drilling depth) below the surface and as such will not affect primary production.

Suspended particles can interfere with feeding behavior of plankton and other suspended particle feeders. The food uptake of *Temora longicornis* and *Acartia clausi* was found to be reduced by approximately 15 to 25 percent in response to the addition of 10 mg clay to the natural phytoplankton community (Dutz 2002, in Smit et al. 2006). The clay interfered with copepod feeding via the formation of aggregates, which fit into the food size spectra of marine copepods. As a consequence, the daily carbon ration of various zooplankton species was reduced. This reduction was accompanied by a pronounced effect on the feeding selectivity of both species, which indicate that the flow of organic matter changes in the presence of clay (Dutz 2002, in Smit et al. 2006). Paffenhöfer (1972) found a 5 to 8 times higher mortality of sub-adult stages of *Calanus helgolandicus*, and reduced growth and changed swimming behaviour, due to exposure to 0.6 to 6 mg/l red mud, which consists of very small anorganic particles.

The filtration activity of the estuarine copepod *Eurytemora affinis* is affected by suspended particulate matter concentrations of approximately 250 mg/l, whereas the filtration activity of *Acartia tonsa* is already reduced at a concentration of 100 mg/l (Sherk et al. 1975).

Overall, there are very few studies on the effects of drill muds and cuttings on water column organisms because of the rapid dilution of the drilling mud and cuttings plume in the water column and because little or no effects have been observed to date. There is much more studies on the effect of drill muds and cuttings on the benthic environment, in part as approximately 90 percent of the releases reach the benthic environment within several hundreds of metres of discharge. The modelling of cuttings released by Old Harry found that the heavier particles will settle out within 30 to 500 m (AMEC 2010), depending upon scenario modelled.

7.1.2.2 Synthetic-based Muds

SBMs include those whose base fluids are composed of synthetic hydrocarbons (olefins, paraffins, and esters) (OGP 2003). SBMs also often contain barite, clays, emulsifiers, water, calcium chloride, lignite, and lime. Water or a saline brine (usually containing calcium chloride: $CaCl_2$), at a concentration of 10 to 50 volume percent, is dispersed into the hydrocarbon phase to form a water-in-organic phase emulsion with water droplets less than 1 µm in diameter (Hudgins 1991; Norwegian Oil Industry Association Working Group 1996). This emulsion is stable because of the small size of the water droplets and because emulsifiers often are used to stabilize it. It is called an invert emulsion because water is dispersed in the organic phase and formation solids that come in contact with the drilling mud become oil-wet (Neff 2005).

Their persistence is related to the physical conditions on and near the sea floor (e.g., re-suspension and transport, current velocity, sediment characteristics), re-working of sediments by burrowing biota and biodegradation of the base fluids. SBM cuttings are treated as per the OWTG requirements prior to discharge and are subject to C-NLOPB approval. The disposal of whole SBM is prohibited and therefore only cuttings retaining residual SBM after treatment is assessed. SBMs enter the aquatic environment as a coating on rock cuttings, discharged from the drilling platforms, and accidental spills.

When SBMs are discharged to the ocean, they tend to clump together in large particles that settle rapidly to the sea floor (Brandsma 1996; Delvigne 1996) especially if the cuttings are shunted to near bottom from fixed drilling platforms (Cordah 1998). The effect of shunting is to decrease the area of the sea floor over which cuttings accumulate and to increase the mass of cuttings deposited per unit area near the well site.

Ester based SBMs are more easily dispersed than olefinic SBMs. Water cannot easily penetrate the oleophyllic mass of cuttings, so they do not disperse efficiently (Neff et al. 2000). Therefore, most SBMs settle rapidly and accumulate at the bottom near the drilling platform discharge sites. Therefore SBM cuttings stay closer to the well site and do not disperse as widely as WBMs and cuttings. Studies from the North Sea, Gulf of Mexico, Australia and Ireland have shown that SBMs cuttings accumulate in a very irregular pattern in sediments around a drilling rig (Neff et al. 2000). Thus, no additional mortality (smothering) of sessile benthic invertebrates is expected to occur as a result of SBM discharge as the area will have been subjected to smothering from WBM deposition.

The pattern of cuttings deposition will be determined by the following conditions at each site:

- quantities and rate of cuttings discharged;
- cuttings discharge configuration (i.e., depth of discharge pipe);
- oceanographic conditions (e.g., current velocities, water column density gradient);
- total amount and concentration of SBMs on cuttings;

- water depth; and
- fall velocity distribution of the cuttings particles and aggregates.

Since the particles are wet with the SBM, the cuttings tend to aggregate once they are discharged. The aggregates fall at a greater fall velocity than the particles in the more easily dispersed WBM cuttings. Less dispersion and greater fall velocity of the SBM cuttings generally results in smaller area but thicker deposition on the seabed compared to WBM cuttings discharged under the same conditions (OPG 2003).

Bioavailability

Bioavailability of nonpolar (un-ionizable) organic chemicals, such as SBM base chemicals, to marine organisms depends on the physical and chemical forms of the compounds (Neff et al. 2000). Nonpolar organic chemicals, such as SBM base chemicals, usually have a low aqueous solubility and a high solubility in the lipids of plants and animals. They are classed as hydrophobic or lipophilic compounds. The rate and extent of bioaccumulation of hydrophobic compounds by marine organisms depends on the relative affinities of the chemical for the ambient water phase and the tissue lipid phase.

Hydrophobic chemicals with a log Kow less than approximately 3 to 3.5 may bioaccumulate rapidly but not to high concentrations in tissues of marine organisms, particularly if they are readily biodegradable (ECETOC 1996). Hydrophobic chemicals with a log Kow greater than about 6.5 to 7 do not bioaccumulate effectively from the water, because their solubility in both the water and lipid phases is very low (Chessels et al. 1993).

Log Kow values for several SBM base chemicals have been measured or estimated in order to predict their bioavailability to marine organisms. Esters are moderately soluble and have a low log Kow. They probably are bioavailable; however, they are readily biodegradable and probably do not bioaccumulate to biologically significant concentrations in tissues of marine animals. The liver and gut enzymes involved in fat metabolism in marine animals can hydrolyze ester bonds and convert the resulting alcohols and fatty acids to low molecular weight organic nutrients. Food chain transfer is significant only for hydrophobic chemicals with log Kows greater than approximately 5 (Thomann 1989). Therefore, esters are not readily bioaccumulated from food and will not biomagnify in marine food chains.

Olefins and paraffins of the sizes found in SBM base chemicals are relatively large linear chains that do not permeate membranes efficiently. They have high log Kows, mostly higher than 9, indicating extremely low aqueous solubility and low potential to bioaccumulate. There is an inverse relationship between log Kow and aqueous solubility. The types of SBMs used for offshore oil and gas exploration in Atlantic Canada have been paraffin-based and as such have a low potential to bioaccumulate.

Schaanning et al. (1996) added marine polychaete worms Hedeste (Neries) diversicolor to NIVA simulated seabed sediment chambers containing sediments contaminated with two esters, one internal olefin, one linear alpha olefin, or a mineral oil base chemical. The results of these studies concluded that SBM base chemicals have a very low bioavailability to marine organisms. There is little or no risk that these chemicals will bioaccumulate to potentially harmful concentrations in tissues of benthic animals or be transferred through marine food chains to important fishery species (Neff et al. 2000).

A potential concern associated with the deposition of treated SBMs is the potential of increased risk of marine habitat contamination due to increases in metals concentrations of barium, arsenic, cadmium, copper, mercury, lead and zinc and hydrocarbon concentrations in sediments. SBMs are essentially non-toxic, have the potential to biodegrade relatively rapidly, require less mud (compared to WBM) for the same distance drilled and tend to disperse less than WBMs (LGL 2005b). The specific rates of biodegradation of SBMs are mostly unknown under all environmental conditions but are known to be related to the type of base fluid, temperature, oxygen levels, the type of bacteria present (aerobic or anaerobic), the species of bacteria present, and the form, mass and topography of the material (OGP 2003; Roberts and Nguyen 2006). In general, biodegradation is expected to occur faster under aerobic conditions than anaerobic conditions (OGP 2003).

Toxicity

SBMs are more biodegradable, and because of their high cost, SBMs are usually recycled rather than disposed of in the environment or reinjected. However, some SBMs reach the ocean in association with drill cuttings discharges. Cleaned SBMs cuttings usually contain approximately 10 percent synthetic chemical (Annis 1997; Neff et al. 2000). Synthetic-based fluids (SBFs) typically have a total PAH concentration of less than 10 mg/kg (<0.001 percent) and are non-acutely toxic in most or all marine toxicity tests. The drilling mud (Paradril-IA35) that has been used for most drilling operations on the Grand Banks is a SBM with PureDrill IA-35 as the base fluid, together with weighting agents, wetting agents, emulsifiers and other additives. PureDrill IA-35 synthetic drilling fluid is classified as a high purity synthetic alkane consisting of isoalkanes and cycloalkanes (Petro-Canada Technical Bulletin). PureDrill IA-35 is a clean, colourless, odourless fluid that is safe to handle. It has an aromatic content of <0.01 percent and a PAH content of <0.001 ppm. It is non-toxic to human, plant and marine life.

PureDrill IA-35 has undergone an evaluation using the Offshore Chemical Management System. The fluid was screened from a facility, human health and environmental perspective. PureDrill IA-35 base fluid is a component of a whole mud system called ParaDrill that received a Group E classification by the Offshore Chemical Notification System classification system employed in the United Kingdom. The Group E classification is the best rating achievable under the Offshore Chemical Notification System and is assigned to chemicals that have relatively low toxicity and/or does not bioaccumulate or readily biodegrades.

The toxicity data for PureDrill IA-35 (Petro-Canada Technical Bulletin; Harris 1998) are:

- mysid shrimp 96-hour LC_{50} of >500,000 ppm;
- rainbow trout 96-hour LC_{50} of >400,000 ppm;
- amphipod *(Corophium volutator*) 10-day LC_{50} of 2,633 mg/L;
- Macoma 20-day LC_{50} of >50,000 mg/L;
- echinoid fertilization (*Lytechinius pictus*) IC_{50} (20 minutes) of >100 percent; and
- bacterial bioluminescence (Microtox test using *Vibrio fischeri*) EC_{50} of >100 percent.

Toxicity studies conducted by the DFO using American plaice, winter flounder (*Pleuronectes americanus*) and the amphipod (*Rhepoxynius abronius*) on Hibernia drill cuttings and solids (Payne et al. 2001a, 2001b) found:

- no acute toxicity in juvenile American plaice exposed for 30 days to Hibernia cuttings approximating hydrocarbon concentrations found 200 to 500 m from platforms in the North Sea;
- no acute toxicity in adult winter flounder exposed to Hibernia cuttings for 90 days; and
- in a dose response study using amphipods, a toxic response at 5,000 ppm hydrocarbon concentration only. The cuttings demonstrated a low acutely toxicity potential and extrapolations have been carried out to determine possible size of toxic zones that would occur in the field. The extrapolations indicate little or no risk of toxicity as close as 1,000 m or less from the platform.

Several SBM base chemicals have been tested using the mysid water column test (Table 7.4). In most cases, the toxicity of SBM base chemicals decreases (LC50 increases) as molecular weight of the chemical increases. This undoubtedly is because as molecular weight increases, the aqueous solubility and bioavailability of most organic chemicals decreases. Most of the SBM base fluids or precursors pass the toxicity criterion of 30,000 mg/L (as noted in Table 7.4). SBMs and SBM constituents exhibit a low overall acute toxicity in water column and solid phase tests with a variety of marine plants and animals. LC_{50}s nearly always are higher (less toxic) than acceptability criteria (Neff et al. 2000).

Table 7.4 Acute Toxicity of Synthetic-based Mud Base Chemicals to Mysids

SBM Base Chemical	Chemical	96-hour LC_{50} (mg/L)
Poly-α-Olefin	Polypropene (MW 170)	10,800
	Polypropene (MW 198)	30,000
	Decene Dimer (MW 290)	574,330
	Polypropene (MW 310)	914,650
	Polybutene (MW 320)	> 1,000,000
	Polypropene (MW 400)	> 1,000,000
Internal Olefin	C_{14}-C_{16} IO	< 30,000
	C_{15}-C_{18} IO	119,658
	C_{16}-C_{18} IO	321,000
Ether	Dibuthyl Ether	> 10,000
	Dihexyl Ether	61,659
	Dioctyl Ether	156,800
Esther	Methyl Laurate	< 10,000
	Isopropyl Palmitate	271,701
	Isopropyl Oleate	52,319
	C_{10}-C_{14} Alcohols	< 10,000
	C_{16} Alcohols	30,158

While pelagic and benthic organisms may be affected by WBM discharges, benthic organisms are the most likely to be affected by SBM cuttings discharges. The effects of SBM cuttings on pelagic organisms are expected to be even less than those of WBMs because of the low toxicity of SBMs and the reduced exposure time due to rapid settling of SBM cuttings clumps and particles out of the water column. Field studies seem to indicate that much of the effects of high concentrations of SBM cuttings in sediments is caused by nutrient enrichment and resulting oxygen depletion in the contaminated sediments rather than by direct toxicity of the SBM base chemicals themselves (Neff et al. 2000).

Biological effects of SBM cuttings on the benthos are expected to be similar to or greater than those of WBMs. The mass of SBM discharged to the ocean per well is much less than the mass of WBM discharged per well, because the drilling fluid itself is not discharged and cuttings are cleaned before discharge (Veil and Daly 1999). SBM cuttings may impact benthic communities by production of anoxia in sediments through microbial biodegradation if SBM cuttings concentrations in sediments are high enough (Olsgård and Gray 1995). WBM cuttings do not usually cause sediment anoxia because they contain only low concentrations of biodegradable organic chemicals. However, they impact benthic communities by burial and smothering, or they may alter sediment texture, rendering the local benthic environment less suitable for some species of benthic fauna and better for others (Neff 1987). Thus, biological effects of SBM cuttings discharges are likely to be greater than effects of WBM cuttings discharges in the immediate vicinity (within 50 to 100 m) of platforms where SBM cuttings are likely to accumulate to high concentrations (Neff et al. 2000).

Field Studies

In 1994, 19 monitoring surveys were performed near platforms discharging SBM to offshore waters of the Norwegian Sector of the North Sea (Bakke et al. 1996). Eight of these surveys included observations of benthic communities near platforms. Low concentrations of SBM base chemical could be detected in sediments out to 2 km of the well site (Frøy platform). The benthic fauna appeared normal, and there was no evidence of disturbance from the drilling and discharge activities. Ester was detected in sediments from the four stations closest to the discharge (Yme Gamma Platform) and in two stations down-current to a distance of 500 m from the platform. Concentrations were low. Elevated concentrations of barium, but not other metals, were detected at most stations. The benthic fauna was highly diverse throughout the field; there were minor effects of the discharges to a distance of 500 m from the platform.

Elevated concentrations of SBM base chemical were detected in sediments up to 2 km down current from the Bragge platform (Bakke et al. 1996). Barium concentrations had increased gradually in the sediments of the area since 1992. The benthic community near the platform had a reduced diversity. Effects of the drilling fluid accumulations on the benthos were detected to 1 km down current of the discharge and to a maximum of 250 m in other directions.

Elevated barium concentrations were distributed uniformly in sediments around the Tordis platform (Bakke et al. 1996). Concentrations of SBF base chemical in sediments were low, but could be detected to 2 km from the platform. There was a gradient of benthic community structure in sediments across the field that was not there at the time of the baseline survey. Benthic faunal disturbance was detected at three stations out to 500 m from the platform.

The physical and biological effects of SBM cuttings discharges were studied at a drilling site in 39 m of water in the northwestern Gulf of Mexico (Candler et al. 1995). WBM was used to drill the first 1,036 m ft of the well. A PAO SBM was used to drill from 1,036 to 2,453 m. Three field surveys, nine days, eight months and 24 months after completion of mud and cuttings discharges were performed at the site. Samples for benthic community analysis were collected only on the 24-month survey. During all three surveys, sediment samples were collected at 25, 50, 100, 200, and 2,000 m along transects in the four compass directions from the well site. A total of 106 taxa of benthic invertebrates were identified in sediments near the drill site two years after completion of drilling. The benthic community was typical of those in shallow waters of the western Gulf of Mexico. The benthic community apparently was unaffected by the drilling discharges (two years after drilling) at all stations east and north of the well site and at stations more than 50 m south and west of the well site.

Impacts of SBM cuttings discharges on deep-water benthic ecosystems are largely unknown (Neff 2000). The only study that included some observations of bottom fauna near a deep-water discharge site was at the Pompano II platform in 565 m of water (Fechhelm et al. 1999). Sediments for benthic faunal analysis were collected with a remotely operated vehicle from stations 25, 50, and 75 m northeast and 25, 50, 75, and 90 m southwest of the template. A total of 2,100 macrofaunal animals were collected; polychaetes were most abundant, followed by gastropod mollusks. The abundance of benthic fauna was significantly higher in sediments along the northeastern transect (highest SBM concentrations in sediment) than in sediments along the southwestern transect. Demersal megafauna (mostly fish) were counted from videotapes taken along each transect. Numbers and densities of demersal fish observed along the four transects were similar. The densities were higher than observed at other locations at similar depths in the northern Gulf of Mexico. The fish may have been attracted to the Pompano drilling template or disturbed sediments nearby. Neither benthic fauna nor demersal fish abundance seems to have been adversely affected by the discharge of SBM cuttings (Neff 2000).

Results similar to those reported in other regions have been reported for the Fortescue Field, located in 70 m of water in the Bass Straight off southeast Australia (Terrens et.al. 1998). While most the drilling was conducted with WBM, the long-reach, high-angle sections of seven wells required the use of SBMs. The fate of these discharges was monitored during five seabed surveys undertaken between August 1995 (pre-SBM cuttings discharges) and August 1997 (11 months after completion of SBM cuttings discharges). Effects of the drilling fluids and cuttings discharges on benthic faunal communities was limited to within 100 m of the platform with recovery evident within four months after completion of drilling. During the time of SBM cuttings discharges, numbers of nematodes and crustaceans decreased and numbers of polychaetes increased in sediments 100 m southwest of the platform. Total abundance of benthic fauna remained nearly constant and benthic faunal diversity declined. These effects are typical of an organic enrichment effect (Pearson and Rosenberg 1978). Within four months after completion of drilling, benthic biological parameters had returned to pre-drilling conditions. Recovery was attributed to a combination of ester biodegradation and the active physical seabed dispersion processes in the eastern Bass Straight.

Field studies (OGP 2003) have shown that for SBM cuttings discharges, the areas that recovered most rapidly were those characterized by higher energy seabed conditions. Because of the tendency for adhesion between SBM cuttings, re-suspension of SBM cuttings requires higher current velocities than those required for WBM cuttings. Laboratory tests found that the critical current velocity required for erosion of SBM cuttings was 36 m/s for cuttings with 5 percent oil content (OGP 2003). SBMs would be expected to be less persistent in areas with thinner deposits as this leads to quicker recovery than areas with deep piles. Therefore, it is important to consider factors that govern the initial deposition thickness and the potential for erosion in assessing recovery potential. Initial deposition thickness will depend on the current profile and water depth. Stronger currents lead to wider dispersion before deposition, and greater water depth generally will lead to thinner initial deposits (OGP 2003).

The water column effects (OPG 2003) from discharging SBMs are considered to be limited due to the following:

- low solubility of base fluid of the SBM in seawater;
- low water column dispersion and residence time due to rapid settling rate; and
- drilling discharges are intermittent and transient.

Hurley and Ellis (2004) reviewed 19 studies to assess environmental effects associated with SBM and found that the area of detection and scale of biological effects were more localized than for WBM. Biological impacts were generally detected at distances of 50 to 500 m from well sites with recovery of benthic communities occurring within one year of well completion. While the biological effects of SBM are localized, there is uncertainty regarding degradation processes of SBM (it can produce anoxic conditions in the sediment). Elevated levels of metals have been found to occur within 250 to 500 m of the drill site, but sometimes occur further, depending on environmental conditions and the number of wells drilled (Hurley and Ellis 2004). Signals of drill muds (i.e., barite) have been detected 5,000 m from Terra Nova (18 production wells) and 8,000 m from Hibernia (32 production wells) (Hurley and Ellis 2004), but not at levels likely to have any biological effect.

Marine birds exposed to metals from drill muds could potentially experience harmful effects. However, a study by Gallagher et al. (1999) found that very high concentrations of heavy metals were required to produce a physiological response in Mallard ducklings (*Anus platyrhynchos*). The concentrations required to produce such a physiological effect were higher than would be expected at an offshore site (Husky 2000).

7.1.3 Routine Discharges

The OWTG (NEB et al. 2010) encourage the reduction of generated waste and substances of potential environmental concern. All solid waste as well as excess chemicals or chemicals in damaged containers will be brought ashore. The transportation of dangerous goods and WHMIS Regulations govern the handling, use, storage, transport and disposal of hazardous materials. All routine discharges associated with the exploration drill program will be discharged in accordance with the OWTG (NEB et al. 2010). Discharges limits are based on best available technologies and are the focus of continuous improvement programs. Where practicable, use of technology to reduce discharge limits below those in the OWTG (NEB et al. 2010) will be implemented.

Mobil (1985) estimated that grey water discharge (e.g. showers, dishwashing, deck drains) associated with an offshore drilling rig accommodating approximately 100 persons would be 40 m^3/day, while black water discharge (sanitary waste) would be 19 m^3/day. This represents a fair estimate of potential discharge for the Project, since the number of persons on the drilling rig is likely to be between 85 and 120. Sanitary waste will be treated and discharged as per the OWTG (NEB et al. 2010). Waste water discharge is treated and tested for compliance with the OWTG (NEB et al. 2010). Organic matter associated with discharges will disperse quickly in an open ocean environment and be quickly degraded by bacteria. The effects of this relatively small amount of organic matter and nutrients on the offshore marine environment will be negligible and not significant.

Other discharges such as BOP fluid will be a glycol-water mixture with low toxicity and other fluids containing oils, such as deck drainage and bilge water, will be treated, recycled, or discharged below the water surface. All treated fluids will comply with the OWTG (NEB et al. 2010). Drilling will require seawater, most of which will be used as cooling water (non-chlorinated). The volume of entrainment will be low and the area of thermal effects small. Therefore, the effects of discharges of these fluids on marine birds (including Species at Rick) will be negligible. Other materials, such as drilling fluids, deck drainage and bilge waters, may negatively affect marine bird health due to the presence of residual hydrocarbons. Any discharged oily water will comply with the OWTG (NEB et al. 2010), as will any other regulated liquid or solid discharged from the drilling platform. The attraction of gulls to platforms as a result of discharges of sanitary and domestic waste may increase the potential for predation of smaller marine birds such as Leach's Storm-Petrels.

Domestic garbage will be transported to shore and will not interact with marine birds. However, sanitary and food waste will be macerated to a particle size of 6 mm or less and discharged at a depth of approximately 15 m. Gulls may be attracted to the discharge area; however, the small amount discharged below the surface is not likely to result in an increase in gull populations in the area. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria. Any biocides used will be screened in accordance with an approved and established chemical management system.

7.1.4 Supply Vessels

Supply vessels will be involved in support of exploration, serving a variety of roles, ranging from personnel transport to re-provisioning to inspection, cargo and maintenance work. In addition to marine vessel traffic, helicopters will fill a vital role especially in the transport of personnel to and from ships and platforms.

This section focuses on effects other than noise, which is discussed in detail in Section 7.1.5.1. Support vessels may affect marine birds through discharges, lighting, the physical presence of the structure and noise. Marine birds are habituated to vessel activity and some species such as gulls and Northern Fulmar are actually attracted to ships and often stay with them for extended periods (Wahl and Heinemann 1979; Brown 1986; Montevecchi et al. 1999). Direct effects to marine birds are not anticipated because these species are highly mobile and can avoid vessels by flying or diving. Energy expended during these events would be minimal and have no physiological effect on the birds.

Research has shown that seabirds react most strongly to low-level flights and the effects of these responses tend to be short-lived. Helicopter overflights at 300 m failed to cause a visible reaction among moulting sea ducks in the North Sea while overflights at 100 m resulted in short-term avoidance reactions (Ward and Sharp 1974). As with their response to vessel traffic, seabirds may habituate to air traffic over time. The greatest sensitivity to aircraft traffic would be at large nesting colonies. An aircraft flying near a seabird colony could cause panic in birds, resulting in eggs and flightless young being accidentally pushed off cliff ledges, being exposed to harsh weather conditions or predation when adults flush.

Toothed whales and pinnipeds are rarely struck by vessels (Laist et al. 2001; Jensen and Silber 2003). These marine mammals are fast swimming and agile, enabling them to avoid approaching vessels. In contrast, the most commonly struck of all marine mammals are the baleen whales (Laist et al. 2001; Jensen and Silber 2003). It is thought that these large, slow-moving animals are often unable to react fast enough to avoid approaching vessels (Laist et al. 2001; Jensen and Silber 2003). High speed container ships are considered to be potentially one of the greatest threats to blue whales. However, evidence suggests that serious (or lethal) vessel strikes to whales are infrequent at vessel speeds less than 25.9 km/hr (14 knots) and are rare at vessel speeds less than 18.5 km/hr (10 knots) (Laist et al. 2001). Supply vessel strikes with marine mammals are therefore considered unlikely given the predictable direction and slow speed of advance 7.4 to 9.3 km/hr (4 to 5 knots) of the vessels. However, as a precautionary mitigation measure, all Project-related vessels will be restricted to a maximum speed of 18.5 km/hr (10 knots) within the Project Area (i.e., not in transit to / from the Project Area).

With respect to sea turtles, a study of green sea turtles by Hazel et al. (2007) suggested that 60 percent of observed turtles (n = 1,819) actively avoided vessels travelling at 3.7 km/hr (2 knots), but only 22 percent avoided vessels travelling at speeds of 11.1 km/hr (6 knots). Such a study has not been done for leatherback turtles; however, this species is recognized as being the fastest reptile 35.2 km/hr (19 knots) when frightened(McFarlan 1992) and might be expected to be better able to avoid a strike.

Underwater sound has the potential to affect species at risk in a variety of ways depending on source levels, duration of exposure, proximity of sound source, animal sensitivities, environmental conditions, and other factors. Marine mammals and in particular marine mammal species at risk are generally believed to be the group most sensitive to underwater sound. The main sources of sound for the proposed Project include helicopters, supply / support vessels, drill rig machinery and thrusters, echo sounders, VSP seismic array, and wellhead removal explosives (if used).

7.1.5 Underwater Sound Sources Associated with Exploratory Drilling

7.1.5.1 Sounds Associated with Vertical Seismic Profiles

The most intense sound source associated with this Project would occur should a VSP survey be undertaken as part of the drilling of the exploratory well. The VSP uses an airgun array to assist in further defining a petroleum resource or locating well boreholes / tracks. Petroleum industry VSP arrays are similar to those employed during 2-D and 3-D seismic surveys but are typically smaller and have lower source sound pressure levels. VSPs are usually conducted in a small area relative to a full 2-D or 3-D seismic survey, and are conducted over shorter periods (i.e., several days). A typical well site survey (VSP survey) could have a peak pressure output of 230 dB re 1 µPa @ 1 m (Davis et al. 1998), with a single streamer array. The energy levels emitted from the VSP will be considerably less in source (760 in^3) and slightly less in output (242 dB re 1 µPa @ 1 m) than typical for 2D or 3D seismic programs (3,000 to 5,000 in^3 airguns and approximately 255 dB re 1 µPa @t 1 m).

A semi-submersible drill rig (one potential drill platform that may be used for drilling the exploration well at old Harry) produces a broad band sound level at approximately 154 dB re 1 µPa (Richardson et al. 1995). Sound from a drillship is emitted at a range between 174 and 185 dB re 1 µPa (Richardson et al. 1995). Dynamically positioned drill ships are typically noisier than semi-submersibles (Richardson et al. 1995). Under typical ambient noise conditions, low frequency noise from a drilling platform might be detectable no more than 2 km away near a shelf break (Richardson and Malme 1993).

Some sound levels reported for ambient and offshore drilling related activities are provided in Table 7.5.

Table 7.5 Natural and Development-related Underwater Sound Levels

Source	Noise Level (dB re 1µPa)	Noise Frequency (Hz)	Notes
Ambient Noise			
Calm Seas	60	-	
Modern Waves/surf	102	100 to 700	
Fin whales	160 to 186	20	Fin whales produce series of one to five second noise pulses across 3 to 4 Hz around the 20 Hz level.
Drilling-related Noise			
Drilling rigs on two icebound gravel islands	125	<200	Recorded under sea ice; Broadband noise decayed to ambient levels within 1.5 km.
Jack-up Drilling Rigs	119 to 127	5	
Moored Semi-submersibles	154	-	Overall broadband sound level did not exceed ambient beyond about 1 km; received levels at 100 m would be approximately 114 dB re 1 µPA.
Moored Drillships	174-185	45 to 7,070	Noise is predicted to attenuate to 115 to 120 dB at distances of 1 to 10 km.
Supply boats	170-180	100	

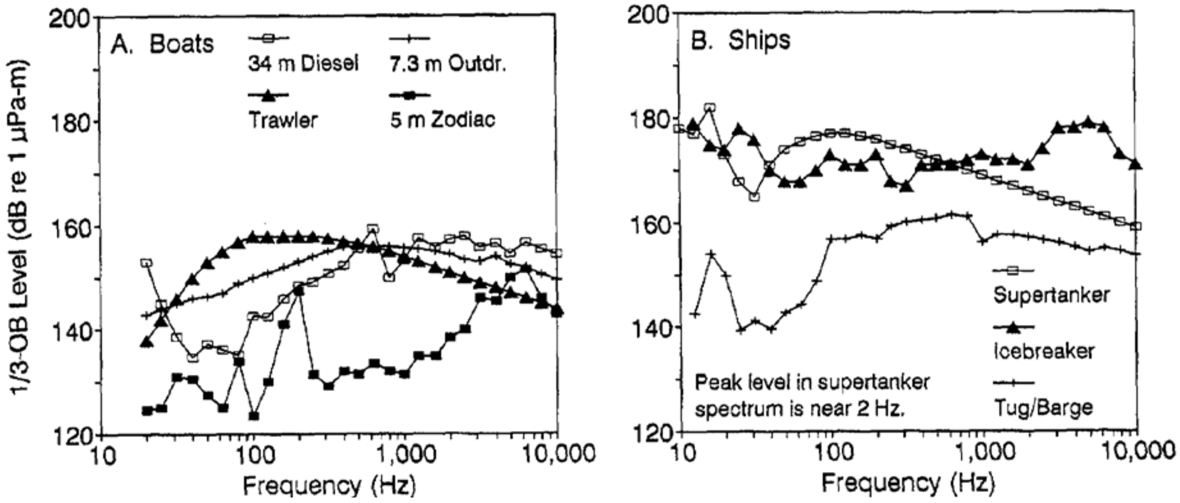
Source	Noise Level (dB re 1µPa)	Noise Frequency (Hz)	Notes
Other Industrial Noise			
Fishing trawlers	158	At 100	
Commercial freighter	172	-	
Supertanker *Chevron London*	190	dominant tone of 6.8 Hz	
Helicopter (Sikorsky @ 305 m above water)	105	-	
Pile-driving (1 km distance)	131 to 135	-	
Source: Richardson et al. 1997, in Hurley and Ellis 2004; Lawson et al. 2000 in Hurley and Ellis 2004; Thompson et al. 2000, in Hurley and Ellis 2004.			

7.1.5.2 Sound Associated with Support Vessels

Support vessels can be characterized essentially as continuous noise sources with helicopter overflight considered a transient noise source due to the limited angle of propagation of the airborne sound into the water column. The vessels involved in offshore oil and gas operations span a wide range of sizes, power ratings and applications and, consequently, generate widely different levels of underwater sound. Vessel and helicopter noise are a combination of tonal and broadband sounds, which in the case of vessels, is dependent on their size, design and speed (Richardson et al. 1995).

Boat and ship noise is attributable mainly to propeller cavitation, propeller singing, propulsion engines (noise transmitted through the vessel's hull) or other machinery. Noise from any of these sources can be exacerbated given any damage or improper operation. Cavitation is usually the dominant noise source according to Ross (1976, in Richardson et al. 1995). The frequency spectrum of cavitation noise has been observed to be a broadband noise consisting of sharp pulses that correspond with the propeller rotation frequency times the number of blades (Erbe and Farmer 2000). Noise from older, medium to high-speed diesel engines built with simple connecting rods is strong enough to potentially overshadow cavitation (Ross 1976). Modern diesels built with articulated connecting rods (mostly found in tankers, freighters and container ships) are slow speed (<250 rpm) and relatively quiet, with cavitation being the dominant noise source (Richardson et al. 1995).

Generally, the larger the vessel, the greater the level and lower the frequency of sound emitted. A comparison of 1/3 octave bands associated with both small and medium to large vessels is provided in Figure 7.5. In an operation involving diverse vessel sizes, noise will be mainly due to medium and large vessels. When operating at relatively close range, small vessels with outboard engines, such as zodiacs, may also contribute considerable underwater noise levels (Erbe 2002).



Note:The icebreaker noise is from the Robert Lemeur (studied by Greene 1987) pushing on ice at full power (7.2 MW) and zero speed. This is estimated to be louder than that generated by an ocean-going tug pulling a load at low speed.
Source: Richardson et al. 1995.

Figure 7.5 Estimated One-third Octave Sound Levels of Underwater Noise at 1 m for A) Boats; and B) Ships

7.1.5.3 Biological Effects

If one examines sounds based on a hierarchal effect, then the most intense sounds associated with the proposed undertaking would most likely be associated with the seismic sources used in the VSP survey, followed by the drill platform and related operations, support vessels and helicopters. Much of the information presented on sound in subsequent sections will be related to seismic sources, as seismic sound sources using a risk management process has the potential to produce the more pronounced responses as it will be the most probable source of the most intense sounds undertaken as part of the exploration drilling activities (VSP surveys). A VSP survey may be undertaken as part of the exploration drilling program. This type of seismic survey produces a lower intensity sound than that associated with the 2D or 3D seismic surveys.

Fish

Little is actually known about the effects of these sounds on fish as a result of a paucity of experimental data. A concern is that anthropogenic sounds affect communication and detection of the acoustic scene. There is a broad range of other potential effects of anthropogenic sounds (Popper and Hastings 2009). The contrast between the two sound types is often that the exposure to intense sound sources is relatively brief because the sounds are in a localized area and the sources are often moving (i.e., sonars and seismic equipment) and go by the fish or they are stationary (i.e., pile driving) and the fish swim by the structure. In contrast, the long-lasting sounds, such as might be found in a harbour with heavy shipping, are pervasive throughout a large region and cannot easily be avoided.

There are over 50 families of fish with sound-producing species (Myrberg 1980). Fish sounds are normally generated in the range of 50 to 3,000 Hz. Fish use sound for communication, navigation and sensing of prey and predators. Sound transmission is thought to play an important role in cod and haddock mating. (Engen and Folstad 1999; Hawkins and Amorin 2000). Seismic signals are typically in the range of 10 to 200 Hz (Turnpenny and Nedwell 1994) and will therefore overlap slightly with signals produced by fish. However, detecting a signal does not mean the fish will have any measurable reaction to the noise. The hearing ability of fish varies considerably by species as will the effects of seismic exploration. Variability in effect may also vary within a species because seismic signals have a more pronounced effect on larger fish than of smaller fish of the same species (Engås et al. 1996).

The limited studies available suggests that anthropogenic sounds, even from very high intensity sources, might have no effect in some cases or might result in effects that range from small and temporary shifts in behaviour all the way to immediate death. All fish studied to date are able to hear sounds (Fay and Popper 2000; Kasumyan 2005; Popper and Fay 2010) and they have two sensory systems for detection of water motions: the inner ear (there is no outer or middle ear) and the lateral line system. The ear serves to detect sound up to hundreds or even thousands of Hz (depending on the species), whereas the lateral line detects low-frequency sound (e.g., <100 Hz), but is generally considered to be primarily a detector of water motion relative to the body (Slabbekoorn et al. 2010).

Fish with swim bladders and specialized auditory couplings to the inner ear (e.g., herring) are highly sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (e.g., cod and redfish) are moderately sensitive, while fish with a reduced or absent swim bladder (e.g., mackerel and flounder) have low sensitivity (Fay 1988). Fay (1988) has developed an approximate threshold for each of these three classifications of hearing sensitivity. The highly sensitive group has a hearing threshold of less than 80 dB re 1 µPa. The moderately sensitive threshold is between 80 and 100 dB re 1 µPa and those fish with a low threshold have a sensitivity of greater than 100 dB re 1 µPa. These sensitivity thresholds were derived under quiet laboratory conditions, so thresholds to seismic sound pressure in the ocean are thought to be 40 dB higher due to ambient noise and the start and stop nature of the seismic signal. A comparison of moderately sensitive species such as cod, haddock, pollock and redfish determined a measurable behavioural response in the range of 160 to 188 dB re 1 µPa (Turnpenny and Nedwell 1994). Source levels during seismic surveys are usually in excess of the noise levels that elicit a response in fish, so the area in which fish react to the noise may extend several kilometres in the open ocean. By comparison, underwater ambient noise in bad weather is in the range of 90 to 100 dB re 1 µPa. As an example, large tankers may have a source noise level of 170 dB re 1 µPa @ 1 m.

The expected distance for fish to react to a typical peak source level of 250 to 255 dB re 1 µPa is from 3 to 10 km (Engås et al. 1996). A reaction may simply mean a change in swimming direction. The spatial range of response in fish will vary greatly with changes in the physical environment in which the sounds are emitted. In one environment, fish distribution has been shown to change in an area of 74 x 74 km (40 x 40 nautical miles) and 250 to 280 m deep for more than five days after shooting ended, with fish larger than 60 cm being affected to a greater extent than smaller fish (Engås et al. 1996).

The first time that sound was used by humans to locate objects underwater was shortly after the Titanic sank in 1912. After that, the use of mid- and later low-frequency sonar has become widespread for navigation and localization of submarines and other objects (Slabbekoorn et al. 2010). Sonar sounds effects were studied by Popper et al. (2007) and Halversen et al. (2006) with the exposure of several different species of fish, including rainbow trout (*Oncorhyncus mykiss*) and channel catfish (*Ictalurus punctatus*) sound emissions from a SURTASS LFA sonar. These studies were conducted using a sonar transducer and exposing fish to received sounds as high as 193 dB re 1 µPa (rms) continuously for up to 216 seconds. The results indicated no mortality and no damage to auditory and non-auditory tissues but demonstrated temporary threshold shift (TSS) in both species. Hearing loss recovered within 48 hours in channel catfish, and there were not enough data to determine recovery in rainbow trout. Data for other marine fish have demonstrated that exposure to moderately loud noises can result in (TTS) in a few species that have been studied including goldfish (*Carassius auratus*) and other fish specialized for hearing (Scholik and Yan 2001, 2002; Amoser and Ladich 2003; Amoser et al. 2004; Smith et al. 2004) Three studies using higher intensity sounds have also shown damage to the sensory hair cells of the inner ear, the cells responsible for transducing sound into neural impulses (Hastings et al. 1996; McCauley et al. 2003).

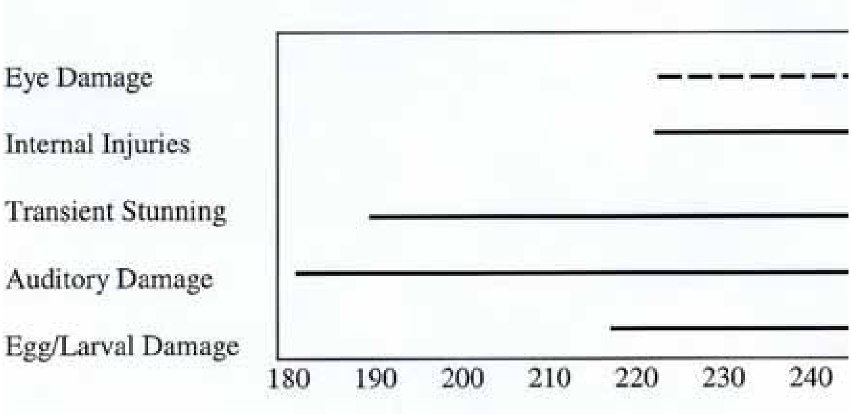
Popper et al. (2005) exposed several different species of fish to shots from a small seismic air gun array in a river and found no damage to sensory hair cells of the ear (Song et al. 2008). Two of the three species tested showed some hearing loss compared to control animals with complete recovery of hearing within 18 to 24 hours after exposure.

There have been several studies that have examined the effects of long-term noise exposure on fish (Scholick and Yan 2001, 2002; Amoser and Ladich 2003; Amoser et al. 2004; Smith et al. 2004, 2006; Wysocki et al. 2006). These studies show that fish that have anatomical specializations that make them better able to detect lower levels of sound pressure (known as hearing specialists) and demonstrate temporary hearing loss when exposed to increased background noise levels for 24 hours or more, whereas fishes without such specializations (known as hearing generalists) may not demonstrate hearing loss. Smith et al. (2004) studied hearing loss after over 20 days of exposure to a broadband noise of 170 dB re 1 µPa (rms) and found that substantial hearing loss in goldfish (hearing specialist), but not in the Nile tilapia (*Oreochromis niloticus*), a hearing generalist. Similar findings for hearing specialists and generalists have been reported by others. The results of these studies suggest that the amount of hearing loss that occurs in fish might be correlated with the sound pressure level of the noise relative to the hearing threshold of the fish.

Fish have been observed to congregate, seek shelter or food, at places with artificially high sound levels. There are numerous anecdotal observations of fish under noisy bridges or near noisy vessels indicating that adverse effects are not necessarily overt and obvious, but anecdotal observations are unable to indicate whether fish experience any negative consequences related to the noise (Slabbekoorn et al. 2010). Several studies in captive fish have shown an increase in secretion of the stress hormone cortisol during exposure to white noise or simulated boat noise (Smith et al. 2004; Wysocki et al. 2006, 2007). Other recent studies on potential indicators of stress in captive fish report noise-related rises in heart rate (Graham and Cooke 2008) and increased motility related to several blood parameters reflecting increased muscle metabolism (Buscaino et al. 2010). Population productivity of noisy areas might not only be affected by lower numbers or lower-quality individuals, but might also decline due to lowered reproductive efficiency. A study reports on actual interruption of spawning in roach (*Rutilus rutilus*) and rudd (*Scardinius erythrophthalmus*) by an approaching fast-moving powerboat (Boussard 1981). These studies suggest that anthropogenic sound could be a stressor in natural water bodies.

The response to sound by fish might range from no overt change in behaviour to the fish exhibiting an awareness of the sound or a startle response but otherwise no change in behaviour (Wardle et al. 2001) to small temporary movements for the duration of the sound to larger movements that might displace fish from their normal locations (Slotte et al. 2004) for short or long periods of time.

Kosheleva (1992) reports no obvious physiological effects beyond 1 m from a source of 220 to 240 dB re 1µPa. Hastings (1990) reports the lethal threshold for fish beginning at 229 dB and a stunning effect in the 192 to 198 dB range. Turnpenny and Nedwell (1994) deduce that blindness can be caused in fish exposed to air sleeve blasts on the order of 214 dB. A summary of fish injuries caused by exposure to sound pressure is given in Figure 7.6. Auditory damage starts at 180 dB, transient stunning at 192 dB and internal injuries at 220 dB.



Source: adapted from Turnpenny and Nedwell 1994.
Note: Dotted line indicates an assumed sound level rather than an estimated one.

Figure 7.6 Sound Pressure Threshold for the Onset of Fish Injuries

A specific noise impact that could potentially result in lower reproductive efficiency for fish is masking of communicative sounds. Over 800 species are known to produce sounds and the sounds they produce are in general broadband signals with most energy <500 Hz. Distinct variation in spectral and temporal characteristics can be related to species, populations, and gender (Slabbekoorn et al. 2010) and suggests that acoustic variation means that sounds can serve as information carriers in acoustic communication among fish (Tavolga 1971; Ladich 2004; Myrberg 1981).

Fish are known to produce sounds in spawning aggregations (Saucier and Baltz 1993; Aalbers 2008) and courtship interactions (Myrberg et al. 1986; McKibben and Bass 1998). Sounds could serve in aggregating reproductive groups, in which they may contribute to synchronization of male and female gamete release (Myrberg and Lugli 2006). Recent experimental evidence has unequivocally shown that sounds can modify mate choice decisions in fish. Female haplochromine cichlids (*Pundamilia nyererei*) provided with a choice between two males, matched in size and colour, preferred to interact with the male associated with playback of conspecific sounds (Verzijden et al. 2010). An acoustic impact on sexual preferences was also inferred for Atlantic cod in which the male drumming muscle mass was correlated with mating success (Rowe et al. 2008).

Masking leading to a reduction in detection distance, can potentially lead to failure in mate attraction. Currently there is a lack of empirical evidence demonstrating this effect for fish. It is not only essential to assess signal-to-noise threshold levels for an impact of anthropogenic noise on detection and recognition of relevant sounds; insight is also required into the potential scale of impact of such masking effects under natural conditions (Slabbekoorn et al. 2010).

Hearing and localizing of sounds can also be used for prey location and predator avoidance. Although sharks and other cartilaginous fish have relatively poor hearing sensitivity as compared to other fishes, they were reported to approach irregularly pulsed broadband sounds, which could be indicative for the presence of struggling prey (Myrberg 2001). Surface-feeding fish can localize prey accurately by listening to the surface waves produced when prey fall into the water (Hoin-Radkovsky et al. 1984). Peacock cichlids (Aulonocara) are even able to sense the sound of prey submerged in the sediment (Konings 2001). In other species, broad hearing bandwidths have been correlated with predator avoidance. Herring species (Clupeidae) of the genus *Alosa* are capable of detecting ultrasound (up to 180 kHz), which could allow detection and avoidance of echo-locating whales (Popper at al. 2004; Doksæter et al. 2009). While data are lacking in fish, it has been suggested that anthropogenic masking effects on predator-prey relationships could be widespread (Slabbekoorn et al. 2010).

Slabbekoorn et al. (2010) note that sound is important to fish and that a rise in artificial noise levels underwater may have negative consequences for individuals as well as populations. They also note that sonar, piling and explosions typically attract the most attention. It is reasonable to argue that the greater impact on fish will be from less intense sounds that are of longer duration and that can potentially affect whole ecosystems.

Plankton

Planktonic species and life stages of fish and invertebrates in the immediate vicinity of seismic air sleeves are probably the most vulnerable to seismic activities simply because they cannot move away. Several studies have concluded that direct physical damage of eggs and larvae is caused by air sleeve levels exceeding 220 dB re 1 μPa (see Table 7.6). From existing evidence, physical damage is therefore restricted to within a few metres of the air sleeve (Gausland 1992). Studies on the effects of seismic exposure on fish eggs and larvae (i.e., Kostyuchenko 1973; Dalen and Knutsen 1987; Holliday et al. 1987; Matishov 1992; Booman et al. 1996; Dalen et al. 1996, in Dalen et al. 2007) have found that effects appeared to be minimal and any mortality effect was generally not significantly different from experimental controls. Generally, any observed larval mortality occurred after exposures within 0.5 to 3 m of the air sleeve source. For example, some retinal tissue damage was observed in cod larvae exposed at 1 m from an air sleeve source (Matishov 1992). One study concluded potential pathological effects on eggs and larvae at 5 m from the source (Kostyuchenko 1973). Application of a 'worst-case scenario' mathematical model to investigate the effects of seismic energy on fish eggs and larvae, concluded that mortality rates caused by exposure to seismic are so low compared to natural mortality, the impact of seismic activity on recruitment to a fish stock would be insignificant (Saetre and Ona 1996).

Shellfish

No physical structures have been discovered in aquatic invertebrates that are stimulated by the pressure component of sound. However, vibrations (i.e., mechanical disturbances of the water) are also characteristic of sound waves. Rather than being pressure sensitive, aquatic invertebrates appear to be most sensitive to the vibrational component of sound (Breithaupt 2002). Statocyst organs may provide one means of vibration detection for aquatic invertebrates.

Table 7.6 Observations from Exposures of Marine Plankton Life Stages to Air Sleeves at Close Range

Organism	Life Stage	Exposure Distance from Air Sleeve (m)	Estimated Exposure Level (dB re 1 μ pA)	Observed Response	Reference
Pollock	Egg	0.75	242	Some delayed mortality	Booman et al. 1996
Cod	Larvae	5	220	Immediate mortality	Booman et al. 1996
	Fry	1.3	234	Immediate mortality	
	5-day-old larvae	1	250	Delamination of retina	Matishov 1992
	Eggs	1 to 10	202 to 220	No signs of injury	Dalen and Knutsen 1987
Plaice (*Pleuronectes platessa*)	Eggs & larvae	1	220	High mortality (unspecified)	Kosheleva 1992
		2	214	No effect	
Anchovy (*Engraulis mordax*)	Eggs	unknown	223	8.2% mortality	Holiday et al. in Turnpenny and Nedwell 1994
	2-day-old larvae	3	238	Swimbladder rupture	
Red Mullet (*Mullus surmuletus*)	Eggs	1	230	7.8% of eggs injured	Kostyuchenko 1973
		10	210	No injuries	
Fish (various spp.)	Eggs	0.5	236	17% dead in 24 hr	Kostyuchenko 1973
		10	210	2.1% dead in 24 hr	
Dungeness Crab (*Cancer magister*)	Larvae	1	231	No observed effect on time to molt or long-term survival	Pearson et al. 1994

A limited number of studies have been conducted on the sensitivity of certain invertebrate species to underwater sound. Available data suggest that they are capable of detecting vibrations but they do not appear to be capable of detecting pressure fluctuations. Many invertebrates are capable of producing sound, including barnacles, amphipods, shrimp, crabs, and lobsters (Au and Banks 1998; Tolstoganova 2002). Invertebrates typically produce sound by scraping or rubbing various parts of their bodies, although they also produce sound in other ways. Sounds made by marine invertebrates may be associated with territorial behaviour, mating, courtship, and aggression.

The acoustic detection capabilities in decapod crustaceans is the best understood and studied of the invertebrate group. Crustaceans appear to be most sensitive to sounds of low frequencies (i.e., <10,000 Hz) (Budelmann 1992; Popper et al. 2001). A study by Lovell et al. (2005) suggests greater sensitivity of the prawn (*Palaemon serratus)* to low-frequency sound than previously thought. Lovell et al. (2006) showed that *Palaemon serratus* is capable of detecting a 500 Hz tone regardless of the prawn's body size and the related number and size of statocyst hair cells. Studies of American lobsters suggest that these crustaceans are more sensitive to higher frequency sounds than previously realized (Pye and Watson III 2004).

There are a limited number of studies assessing the potential for effects on invertebrates from exposure to seismic sound. A pilot study on snow crabs (*Chionoecetes opilio*) under controlled field experimental conditions on captive adult male snow crabs, egg-carrying female snow crabs, and fertilized snow crab eggs exposed to variable sound pressure levels (191 to 221 dB re 1 µPa0-p) and sound energy levels (<130 to 187 dB re 1 µPa2•s) was conducted (Christian et al. 2003, 2004). Neither acute nor chronic (12 weeks post-exposure) mortality was observed for the adult crabs. However, a significant difference in development rate was noted between the exposed and unexposed fertilized eggs / embryos. The egg mass exposed to seismic energy had a higher proportion of less-developed eggs than did the unexposed mass. It should be noted that both egg masses came from a single female and as such there is no measure of natural variability associated with this study (Christian et al. 2003, 2004). Stress indicators in the haemolymph of adult male snow crabs were monitored immediately after exposure of the animals to seismic survey sound (Christian et al. 2003, 2004) and at various intervals after exposure. No significant acute or chronic differences were found between exposed and unexposed animals in which various stress indicators (e.g., proteins, enzymes, cell type count) were measured.

Benthic macroinvertebrates are less likely to be impacted by seismic activity because few invertebrates have gas-filled spaces and benthic species are usually more than 20 m away from the seismic source. The resilience of various macroinvertebrates has been tested by exposing them at a short distance to an active air sleeve (Table 7.7). The rate of injury experienced by macroinvertebrates due to the passage of a seismic survey should be less than indicated for planktonic organisms and fish. Lobsters are similar to crab in that they are thought to be resilient to seismic activity because decapods lack the gas-filled voids that would make them sensitive to changes in pressure. Mortality and development rates of Stage II Dungeness crab larvae exposed to single discharges from a seismic array were compared with those of unexposed larvae. No statistically significant differences between the exposed and unexposed larvae were observed with respect to immediate and long-term survival and time to molt, even for those exposed larvae within 1 m of the seismic source (Pearson et al. 1994).

Table 7.7 Observation from Exposures of Marine Macroinvertebrates to Air Sleeves at Close Range

Organism	Exposure Distance from Air Sleeve (m)	Estimated Exposure Level (dB re 1 μ Pa)	Observed Response	Reference
Iceland Scallop (*Acequipecten irradians*)	2	217	Shell split in 14 of 3 tested	Matishov 1992
Sea Urchin (*Strongylocentrotus droebachiensis*)	2	217	15% of spines fell off	Matishov 1992
Mussel (*Mytilus edulis*)	0.5	229	No detectable effect within 30 days	Kosheleva 1992
Periwinkle (*Littorina* spp.)	0.5	229	No detectable effect within 30 days	Kosheleva 1992
Crustacean (*Gammarus locusta*)	0.5	229	No detectable effect within 30 days	Kosheleva1992
Brown Shrimp (*Cragnon cragnon*)	1	190	No mortality	Webb and Kempf 1992

A collaborative study was conducted in the southern Gulf to investigate the effects of exposure to sound from a commercial seismic survey on egg-bearing female snow crabs (DFO 2004d). This study had design problems that impacted interpretation of some of the results (Chadwick 2004). Caged animals were placed on the ocean bottom at a location within the survey area and at a location outside of the survey area. The maximum received sound pressure level was approximately 195 dB re 1 µPa0-p. The crabs were exposed for 132 hours of the survey, equivalent to thousands of seismic shots of varying received sound pressure level. The animals were retrieved and transferred to laboratories for analyses. Neither acute nor chronic lethal or sub-lethal injury to the female crabs or crab embryos was indicated. DFO (2004d) reported that some exposed individuals had short-term soiling of gills, antennules and statocysts, bruising of the hepatopancreas and ovary, and detached outer membranes of oocytes.

Payne et al. (2007) conducted a pilot study on the effects of seismic sound on lobster (*Homarus americanus*) assessing several physiological endpoints in animals exposed to a "low level" exposure of approximately 202 dB peak-to-peak and a "high level" exposure of approximately 227 dB peak-to-peak. The endpoints included lobster survival, food consumption, turnover rate, serum protein, serum enzymes, and serum calcium. A limited histopathological study was also conducted on lobsters from one of the five trials. Observations were conducted over a period of a few days to several months.

Exposure of lobster to high and low seismic sound levels had no effect on delayed mortality or damage to mechano-sensory systems associated with animal equilibrium and posture, as assessed by turnover rates (Payne et al. 2007). There was no evidence for loss of legs or other appendages. Sub-lethal effects were observed with respect to feeding and serum biochemistry with effects sometimes being observed weeks to months after exposure. A histochemical change was also noted in the hepatopancreata of animals previously exposed to seismic sound (four months prior), which may be linked to organ 'stress'. While these initial studies were exploratory in nature, the scientists indicate the need for comprehensive studies regarding the potential for seismic surveys to affect lobster (Payne et al. 2007).

Price (2007) found that blue mussels (*Mytilus edulis*) responded to a 10 kHz pure tone continuous signal by decreasing respiration. Smaller mussels did not appear to react until exposed for 30 minutes whereas larger mussels responded after 10 min of exposure. The oxygen uptake rate tended to be reduced to a greater degree in the larger mussels than in the smaller animals.

Marine Birds

Birds have good hearing abilities in air (Fay 1988), but information on their underwater hearing is unknown and is generally lacking. Investigations into the effects of airguns and other sounds associated with offshore oil and gas activities on seabirds are extremely limited. The lack of data regarding seabirds and seismic activity (as well as sounds associated with other offshore oil and gas activities) may be a reflection of the fact that there is little evidence that problems occur (Davis et al. 1998) or maybe as a result of the paucity of data.

The sound created by air sleeves is focused downward below the surface of the water and sound levels at and immediately below the surface are likely greatly reduced compared to levels deeper in the water (LGL Limited 2002). The sound created by air sleeves is focused downward below the surface of the water. Above the water, the sound is reduced to a muffled shot that should have little or no effect on birds that have their heads above water or are in flight. It is possible that birds on the water at close range would be startled by the sound. However, the presence of the ships and other related oil and gas platforms should have already warned the bird of unnatural visual and auditory stimuli (LGL 2005b).

Observations made during a seismic program in the Davis Strait area showed no evidence of mortality or distributional effects on marine birds (Stemp 1985). Parsons (in Stemp 1985) reported that shearwaters with their heads under water were observed within 30 m of seismic sources (explosives) and did not respond. Similarly, trained observers reported no ill effects on guillemot, fulmar and kittiwake species that were monitored during air sleeve seismic surveys in the North Sea (Turnpenny and Nedwell 1994). Evans et al. (1993) noted that there was no evidence to suggest that seabirds were either attracted to or repelled by seismic testing in the Irish Sea.

Most species of marine birds that are expected to regularly occur in the Study Area feed at less than 1 m from the surface of the ocean and this would include members of Procellariidae, Hydrobatidae, Phalaropodinae and Laridae. The only group of marine birds that spends considerable time submerged underwater is the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot and Atlantic Puffin). Alcids secure food by diving under the water and propelling their bodies rapidly through the water with their wings. All are capable of reaching considerable depths and spending prolonged periods of time submerged (Gaston and Jones 1998). Murres regularly dive to a maximum depth of 100 m and have been recorded underwater for up to 202 seconds (Gaston and Jones 1998). The effects of seismic sounds on Alcidae are unknown but sounds are probably not important to Alcidae in securing food. However, all six species are quite vocal at breeding sites, indicating auditory capabilities are important in that part of the life cycle of Alcidae.

A study of the effects of seismic surveys on moulting long-tailed ducks in the Beaufort Sea found no effects on movement or diving behaviour, although the authors cautioned that they had limited ability to detect subtle disturbance effects (Lacroix et al. 2003). Northern Gannet plunge dive to a depth of 10 m, but animals remain submerged for only a few seconds in total, so would have minimal chance to receive underwater sound.

Marine Mammals

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Studies also show that marine mammals hear and react to many man-made sounds including sounds made during seismic exploration (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Tyack 2008). Marine mammals are highly dependent on sound for communicating, detecting predators, locating prey and in toothed whales, echolocation.

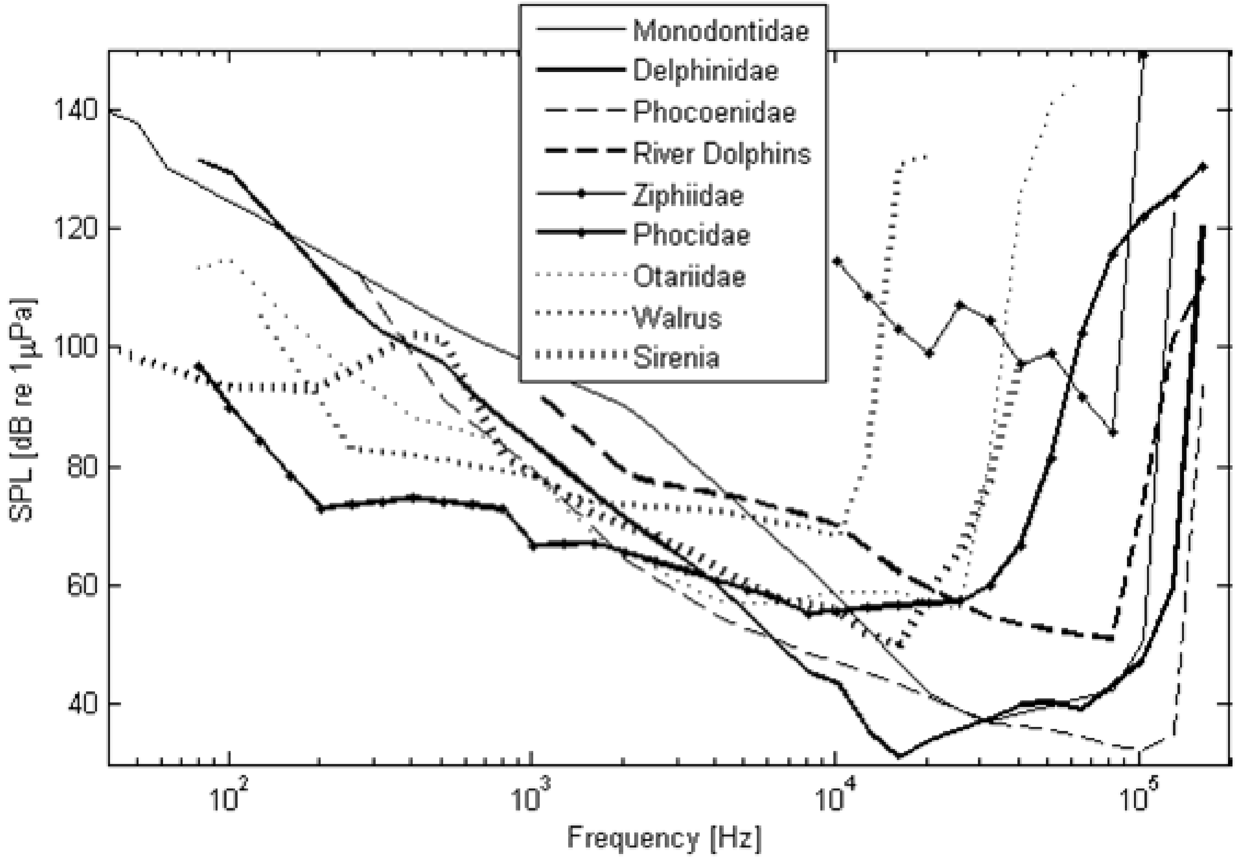
The hearing abilities for some toothed whales have been studied in detail (Richardson et al. 1995; Au et al. 2000), with the hearing sensitivity for several species having been determined as a function of frequency. The small to moderate-sized toothed whales hearing that have been studied showed relatively poor hearing sensitivity at frequencies below 1 kHz and extremely good sensitivity at, and above, several kHz.

There are very few data on the absolute hearing thresholds of most of the larger, deep-diving toothed whales, such as the sperm and beaked whales. Cook et al. (2006) found that a stranded juvenile Gervais' beaked whale showed evoked potentials from 5 kHz up to 80 kHz (the entire frequency range that was tested), with best sensitivity at 40 to 80 kHz. An adult Gervais' beaked whale had a similar upper cutoff frequency of 80 to 90 kHz (Finneran et al. 2009).

Most of the toothed whale species have been classified as belonging to the "mid-frequency" hearing group, and the mid-frequency odontocetes (collectively) have functional hearing from about 150 Hz to 160 kHz (Southall et al. 2007). The porpoises, river dolphins, and members of the genera Cephalorhynchus and Kogia of the toothed whales are classified as "high frequency" hearing group with functional hearing from about 200 Hz to 180 kHz (Southall et al. 2007).

Sound levels decrease with range due to propagation losses. Audibility is limited by the sound dropping either below the animal's hearing curve (audiogram) or below ambient noise levels. An audiogram is a graph showing hearing thresholds of pure tones as a function of frequency. Audiograms have been measured from only approximately 20 marine mammal species and from only a few individuals. Audiogram variability on an individual (let alone species or genus) level is barely understood. The reported threshold is a statistical quantity (e.g., depending on the method used, the level at which the tone was heard 50 percent of the time).

Marine mammal audiograms, grouped into families, are shown in Figure 7.7. Published audiograms were assembled and interpolated for the centre frequencies of 1/3 octave bands between 40 Hz and 200 kHz. Within each family, the lowest threshold of all species and individuals was plotted at each frequency. The computation of 1/3 octave band levels (commonly used for marine mammal impact assessment) provide a convenient way of averaging individual audiograms and smoothing audiograms for different species (Figure 7.7).



Note: Shows the minimum thresholds over all species belonging to the same family.

Figure 7.7 Underwater Audiograms of Marine Mammals

There are no direct measurements of underwater audiograms of sea otters, sperm whales and baleen whales. It is expected that their frequencies of best sensitivity overlap to some degree with the frequencies of their calls. Other indicators for what these animals can hear come from controlled exposure experiments looking for responses of animals to sound. Anatomical studies of baleen ears have suggested good hearing sensitivity between 10 Hz and 30 kHz (Ketten 2000). Although, the hearing abilities of baleen whales (mysticetes) have not been studied directly, behavioural and anatomical evidence indicates that they may hear well at frequencies below 1 kHz (Richardson et al. 1995; Ketten 2000). It has been noted that some baleen whales react to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at 36 kHz or above (Watkins 1986). Baleen whales have been observed to produce sounds at frequencies up to 8 kHz and, for humpbacks, with components to >24 kHz (Au et al. 2006). Frankel (2005) noted that gray whales reacted to a 21 to 25 kHz whale-finding sonar.

The anatomy of the baleen whale inner ear indicates that it may be well adapted for detection of low-frequency sounds (Ketten 1991, 1992, 1994, 2000; Parks et al. 2007). However, humpbacks and minke whales (Berta et al. 2009) may have some auditory sensitivity to frequencies above 22 kHz. Baleen whales as a group have a functional hearing range that is thought to be about 7 Hz to 22 kHz and are considered to be represent "low-frequency" hearing group (Southall et al. 2007). The absolute sound levels that they can detect below 1 kHz are probably limited by increasing levels of natural ambient sound at decreasing frequencies (Clark and Ellison 2004). Ambient sound levels are higher at low frequencies than at mid frequencies. At frequencies below 1 kHz, natural ambient levels tend to increase with decreasing frequency.

The hearing systems of baleen whales are thought to be more sensitive to low-frequency sounds than are the ears of the small toothed whales that have been studied directly. Therefore, baleen whales are likely to hear airgun pulses farther away than small toothed whales and, at closer distances, airgun sounds may seem more prominent to baleen than to toothed whales. However, baleen whales have commonly been seen well within the distances where seismic (or other source) sounds would be detectable and often show no overt reaction to those sounds.

The functional hearing range for pinnipeds in water is considered to extend from 75 Hz to 75 kHz (Southall et al. 2007), although some species, in particular the eared seals, do not have as broad an auditory range (Richardson et al. 1995). In comparison with toothed whales, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the best frequency.

Some of the phocid seals have better sensitivity at low frequencies (≤1 kHz) than do toothed whales. Below 30 to 50 kHz, the hearing thresholds of most pinniped species tested are essentially flat down to approximately1 kHz, and range between 60 and 85 dB re 1 μPa. Measurements for harbour seals indicate that, below 1 kHz, their thresholds under quiet background conditions deteriorate gradually with decreasing frequency to approximately 75 dB re 1 μPa at 125 Hz (Kastelein et al. 2009). For the eared seals, the high frequency cutoff is lower than for phocinids, and sensitivity at low frequencies (e.g., 100 Hz) is poorer than for harbour seals.

Underwater ambient or anthropomorphic sounds may prevent an animal from detecting another sound through a process known as masking. Masking is the obscuring of sounds of interest by interfering sounds, generally at similar frequencies (Richardson et al. 1995). Introduced underwater sound will, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al. 1995). Masking can occur as a result of either natural sounds (e.g., periods of strong winds or heavy rainfall) or anthropogenic sounds (e.g., ship propeller sound). The sea is a naturally noisy environment and even in the absence of anthropogenic sounds, this natural sound can "drown out" or mask weak signals from distant sources. Signals that might be masked include social sounds, communication sounds, predator sounds, prey sounds, echolocation sounds and environmental sounds (e.g., the sound of surf) that animals might listen to for navigation. If little or no overlap occurs between the introduced sound and the frequencies used by the species, communication is not expected to be disrupted.

All marine mammals emit sound that is produced internally. Other sounds, that may also take a social or communicative role, are generated when an animal strikes an object or the water surface. Toothed whales (e.g., dolphins, pilot whale, and sperm whale) sounds are generated within the nasal system, not the larynx. They can be classified into three categories: tonal whistles, burst-pulse sounds and echolocation clicks. Whistles and burst-pulse sounds have a social function. Some toothed whales do not whistle (e.g., Phocoenidae, *Cephalorhynchus* sp., *Kogia* sp., *Physeter macrocephalus*). Whistles have a fundamental frequency below 20 to 30 kHz plus higher harmonics. Whistles may be categorized according to the shape of the fundamental frequency with time: constant frequency, upsweep, downsweep, concave (hill), convex (valley), sinusoidal. Burst-pulse sounds are series of broadband pulses with substantial ultrasonic energy. Echolocation clicks are broadband and mostly in the ultrasonic range. Burst-pulse sounds have lower source levels and lower interclick intervals than echolocation click trains. Both have highly directional beam-patterns.

Toothed whales (e.g., dolphins, pilot whale, and sperm whale) communicate using two types of sounds: 1) continuous, narrowband, frequency-modulated signals which range in duration from several tenths of a second to several seconds and range in frequency from approximately 2 to 25 kHz (Tyack and Clark 2000); and 2) broadband click trains with peak frequencies that vary from tens of kilohertz to well over 100 kHz (Norris and Evans 1966; Au 1980). Click trains contain few to hundreds of clicks and are used for communication, navigation and object detection and discrimination (Au 1993). The low frequency spectrum of industrial sound generally will not overlap with the high frequency echolocation of toothed whales. The side-scan sonar emits pulses of sound in narrow beams at 105 and 390 kHz. The echo-sounder emits pulses at 24, 200 and 240 kHz. The 105 kHz pulse from the side-scan sonar and the 24 kHz pulse from the echo-sounder are likely audible to toothed whales, but significant masking of communication signals is improbable due to the fact that the pulses are short and have narrow band widths.

The sound production mechanism of baleen whale (e.g., minke, humpback and fin whales) sounds is unclear. Sounds can be classified into calls and songs. Calls have been categorized further into simple calls (low frequency <1 kHz, narrow band, frequency and amplitude modulated), complex calls (broadband, 500 to 5,000 Hz, frequency and amplitude modulated), grunts and knocks (<0.1 s duration, 100 to 1,000 Hz), and clicks and pulses (short duration <2 milliseconds, 3 to 30 kHz) (Clark 1990). Songs have been recorded from humpback, bowhead, blue and fin whales. Humpback song can be broken down into themes, which consist of repetitions of phrases, which are made up of patterns of units (with energy up to 30 kHz). Baleen whales communicate using low frequency sounds (generally between 25 Hz and 4 kHz (Richardson et al. 1995; Erbe 2002)) that can propagate for long distances. These sounds range in duration from 50 msec thumps produced by minke whales (Winn and Perkins 1976; Thompson et al. 1979) to moans produced by blue whales, which can have durations up to 36 sec (Cummings and Thompson 1971).

Pinniped sounds occur in air and underwater, and are often described by onomatopoeic words: grunts, snorts, buzzes, barks, yelps, roars, groans, creaks, growls, whinnies, clicks (Richardson et al. 1995; Au and Hastings 2008).

The frequency bands of sounds emitted by marine mammals (including echolocation) are illustrated in Figure 7.8.

Marine animals themselves also contribute to the level of natural ambient noise. The calls of a blue whale have been recorded for 600 km (Stafford et al. 1998). A sperm whale call can be as loud as 232 dB re 1µPa at 1 m (rms) (Møhl et al. 2003) and a species of shrimp has been recorded at 185 to 188 dB re 1µPa at 1 m (Au and Banks 1998). In areas where natural background noise is relatively high, such as near a shelf break or high surf, anthropogenic noise itself can be masked and reduce the area in which it is detectable. The anthropogenic noise is undetectable for marine mammals once it falls below ambient noise level or the hearing threshold of the animal. Given this, and the fact that mammal response will vary by species and between individuals, the zone of potential influence of noise on marine mammals is highly variable.

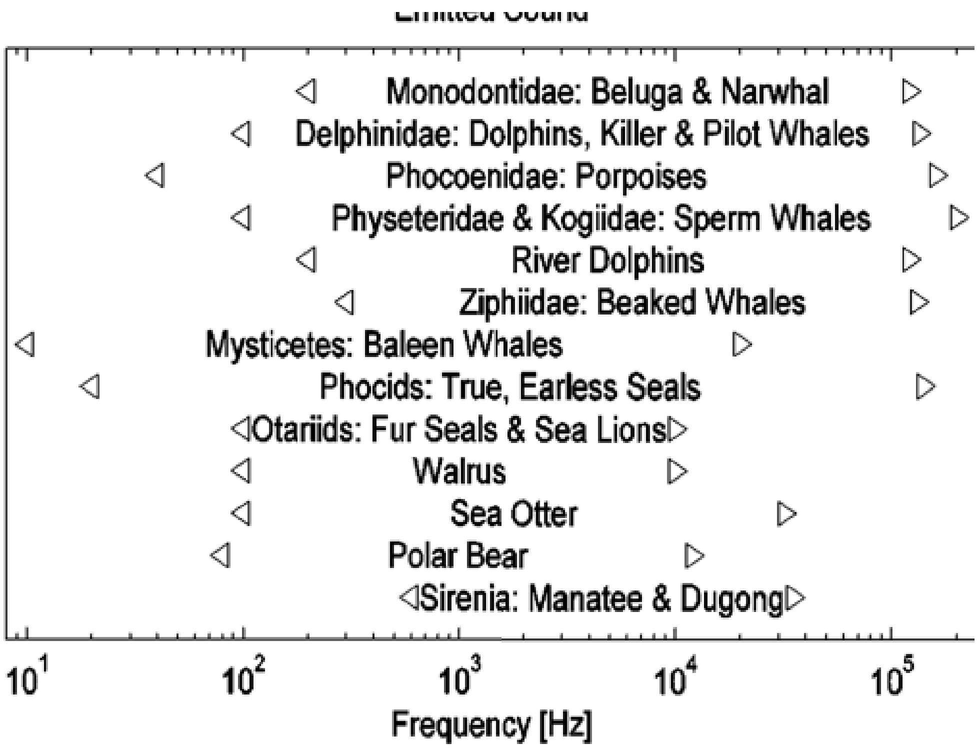


Figure 7.8 **Frequency Bands of Marine Mammal Sounds**

Marine mammals have evolved in an environment that contains a variety of natural sounds and as such, some degree of masking occurs; thus, marine mammals have evolved systems and behaviour to reduce the impacts of masking (NRC 2003). Since little is known about the importance of how a temporary interruption in sound detection affects mammals (Richardson et al. 1995), it is very difficult to assess the environmental effect. In general, the environmental effect of both natural and anthropogenic noise is less severe when it is intermittent than continuous (NRC 2003). The level of masking may be significantly reduced if the anthropogenic noise originates from a different direction than the mammal vocalization (NRC 2003). While marine mammals may adapt behaviour changes to reduce masking, the physiological costs associated with the behavioural changes cannot be estimated at this time (NRC 2003).

Acoustic energy in the sound pulses produced by seismic air guns and sub-bottom profilers overlaps with frequencies used by baleen whales, but the discontinuous, short duration nature of these pulses is expected to result in limited masking of baleen whale calls. Side-scan sonar and echosounder signals do not overlap with the predominant frequencies of baleen whale calls, which limits significant masking. Several species of baleen whales have been observed to continue calling in the presence of seismic pulses, including bowhead whales (Richardson et al. 1986), blue whales and fin whales (McDonald et al. 1995).

The low frequency spectrum of industrial noise will not overlap with the high frequency echolocation of belugas, dolphins, or pilot whales, for example. Because seismic and sub-bottom profiler pulses are intermittent and predominantly low frequency, masking effects are expected to be negligible for toothed whales. However, while Madsen et al. (2002) reported that sperm whales off northern Norway continued calling in the presence of seismic pulses, Bowles et al. (1994) reported that sperm whales ceased calling when exposed to pulses from a distant seismic ship. Some pulses emitted by side-scan sonars and echo-sounders are likely audible to toothed whales, but significant masking of communication signals is improbable due to the fact that the pulses are short and have narrow beam widths.

Anthropogenic sounds have the potential to disturb behaviour and/or interfere with important functions (Richardson et al. 1995; NRC 2003). The zone of behavioural response is mostly going to be smaller than the zone of audibility. Richardson et al. (1995) reported that marine mammals tend not to respond overtly to barely audible man-made sounds. Indicators of ‘disturbance’ include changes in swim direction, swim speed, dive duration, surfacing duration, respiration (blow rate), movement towards or away from the noise, changes in acoustic behaviour. Marine mammals are generally more tolerant of stationary sources of noise than moving sources. This seems especially true for seals which will approach a stationary vessel or fixed platform (LGL et al. 2000). Dolphins and other toothed whale species have also reportedly approached offshore drilling platforms (Richardson et al. 1995).

Available detailed data on reactions of marine mammals to airgun sounds (as well as other anthropogenic sounds including those associated with exploratory drilling) are limited to a few species and limited documented situations (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Behavioural reactions of marine mammals to sound are difficult to predict in the absence of site- and context-specific data. Reactions to sound would depend on species, state of maturity, experience, current activity, reproductive state, time of day, as well as other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007). The data and studies summarized below present a flavour for the type of reactions to sound exhibited by marine mammals. As indicated earlier, the majority of current scientific information on the effects of sound on marine mammals is based on seismic sound, which has been the primary focus of research studies. For an exploration drilling program, seismic-based activities would likely produce the largest sound source. Other sound sources would produce lower levels of sound than seismic sources and as such marine mammals may exhibit similar responses but within a potentially smaller zone of influence.

Behavioural responses of marine mammals to noise are highly variable and dependent on a suite of internal and external factors (NRC 2003). Internal factors include:

- individual hearing sensitivity, activity pattern and motivational and behavioural state at time of exposure;
- past exposure of the animal to the noise, which may have led to habituation or sensitization;
- individual noise tolerance; and
- demographic factors such as age, sex and presence of dependent offspring.

External factors include:

- non-acoustic characteristics of the sound source, such as whether it is stationary or moving;
- environmental factors that influence sound transmission;
- habitat characteristics, such as being in a confined location; and
- location, such as proximity to a shoreline.

Behavioural responses by marine mammals such as moving a short distance in reaction to sound is unlikely to result in significant impacts to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007). It has been noted in some studies that some marine mammals that have shown no obvious avoidance or behavioural changes may still be adversely affected by noise (Brodie 1981; Richardson et al. 1995: Romano et al. 2004; Weilgart 2007; Wright et al. 2009). Some research suggests that animals in poor condition or in an already stressed state may not react as strongly to human disturbance as would more robust animals (e.g., Beale and Monaghan 2004).

Baleen whales generally tend to avoid intense sound sources with the avoidance zone being variable among species, locations, whale activities and oceanographic conditions affecting sound propagation (Richardson et al. 1995; Gordon et al. 2004). Baleen whales, like the fin and blue whales, exposed to strong sound pulses from airguns have been observed to react by deviating from their normal migration route and/or interrupting their feeding and moving away (Malme et al. 1984, 1985, 1988; Richardson et al. 1986, 1995, 1999; Ljungblad et al. 1988; Richardson and Malme 1993; McCauley et al. 1998, 2000a, 2000b; Miller et al. 2005; Gordon et al. 2004; Moulton and Miller 2005; Stone and Tasker 2006; Johnson et al. 2007; Nowacek et al. 2007; Weir 2008). Reactions of baleen whales to vessels have been studied directly for species such as gray whales, humpback whales, and bowhead whales. Reactions have been found to vary from approach to avoidance. In general, baleen whales tend to change their behaviour in response to strong or rapidly changing vessel noise (Watkins 1986; Beach and Weinrich 1989). Behavioural changes include course changes, changes in surfacing and respiration patterns, and displays such as breaching, flipper slapping, and tail slapping (Wyrick 1954; Edds and Macfarlane 1987; Stone et al. 1992).

Limited information is available with respect to reactions of toothed whales to sound pulses. There are relatively few studies similar to the more extensive baleen studies that have been previously summarized. The sounds produced by seismic air guns are in the frequency range of low hearing sensitivity for toothed whales. However, they are high intensity sounds and their received levels can sometimes remain above the hearing thresholds of toothed whales for distances out to several tens of kilometres (Richardson and Würsig 1997). Based on the literature reviewed in Richardson et al. (1995), it is apparent that most small and medium-sized toothed whales (harbour porpoise) exposed to prolonged or repeated underwater sounds are unlikely to be displaced unless the overall received level is at least 140 dB re 1 μPa. There have been dolphins observed to be attracted to the seismic vessel and related gear, with some riding the bow wave of the seismic vessel even when a large array of airguns was firing (Moulton and Miller 2005). However, small toothed whales do tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (Stone 2003; Moulton and Miller 2005; Holst et al. 2006; Stone and Tasker 2006; Weir 2008; Richardson et al. 2009). The avoidance zone appears to be small, on the order of 1 km or less, with some individuals showing no apparent avoidance. Responses of toothed whales to vessels vary within and among species and range from avoidance to approach and bowriding (Baird and Stacey 1991a, 1991b; Stacey and Baird 1991; Mullin et al. 1994a, 1994b).

Very little information exists on the reactions of pinnipeds to sounds from seismic exploration in open water (Richardson et al. 1995). Visual monitoring from seismic vessels has shown that pinnipeds frequently do not avoid the area within a few hundred metres of an operating air gun array (Harris et al. 2001). However, the telemetry research of Thompson et al. (1998) suggests that reactions may be stronger than has been evident from visual studies. Based on anecdotal evidence, pinnipeds appear to show little reaction to vessels in open water (Richardson et al. 1995). However, there are few studies that describe the responses of pinnipeds in the water to vessel traffic.

Moulton and Holst (2010) summarized marine mammals monitoring results from eight seismic programs off eastern Canada during 2003 to 2008. Marine mammal observations were recorded for 9,180 hours from seismic vessels. During these seismic surveys, it was found that mysticetes exhibited localized avoidance of the active airgun array. Sighting rates were significantly lower during operations with the full airgun array compared with non-seismic periods and these reduced sighting rates suggest that some baleen whales avoided the source vessel by several kilometres. Mysticetes were also observed significantly further from the source vessel during seismic as compared to non-seismic periods. On average, it was found that baleen whales were observed approximately 200 m further from the vessel during seismic operations. Mysticetes were also noted to swim away from the vessel more often during seismic compared with non-seismic periods. Delphinids were initially detected significantly farther away during airgun activity (by approximately 200 m) compared with non-seismic periods, but there was no significant difference between sighting rates. For large toothed whales such as sperm whales and beaked whales the sighting rates and distances were similar during periods when airguns were active versus silent.

Behavioural responses by baleen whales to seismic pulses have been documented; however, the received level of pulsed sounds necessary to elicit these reactions are typically well above the minimum detectable levels (Richardson et al. 1986; 1995; 1999). In addition, baleen whales have often been seen well within distances where seismic sounds would be audible and yet show no obvious reaction to those sounds (LGL 2005b). Little is known about the significance of how a temporary interruption in sound detection affects mammals (Richardson et al. 1995). In general though, the impact of both natural and man-made noise is less severe when it is intermittent rather than continuous (NRC 2003).

Little is known about the potential for the sounds produced during geohazard surveys to cause auditory threshold shifts or other effects in marine mammals. Data suggests that if these effects do occur, they would only occur in close proximity to the sound sources. Thus, species that show behavioural avoidance of noise, including most baleen whales, some toothed whales and some pinnipeds, would not likely experience threshold shifts or other physical effects (LGL 2005b).

Sea Turtles

Very little is known about the importance of hearing to sea turtles. It has been suggested that sound may play a role in navigation, but recent studies suggest that visual, wave and magnetic cues are the main navigational cues used by hatchling and juvenile sea turtles (Lohmann and Lohmann 1998; Lohmann et al. 2001). Sea turtles are likely to avoid underwater sound (McCauley et al. 2000a, 2000b). Avoidance may reduce the risk of potential physiological effects of sound exposure. Sea turtles are not believed to use hearing for prey detection or navigation; therefore, masking is unlikely to be an important issue for sea turtles.

The limited available information indicates that turtles hear at low frequency (100 to 500 Hz (Office of Naval Research website 2002); 100 to 700 Hz (Environment Australia 2003)) range and are therefore more like seals than other marine mammals. Sea turtle auditory perception occurs through a combination of bone and water conduction rather than air conduction (Lenhardt 1982; Lenhardt and Harkins 1983). Detailed descriptions of sea turtle ear anatomy are found in Ridgway et al. (1969), Lenhardt et al. (1985), and Bartol and Musick (2003). Sea turtles do not have external ears, but the middle ear is well adapted as a peripheral component of a bone conduction system. The thick tympanum is disadvantageous as an aerial receptor, but enhances low-frequency bone conduction hearing (Lenhardt et al. 1985; Bartol et al. 1999; Bartol and Musick 2003). When the tympanum is depressed, the vibrations are conveyed via the fibrous stapedo-sacular strands to the sacule (Lenhardt et al. 1985). The ear arrangement of sea turtles comprised of fat deposits and bone enables sea turtles to hear low-frequency sounds while underwater and makes them relatively insensitive to sound above water. Sound vibrations can also be conducted through the bones of the carapace to reach the middle ear.

The limited available data indicate that the frequency range of hearing sensitivity of sea turtles extends from approximately 200 to 700 Hz. Sensitivity deteriorates as one moves away from this range to either lower or higher frequencies.

O'Hara and Wilcox (1990) tested the reactions to airguns by loggerhead sea turtles held in a 300 × 45 m area of a canal in Florida with a bottom depth of 10 m. The sound source consisted of one 10 inch airgun plus two 0.8 inch "poppers" operating at 2,000 psi and an airgun-depth of 2 m for prolonged periods of 20 to 36 hours. The turtles maintained a standoff range of approximately 30 m when exposed to airgun pulses every 15 or 7.5 seconds. Some turtles may have remained on the bottom of the enclosure when exposed to airgun pulses.

Lenhardt (2002) exposed loggerhead turtles while they were near the bottom of holding tanks at a depth of 1 m to tones from 35 to 1000 Hz. The turtles exhibited startle responses (neck contractions) to these tones. The lowest thresholds were in the 400 to 500 Hz range (106 dB sound pressure level re 1 µPa), and thresholds in the 100 to 200 Hz range were approximately 124 dB (Lenhardt 2002). Diving behaviour was exhibited at 30 Hz and 164 dB. Lenhardt (2002) suggested that exposure of sea turtles to airguns at water depths >10 m may result in exposure to more energy in the low frequencies with unknown biological effects.

Moein et al. (1994) investigated the avoidance behaviour and physiological responses of loggerhead turtles exposed to an operating airgun. The turtles were held in a netted enclosure approximately 18 m by 61 m by 3.6 m deep, with an airgun of unspecified size at each end. Only one airgun was operated at any one time; the firing rate was one shot every five to six seconds. The airgun was initially discharged when the turtles were near the center of the enclosure and the subsequent movements of the turtles were documented. The turtles exhibited avoidance during the first presentation of airgun sounds at a mean range of 24 m, but the avoidance response waned quickly which suggested that the turtles had become habituated to the sound.

Data on sea turtle behaviour during airgun operations have also been collected during marine mammal and sea turtle monitoring and mitigation programs associated with various seismic operations worldwide. Results suggest that some sea turtles exhibit behavioural changes and/or avoidance within an area of unknown size near a seismic vessel. However, avoidance of approaching seismic vessels is sufficiently limited and small-scale such that sea turtles are often seen from operating seismic vessels.

Weir (2007) reported on the behaviour of sea turtles near seismic exploration operations off Angola, West Africa. A total of 240 sea turtles were seen during 676 hours of vessel-based monitoring. Airgun arrays with total volumes of 5085 and 3147 in^3 were used at different times during the seismic program. Sea turtles tended to be seen slightly closer to the seismic source, with the sighting rates twice as high, during non-seismic versus seismic periods (Weir 2007). There was no significant difference in the median distance of turtle sightings from the arrays during non-seismic versus seismic periods, with means of 743 m and 779 m respectively.

Based on experimental studies (primarily) and field observations, sea turtles generally respond to seismic sound (loudest sound anticipated to be associated with an exploratory drilling program) by startling, increasing swimming speed, and/or swimming away from the sound source. The paucity of data precludes clear predictions of sea turtle responses to seismic sound and other sounds related to exploration drilling. Available evidence suggests that localized behavioural and distributional effects on sea turtles are likely during seismic operations, including responses to the seismic vessel, airguns, and gear (McCauley 1994; Pendoley 1997; Weir 2007).

Commercial Fisheries

Collins et al. (2002) looked at potential effects on fish catches during and after two independent inshore and nearshore seismic surveys undertaken in the Bay St. George and Port au Port areas of western Newfoundland. While not statistically conclusive, their analyses suggested no observable effects on overall fish catches including snow crab, during or in the years following the seismic surveys. This indicates that fish behaviour was not measurably affected. Turnpenny and Nedwell's (1994) general conclusion is that seismic activity has a reduced affect on fish behaviour inshore, in shallow water because attenuation of the sound is more rapid.

Recent studies using a number of methods to estimate fish distribution in open sea fisheries showed a decrease in gadoid abundance during seismic surveys (Løkkeborg and Soldal 1993; Engås et al. 1996). The areas apparently affected extended up to 33 km from the survey centre, but the most pronounced reduction in catch occurred within the seismic shooting area (Engås et al. 1996). Dalen and Raknes (1985, in Engås et al. 1996) suggested that cod may swim toward the bottom and remain immobile during disturbance by sound and Løkkeborg and Soldal (1993) have suggested that this change in behaviour could explain increases in catch rates of cod in saithe trawls during seismic activity. Chapman and Hawkins (1969) illustrated how whiting in mid-water schools moved deeper below air sleeves. Pearson et al. (1992) showed rock fish catches declined, mainly due to changes in fish depth rather than to dispersal of the shoals.

McCauley et al. (2000a, 2000b) summarized that many finfish species and squid display an alarm response of increased swimming speed, tightening schools and moving towards the sea floor at levels between 156 to 168 dB re 1m. A level of 156 dB re 1 m can be expected between 3 and 5 km from a 3-D array (2,678 in^3 100 to 120 m of water) and therefore it is the distance at which swimming speed may begin to increase. Active avoidance behaviour may begin at distances of 1 to 2 km from a source of this level. In water less than 50 m in depth, the affected area is 0.01 percent of the area affected by seismic activity in deep water (Turnpenny and Nedwell 1994).

Davis et al. (1998) summarized that most schools of fish will not show avoidance if they are not in the path of the approaching vessel. Schools that the vessel passes over may show lateral avoidance or compress towards the bottom. Observed responses indicate that the fish schools are quite variable and depend on species, life history stage, current behaviour, time of day, whether the fish have fed and how the sound propagates in a particular setting. Fish moving to the bottom appears to be a common response to seismic activity, especially for demersal or benthic species (see Davis et al. 1998). Seismic activity has also been demonstrated to reduce the density of demersal species several kilometres from the source, in up to 250 m of water (Engås et al. 1996).

There are studies that have reported an effect of vessel noise on fish flight behaviour in the context of population assessments and catch rates for commercially important fish stocks. Horizontal and vertical movements away from vessels have been reported for Atlantic herring and Atlantic cod (Vabø et al. 2002; Handegard et al. 2003) presumably in response to ship noise. Another example concerns effects of nearby boating noise on bluefin tuna in large oceanic pens. In the presence of boat noise, tuna schools were less coherent than when the noise was not present and individual fish often swam independently towards the surface or the bottom (Sarà et al. 2007). Fish have also been reported to flee from seismic shooting areas as inferred from decreased catches.

Studies have shown a startle response to received sounds as low as 160 dB, but this level sound did not appear to elicit a decline in catch (Pearson et al. 1987, 1992; Skalski et al. 1992). The basis for the decrease in catch is not clear, and it should be noted that, for the most part, there was no actual visual observation of the behaviour of the fish during airgun exposure.

Engås et al. (1996) and Engås and Løkkeborg (2002) examined the effects of a seismic exploration on fishing success for haddock and Atlantic cod. They found that, compared to pre-seismic catches, there was a significant decline in the long-line catch rate during and after the seismic study. The catch rate did not return to normal for at least five days after the end of the seismic study. More recently, the same group used sonar to observe the behaviour of blue whiting and Norwegian spring spawning herring during a seismic operation and observed that fish would move away from the seismic source and not return until after the activity had stopped (Slotte et al. 2004).

The often contradictory results of these studies demonstrate the paucity of scientific data, the general lack of understanding of hearing in fish, and may represent the differences in the effects of sound of fish that are hearing specialist versus hearing generalist. There is evidence that suggests that sounds associated with research and fish vessels may impact studies (Mitson 1995; Handegard et al. 2003; Mitson and Knudsen 2003), while other data suggest less of an effect from “quieted” ships (Ona et al. 2007; De Robertis et al. 2008). Therefore, studying responses of fish from a vessel might in actuality provide results that do not reflect the fish behaviour that would occur if the research vessel were not present.

The lack of swim bladder in shrimp, crab and lobster should also make these species less sensitive to sound. Large displacements of macroinvertebrates through avoidance behaviour are very unlikely (Turnpenny and Nedwell 1994). Christian et al. (2003) reported no drastic decrease in catch rate for snow crab during an experimental commercial fishery conducted before and after an area was exposed to seismic shooting. However, study limitations were noted including variability in set durations and a relatively low number of sets conducted.

7.1.6 Atmospheric Emissions

Atmospheric emissions will occur from the drilling rig during exploration drilling. However, all equipment is designed to meet regulatory requirements for emissions and regular maintenance plans ensure equipment operates as efficiently as possible. There is ample assimilative capacity for emissions resulting from Project activities because of the strong average winds at the site. There will be negligible environmental effects to air quality beyond the safety exclusion zone.

7.1.7 Well Abandonment / Suspension

All wells will eventually be abandoned following the completion of drilling, any well testing activities, and production. Well abandonment procedures will follow industry standard practices, in accordance with C-NLOPB regulations.

The typical abandonment process for a well consists of placing mechanical and cement plugs at strategic depths in the wellbore to separate and permanently seal off zones of varying ages and pressures. This process isolates these zones from each other and prevents any subsurface fluids (including oil, natural gas and brine) escaping from the wellbore in the future.

For this Project, depending on the preliminary information received during drilling, the exploration well may be suspended for future re-entry. The wellbore would be plugged below the seafloor using mechanical and/or cement plugs in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2011). A suspension cap would be installed to protect the wellhead connector for potential future re-use.

If the offshore well is abandoned, the wellhead may be removed, or in some cases, approval may be granted for leaving the wellhead in place. When the wellhead is removed, the wellhead and associated equipment are removed to at least 1 m BSF. This is typically performed using mechanical cutters from the drilling unit. However, there are cases that require subsea cutting involving the use of shaped explosive charges. This option is employed only in instances where mechanical removal has failed. It is a requirement that operators have authorization from C-NLOPB before shaped charges are used. If approval is granted for leaving a wellhead in place, several factors are considered, including the occurrence and type of fishery in the area, as well as water depth at the location of the wellhead.

Typical effects associated with well abandonment and suspension are noise (Section 7.1.5.3) and physical disturbance of the bottom in the immediate area surrounding the wellhead.

7.2 Species at Risk

Species at risk are considered a VEC in this environmental assessment because certain bird, fish, marine mammal and turtle species that may occur within the Study Area have been assessed as species at risk listed under Schedule 1 of the SARA, the official list of wildlife and plant species at risk in Canada. It legally protects those species classified as extirpated, endangered, threatened, or of special concern. Once a species is listed on Schedule 1, measures to protect it and its critical habitat and help its recovery are implemented. Section 32 of SARA prohibits killing, capturing and destruction of critical habitat for those species listed on Schedule 1 as extirpated, endangered and threatened. Species designated by COSEWIC, but not listed under SARA are also considered in this VEC.

Potential interactions, between species at risk and routine Project activities include:

- environmental effects associated with the presence of drilling platform and related lights;
- environmental effects associated with discharge of drill mud and cuttings;
- environmental effects associated with the discharge of waste and wastewater;
- environmental effects of sound from all routine exploration drilling activities (including support vessels and VSP profiling); and
- environmental effect from collisions with vessels.

The effects of accidental events are assessed in Chapter 8. Cumulative environmental effects in consideration with other projects and/or activities are assessed in Chapter 9.

7.2.1 Residual Environmental Effects Significance Criteria

A significant adverse residual environmental effect to Species at Risk is one that:

- jeopardizes the achievement of self-sustaining population objectives or recovery goals;
- is not consistent with applicable allowable harm assessments;
- results in permanent loss of critical habitat as defined in a recovery plan or an action strategy; or
- an effect for which an incidental harm permit would not likely be issued.

Due to the sensitive nature of Species at Risk, residual adverse environmental effects on one individual may be considered significant.

An adverse environmental effect that does not meet the above criteria is considered to be not significant.

7.2.2 Effects Assessment

The primary interactions between Species at Risk and routine Project activities will result from drill cuttings and sound associated with the drilling platform and VSP surveys. As many Project-related activities are limited to the Project Area, they would only interact with species likely to occur in EL 1105. Species which occur in the nearshore of the Study Area would only interact with supply vessel and helicopter traffic. These distinctions are identified and characterized below.

7.2.2.1 Presence of the Drill Platform

Marine Fish Species at Risk

Water depths at the wellsite are approximately 470 m which influence the marine fish species at risk likely to occur in the Project Area. Species with a moderate to high potential to occur in the Project Area include wolffish, Atlantic cod, redfish, American plaice and Atlantic Bluefin tuna. Other marine fish species identified in Tables 5.1 and 5.2 are considered to have a lower potential for occurrence in the Study Area. This includes winter skate, roundnose grenadier, porbeagle shark, white shark, Atlantic salmon, shortfin mako, striped bass, cusk, roughead grenadier, spiny dogfish, blue shark, basking shark, and American eel. The occurrence of these species in the Project Area or Study Area would be a more transient and infrequent occurrence.

Since wolffish, cod, and plaice are benthic species, they are not expected to be attracted to the surface by increased illumination due to the rig and vessel lights or flares. Redfish are also benthic, but are pelagic or bathypelagic feeders, rising off the bottom at night to feed and could therefore be attracted to the platform’s lights. Other species with low potential for occurrence in the Project Area could also occasionally be attracted to the light or because of the artificial reef effect.

Existing knowledge related to the effects of the presence of the drill platform, safety zone, lights and flaring have been discussed in Section 7.4.1, including information applicable to marine fish species at risk. If individuals are attracted to the rig, this would represent a temporary refuge due to the FEZ. Since the rig would be present for 25 to 50 days, the above effects would be localized, short-term and reversible. No significance residual adverse environmental effects are predicted.

Marine Bird Species at Risk

The Ivory Gull is an unlikely visitor in the Project Area, except on those occasions where the pack ice extends into the Project Area. Due to the potential timing of the Project activities (i.e., drilling would occur during ice free periods) and the unlikelihood of the Ivory Gull being in the Project Area, it is also unlikely that light attraction would be an issue for this Species at Risk. All other marine birds considered within this VEC would occur in nearshore / coastal waters of the Study Area and would therefore not interact with the presence of the drilling platform.

Marine Mammal and Sea Turtle Species at Risk

The potential interaction between the presence of the drilling platform and marine mammals and sea turtle species at risk is limited. Artificial light might attract prey species of marine mammal and sea turtle Species at Risk and result in a positive environmental effect on its habitat use; however, the sound emission associated with the VSP and drilling noise would result in avoidance or temporary displacement, negating any potential positive effect. The Project Area does not represent any known critical habitat for any of the species that may pass through the area. The MODU is not expected to present any physical obstruction as marine mammals / sea turtles will avoid collision with stationary structures of this size (the risk of collision with vessels is assessed separately below in Section 7.2.2.4). The residual adverse environmental effects are therefore assessed as not significant.

7.2.2.2 Drill Muds and Cuttings

Marine Fish Species at Risk

The primary effect of SBM and WBM discharges on marine fish Species at Risk is the physical disturbance near the drill site. Contamination of the fish or their prey is of limited concern due to the spatial extent of the drilling discharge deposition and related potential effects. Potential effects to marine fish species at risk include avoidance of the area of drilling discharge deposition and smothering of potential prey of marine species at risk. The smothering effect is a localized effect that is restricted generally to 100 m or less from the drilling platform (more information on smothering is provided in Section 7.1.2). The Project Area does not represent any important habitat for these species with the exception of redfish (further assessed in Section 7.7) and therefore any temporary avoidance of the wellsite would not result in any significant effects.

Marine Bird Species at Risk

There is no interaction expected between the drill muds and cuttings and marine bird Species at Risk. As identified above, the Ivory Gull is the only species that may occur in the Project Area and this rare occurrence is unlikely to overlap temporally with the Project. The effects associated with drill muds and cuttings are mostly associated with the benthic environment and unlikely to contaminate food for marine birds.

Marine Mammal and Sea Turtle Species at Risk

The discharge of drill muds and cuttings are not expected to interact with marine mammal species at risk directly, since mammals will likely avoid the immediate areas of discharge due to sound avoidance. Any potential of an indirect effect on these species would be as a result of an impact on their food supply, which is also unlikely since the drilling waste disposal to the seafloor will be localized near the rig. Fin, right and blue whales feed on plankton and on small schooling fish, like capelin, from the water column, which will not be affected by the discharge of drill waste. As well, harbour porpoise feed primarily on schooling fish from the water column.

As with the mammal species at risk, the sea turtles will not likely be affected by the discharge of drilling mud and cuttings due to avoidance of the immediate area and because they feed primarily on jellyfish. The residual environmental effects are predicted to be not significant.

7.2.2.3 Routine Discharges

Marine Fish Species at Risk

Existing knowledge related to the effects of routine discharges have been discussed in Section 7.1.3 and would be applicable to marine fish, including species at risk. Routine discharges will be of limited duration and frequency over the drilling period and will comply with applicable regulations. Any discharge with potential for toxicity to the marine environment is regulated and monitored for compliance, so the risk of contamination of biota is limited. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria. The effects of this relatively small amount of waste and wastewater on marine fish Species at Risk over a limited time period are considered not significant.

Marine Bird Species at Risk

While gulls can be attracted to discharges of sanitary and food waste, the potential for interaction between routine discharges and marine bird Species at Risk would again be limited to the Ivory Gull and interaction is considered unlikely given the rarity of the occurrence of this species in the Project Area and the potential timing of this occurrence (i.e., associated with presence of pack ice). Should the Ivory Gull interact with routine discharges, the adverse residual effect is predicted to be not significant. Minimal effects of cooling water are expected due to low use concentrations, large dilution factors and the small area of any thermal effect. Residual hydrocarbons in discharges are generally not associated with the formation of a slick, as discharges will comply with the OWTG and ship operations will adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). The waste generated by the Project (including any recyclables) will be limited due to the length of the drilling program and will be brought back to shore.

Marine Mammal and Sea Turtle Species at Risk

Marine mammals and sea turtle Species at Risk are unlikely to be directly or indirectly affected by the waste discharges from the rig as they are likely to avoid the noise from rigs and therefore the associated discharges. Any contact with the rig discharges will likely be short-term. All drilling discharges will meet the OWTG which were established to protect the environment. Rig discharges are expected to be temporary, non-bioaccumulating, non-toxic in nature, and subject to high dilution in the open ocean. Thus, the residual adverse environmental effect of waste and wastewater from routine Project activities on marine mammals and sea turtles species at risk is predicted to be not significant.

7.2.2.4 Supply Vessels

Marine Fish Species at Risk

Potential interactions between support vessels and this VEC are mostly related to noise generated by the vessels. The effects of ship lights would be the same as for the drilling platform, assessed in Section 7.4.2.1. Most available literature indicates that the effects of noise on fish are transitory and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible effects on individuals and populations. Existing knowledge related to the biological effects of noise (including vessel traffic) on marine fish is described in detail in Section 7.1.5.3. The effects of noise on marine fish Species at Risk are also further assessed below in Section 7.2.2.5. As vessel traffic would be a less intense noise source than VSP surveys, the effects would also be less. All vessels will comply with Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and the *Canada Shipping Act*. The residual environmental effect associated with the short-term and slight increase in vessel traffic within the Study Area as a result of this Project is predicted to be not significant.

Marine Bird Species at Risk

As supply vessels and helicopter traffic will travel between the Project Area and Newfoundland, there is potential for this routine Project activity to interact with any of the marine bird Species at Risk that occur within the Study Area (any support vessels that may come from St. John's, NL, will use the recognized shipping lane through the Laurentian Channel). This includes the following species protected under SARA: Ivory Gull; Piping Plover; Barrow's Goldeneye; and Harlequin Duck. Some species listed under SARA (i.e., Eskimo Curlew and Roseate Tern) are considered unlikely to occur in the Study Area so the potential for interaction with supply vessels or helicopters are also considered unlikely.

Marine birds in the Study Area should be habituated to vessel activity and direct effects are not anticipated as these species are highly mobile and can avoid vessels by flying or diving. Energy expended during these events would be minimal and have no physiological effect on the birds.

With respect to helicopter traffic, research has shown that seabirds react most strongly to low-level flights and the effects of these responses tend to be short-lived. Helicopter overflights at

300 m failed to cause a visible reaction among moulting sea ducks in the North Sea, while overflights at 100 m resulted in short-term avoidance reactions (Ward and Sharp 1974). Helicopters servicing the Project will avoid major colonies and will fly at a minimum of 600 m above sea surface whenever possible, limiting potential for disturbance. When taking off and landing on the drilling platform, marine birds in the vicinity may be disturbed; however, this issue would be limited to the Ivory Gull, which is considered an unlikely to occur during the Project timeframe.

Supply vessels travelling from Newfoundland to the Project site will follow established shipping lanes and will comply with applicable pollution prevention regulations. The volume of increased vessel traffic as a result of the Project will be minimal and short-term. Residual adverse environmental effects of ship and helicopter traffic on marine bird Species at Risk is predicted to be not significant.

Marine Mammal and Sea Turtle Species at Risk

As indicated by the existing knowledge presented in Section 7.1.4, toothed whales and pinnipeds are rarely struck by vessels as they are fast swimming and agile, enabling them to avoid approaching vessels. The most commonly struck of all marine mammals are the baleen whales, which are large, slow-moving animals often unable to react fast enough to avoid approaching vessels, particularly vessels traveling at more than 14 knots. If a mammal is in the path of a vessel, every safe effort will be made by the vessel operator to avoid collision, if the mammals has not moved upon approach. By nature of the slow and steady movement of each vessel during this Project, and the practice of avoiding concentrations of marine mammals, the risk of collision is low.

There is limited information pertaining to the potential effects of vessel traffic on sea turtles. Studies, as described in Section 7.1.4, suggest that some sea turtles exhibit behavioural changes and/or avoidance within an area of unknown size near a seismic vessel. However, avoidance of approaching supply vessels is sufficiently limited and small-scale such that sea turtles are often seen from operating supply vessels. Therefore, the most likely effect on sea turtles is that they will temporarily avoid an area due to noise, with the spatial extent of any such temporary disturbance from an approaching supply vessel likely being small.

Helicopter traffic noise may elicit diving behaviour in many marine species. Minke whales have changed course or gone into a slow dive in response to helicopters flying at an altitude of 230 m (Leatherwood et al. 1982) and seals may also dive in response to low-flying aircraft. However, the effect is temporary.

Given the temporary and reversible nature of any disturbance and behavioural effects and the mitigation in place to avoid the potential for collisions, the environmental effect of vessel and helicopter traffic on marine mammals and sea turtle species at risk is predicted to be not significant.

7.2.2.5 Drilling Noise / Vertical Seismic Profiles

If one examines sounds based on a hierarchal effect, then the most intense sounds associated with the proposed undertaking would most likely be associated with the seismic sources used in the VSP survey, followed by the drill platform and related operations, support vessels and helicopters. Much of the information presented on sound in subsequent sections will be related to seismic sources, as seismic sound sources using a risk management process has the potential to produce the more pronounced responses as it will be the most probable source of the most intense sounds undertaken as part of the exploration drilling activities. The information presented on sound is based on the traditional 2-D or 3-D seismic surveys and not the lower intensity sounds associated with VSP surveys.

Marine Fish Species at Risk

Sound likely to be generated by Project activities (including drilling and VSP surveys) and the likely biological effects of this sound is presented in detail in Section 7.1.5 and related subsections. Specifically, existing knowledge regarding the biological effects of sound on fish is presented in Section 7.1.5.3 and would be considered applicable to Species at Risk. Where specific information is available for the species at risk that may occur in the Project Area, it has been included below.

The *Recovery Strategy for Northern Wolffish and Spotted Wolffish and Management Plan for Atlantic Wolffish in Canada* (Kulka et al. 2007) specifically addresses the potential effects of seismic activity (not VSP surveys in particular) on wolffish. While the report concludes that the effect of seismic activity needs to be quantified with respect to wolffish and their habitat and little is known about the possible effect on wolffish species at any stage of their life history, it is acknowledged that there are no documented cases of mortality of any fish species upon exposure to seismic sound under field operating conditions (DFO 2004e). Kulka et al. (2007) speculate that it is possible that wolffish adults guarding nests could leave the area of disturbance to the detriment of the egg cluster, although there is no information to confirm potential effects for wolffish. There are no reports of either of the wolffish species spawning within the Project Area. A study by DFO (2004e) determined that oil and gas exploration activities are considered to have negligible effects on the ability of both northern and spotted wolffish to survive and recover.

Atlantic cod may also occur within the Project Area. Compared to other species, cod is considered a moderately sensitive species in terms of hearing. A measurable behavioural response is anticipated in the range of 160 to 188 dB re 1 µPa (Turnpenny and Nedwell 1994), which may be expected from this Project; temporary avoidance of the immediate area around the sound may be a result. DFO (2004a) concludes that some fish exposed to seismic sounds are likely to exhibit a startle response, a change in swimming pattern and/or a change in vertical distribution. However, these effects are expected to be short term and of low ecological significance except where fish reproductive activity may be affected. The greatest risk from sound would also apply to cod eggs and larvae near the surface. No measurable effect of sound on cod is expected due to the low probability of spatial and temporal overlap between the VSP survey of two to three days and the presence of cod eggs and larvae near the source.

Because of their long lifespan, slow growth rate and late maturity, Redfish are considered to have low resilience, with the principal threats identified as directed fisheries and bycatch (COSEWIC 2010b).

Sarà et al. (2007) studied the response of bluefin tuna in the Mediterranean Sea to noise from vessels. They studied semi-captive fish and their response to sound generated by hydrofoil passenger ferries, small boats and large car ferries. Authors reported that in response to approaching vessels, tuna changed swimming direction and increased their vertical movement toward surface or bottom, with the school exhibiting an unconcentrated structure and uncoordinated swimming behaviour. Hydrofoils appeared to elicit a similar response, but for shorter periods. As schooling enhances tuna homing accuracy during their spawning migration, alteration in this behaviour can affect the accuracy of their migration to spawning and feeding grounds. Iversen (1967, in Sarà et al. 2007) tested yellowfin tuna (*Thunnus albacares*) and determined that the greatest sensitivity occurs between 200 and 800 Hz, where the mean thresholds ranged from 89 to 100 dB re 1 µPa. This evidence concurs with that of the vast majority of fish studied to date which appear to have a relatively narrow audible frequency range (Popper 2000).

Noise from a seismic source array used in VSP or geohazard surveys may cause mortality of fish eggs and larvae within tens of meters, if they come near the source. Physical effects on fish may occur within a few hundred meters of this magnitude sound source, but no mortality of fish is expected. Fish will likely be startled and avoid the area temporarily within a few kilometres. Due to the spatial limits of mortality and potential physical effects, and due to the temporary nature of behavioural effects, noise is considered a not significant environmental effect on marine fish Species at Risk.

Marine Bird Species at Risk

The Ivory Gull is an unlikely visitor in the Project Area except on those occasions where the pack ice extends into the Project Area. The risk of hearing impairment to Ivory Gull from VSP surveys is low as this species would not spend considerable amounts of time below the surface of the water or in close proximity to airgun pulses. It is also unlikely that the Ivory Gull would be feeding beneath the surface at the same time a geohazard streamer is activated. The residual adverse environmental effect of sound sources on marine bird Species at Risk is predicted to be not significant.

Marine Mammal and Sea Turtle Species at Risk

In general, avoidance of the Project Area by marine mammal species at risk is not expected for prolonged periods as the exploration drilling is anticipated to be undertaken over a period of 20 to 50 days. Project activities may illicit a startle response, causing increased heart rate and breathing or a change in swimming path, but these responses are not considered biologically critical (Erbe 2000). If the opportunity for feeding is presented to marine mammal species at risk within the Project Area, they may tolerate sound they may otherwise avoid while feeding (Wartzok et al. 2004) and then move out of the Project Area.

The spatial extent of any such avoidance behaviour by humpback and minke whales can be expected to be 0.5 to 1 km. Humpbacks exhibited no avoidance when exposed to simulated semi-submersible and drill platform sounds (Malme et al. 1985). Whales known to exhibit long distance avoidance, such as Northern Atlantic right and bowhead (*Balaena mysticetus*) whales, are not known to occur within the Project Area. Under typical ambient sound conditions, low frequency sound from a drilling platform might be detectable no more than 2 km away near a shelf break (Richarson and Malme 1995). The effect of sound on marine mammals is considered highly reversible; therefore, once the source is removed, marine mammals are expected to return to the area (Davis et al. 1987).

It is probable that any behavioural changes in baleen whales, toothed whales, pinnipeds and sea turtles (including species at risk) triggered by a MODU and its support vessels will be temporary. The proposed surveys(s) are of short duration and will occur over a relatively small area within the Project Area boundary. Thus, disturbance from vessel traffic is expected to be low.

Avoidance of the Project Area by sea turtles as a result of sound is also not expected to cause any adverse biological effects given that the area is not known to congregate jellyfish, a primary prey item. Jellyfish are transitory, with distributions changing within and between years, so there is no more reason to expect jellyfish within the Project Area than any other area of the Gulf. Furthermore, the Project Area is not an area that would be used for nesting or hatching.

Overall, the residual adverse effects of Project-related noise from drilling, ships and VSPs is not predicted to result in any significant residual adverse environmental effects.

7.2.2.6 Atmospheric Emissions

Atmospheric emissions will occur from the drilling rig during exploration drilling and could interact with marine bird Species at Risk that are present in the Project Area (i.e., the Ivory Gull). All equipment is designed to meet regulatory requirements for emissions and regular maintenance plans ensure equipment operates as efficiently as possible. There is ample assimilative capacity for emissions resulting from Project activities because of the strong average winds at the site. There will be negligible environmental effects to air quality beyond the safety exclusion zone. Therefore, the effects of atmospheric emissions on marine birds including Species at Risk will be not significant.

7.2.2.7 Well Abandonment / Suspension

During well abandonment / suspension, any noise would be similar to the noise associated with drilling and would be temporary and localized. Permanent alteration of habitat would be localized to the immediate area of the wellhead. No significant adverse environmental effects are predicted on any species at risk as a result of this activity.

7.2.3 Mitigation

Based on the potential interactions identified above and existing knowledge regarding these interactions, the following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on species at risk have been identified:

- the vessel will be monitored for stranded marine bird Species at Risk;
- use of a trained marine mammal observer during VSP activities;
- adherence to all relevant mitigation standards as outlined in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011b) (including the appended Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment) during any VSP activities;
- use of water-based drilling muds wherever possible;
- use of non-toxic or low toxicity chemicals and muds, and treating synthetic oil-contaminated cuttings as per the OWTG;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible; and
- all equipment designed to meet regulatory requirements for emissions and regular maintenance plans to ensure equipment operates as efficiently as possible.

7.2.4 Residual Environmental Effects

A summary of potential environmental effects on Species at Risk is provided in Table 7.8. Based on existing knowledge of the effects of exploration drilling program activities on species at risk and with the mitigation that will be implemented, routine Project activities are predicted to have only minor environmental effects on Species at Risk. As no non-permitted contravention of any of the prohibitions stated in Sections 32 to 36 of *SARA* will occur, the residual adverse environmental effects of the Project on Species at Risk is predicted to be not significant.

Table 7.8 Potential Environmental Effects Assessment Summary – Species at Risk

Project Components / Activities	Potential Interactions/ Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Presence of Drilling Platform (including safety zone, lights, flaring)	Behavioural effects (A) Artificial reef effect, increased food and shelter (P) Attraction/stranding (A)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1
Drill Mud and Cuttings	Loss of habitat (A) Contamination (A)	Use of WBMs where feasible; Treatment of mud and compliance with OWTG	1	1	6	4	R	1

Project Components / Activities	Potential Interactions/ Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	Nutrient enrichment (A/P); Contamination (A)	Solid waste transported to shore; Adherence to MARPOL 73/78 and *Pollution Prevention Regulations* Compliance with OWTG	1	1	6	2	R	1
Support Vessels (supply boat and helicopter)	Attraction or Avoidance (A); Collision resulting in injury or mortality(A)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1
VSP Survey / Drilling Noise	Mortality (eggs and larvae) (A) Behavioural and Physiological Effects (A); Avoidance (A)	Adherence to *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*	1	1	6	1	R	1
Routine Air Emissions	Avoidance (A)	Proper equipment inspection / maintenance practices	1	1	6	2	R	1
Well Abandonment / Suspension	Behavioural effects (A)		1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

7.3 Marine Ecosystems

A healthy marine ecosystem supports the biological communities and socio-economic uses of the marine environment. The marine ecosystem includes water (including plankton) and benthic (including coral) communities. It is identified as a VEC as effects to the marine ecosystem can in turn affect other marine components including fish and fish habitat, marine mammals and marine birds. It was also identified for consideration in the Scoping Document (C-NLOPB 2011a). This assessment focuses in particular on potential Project effects on corals and plankton. Assessment of Project effects on pelagic and benthic fish species is provided in Section 7.4. As stated in Section 5.3.3, sea pens are present but not common in the Project Area; deep-water corals and sponges are not considered likely in this area.

Kelp forests were also identified in the Scoping Document (C-NLOPB 2011a) as an important component of marine ecosystems. Kelp forests occur in nearshore areas and therefore the only potential interactions with routine Project effects would be supply vessel traffic to and from the Project site. Vessels will follow existing shipping routes and will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and Pollution Prevention Regulations of the *Canada Shipping Act.* Therefore, any routine interactions between supply vessels and kelp forests would be limited in nature and have not been further assessed.

In this section, the potential effects of routine Project activities on the Marine Ecosystem are evaluated. The effects of accidental events are assessed in Chapter 8. Cumulative environmental effects in consideration with other projects and/or activities are assessed in Chapter 9.

7.3.1 Residual Environmental Effects Significance Criteria

A significant adverse environmental effect is defined as one that affects the marine ecosystem physically, chemically, or biologically, in quality or extent, to such a degree that there a decline or change in abundance and/or distribution of marine populations in the Study Area and natural recruitment (reproduction and in-migration from unaffected areas) may not re-establish these population to its original (i.e., pre-Project) level within several generations or avoidance of the area becomes permanent.

A not significant adverse environmental effect is defined as an adverse effect that does not meet the above criteria.

7.3.2 Effects Assessment

7.3.2.1 Presence of Platform

During drilling, the seafloor will be affected by physical disturbances, including the drilling of one well in the seafloor, placing the drill plate on the seafloor, placing anchors, retrieving anchors, and removing the drill plate. Effects may include direct smothering, increased turbidity, physical disturbance, and elevated levels of metals on the seafloor and water column. Physical disturbances on the soft seafloor are expected to cause temporary changes in species abundance or composition. The infaunal community in these habitats is expected to rapidly repopulate or recolonize and changes are likely well within natural variability from the natural disturbance regime (i.e., sediment transport during severe storms).

Deepwater corals are susceptible to physical damage and consequential reductions in their populations in many areas through human activities such as bottom trawling (Dayton et al. 2002). The very long growth period required for large corals makes them of particular concern. As described above, sea pens are known to occur in the Project Area and can be sensitive to anthropogenic activities (OSPAR Commission 2010). The highest threat was identified as habitat degradation through physical disturbance as a result of bottom trawling. Large, slow-growing species such as sea-pens were found to be particularly vulnerable to trawling disturbance, while smaller individuals and species suffer lower mortality rates (Dinmore et al. 2003).

The direct footprint of exploratory or production drilling for oil and natural gas has the potential to damage or destroy cold-water corals and sponges, if sited atop or in close proximity to cold-water coral or sponge communities. Physical damage in the form of breakage and dislodgement of organisms and hard substrate, and/or crushing of cold-water corals and sponges can result from anchoring of support and transport vessels, anchoring of semi-submersible drilling units, platform installation and chains associated with moorings (Cimberg et al. 1981, Raimondi et al. 1997; Freiwald et al. 2004; Lophelia 2010).

Based on a review of seafloor video taken at the Old Harry Site as part of the Geohazard Survey (see Section 5.4.1), physical disturbance of corals as a result of the platform placement will be minimal. Due to the relatively small size of potential disturbance, and the fact that corals, other than small numbers of sea pens, are not likely to occur in the Project Area as per the seabed video, residual effects will be not significant.

The presence of lights on the platform may also affect plankton. Many planktonic species and life stages are phototaxic; floating to near surface during the day and settling to deeper water at night. Any lights on the water at night may attract nekton that have active swimming ability. This affect would be localized and temporary, reversing once the drilling period is over.

7.3.2.2 Drill Muds and Cuttings

As discussed in Section 7.1.2 in detail, the effects of WBM, SBM and associated cuttings have been well studied. While the discharge of WBMs may increase metals in sediments, these increases are generally limited to within 250 to 500 m of the drill site and few if any biological effects have been associated with these increases (CAPP 2001b; Neff 2005). Most microcosm and field studies (Neff 2010) on the effects of WBM cuttings have shown no or minimal short term effects on zooplankton communities, and minimal effects on benthic macro- and mega-faunal communities (effects are generally restricted to within 100 m).

In comparing WBM and SBM discharges, the effects of SBM discharges are limited to benthic organisms. The water column effects (OPG 2003) from discharging SBMs are considered to be negligible due to the low solubility of base fluid of the SBM in seawater, low water column dispersion and residence time due to rapid settling rate, and the fact that drilling discharges are intermittent and transient. Biological effects of SBM cuttings on the benthos are expected to be similar to or greater than those of WBMs, with benthic communities taking longer to recover from SBM releases than WBM releases.

Corals and other hydrozoa, as well as sponges, have been shown in many areas to be sensitive to elevated suspended sediment concentrations (Moore 1977). Settling WBM and cuttings could lead to short-term elevated suspended particulate matter concentrations in near-seabed zones, and at high levels could impact particle-feeding organisms (e.g., corals, sponges and anemones). While it was recognized that offshore oil rigs and other oil installations can cause a variety of disturbance effects, such as smothering due to disposal of drill cuttings, the OSPAR Commission (2010) considered threats to sea pens in the North Sea and ranked potential alteration or loss of habitat due to oil and gas activities as low. Re-suspension of fine mud particles by bottom trawling and the resulting sedimentary modification was identified as a main threat. Any effects on sea pens as a result of drilling for this Project would likely be limited to within 500 m of the drill site.

Given both the short-term and localized nature of predicted effects, the residual effects of drill muds and cuttings on the marine ecosystem are predicted to be not significant.

7.3.2.3 Routine Discharges

All routine discharges associated with the exploration drill program will be discharged in accordance with the OWTG (NEB et al. 2010), including sanitary and waste water. Organic matter associated with discharges will disperse quickly in an open ocean environment and be quickly degraded by bacteria. The effects of this relatively small amount of organic matter and nutrients on the offshore marine environment will be negligible and not significant. Drilling will require seawater, most of which will be used as cooling water (non-chlorinated). The volume of entrainment will be low and the area of thermal effects small. Any discharge with potential for toxicity to the marine environment is regulated and monitored for compliance, so the risk of contamination of biota is limited.

7.3.2.4 Support Vessels

The aspects of the marine ecosystem being assessed as part of this VEC will have limited interactions with support vessels and helicopters and therefore this interaction is not assessed further.

7.3.2.5 Drilling Noise / Vertical Seismic Profiles

Existing knowledge related to the biological effects of sound on plankton and benthic organisms is presented in Section 7.1.5.3.

The US Minerals Management Service's environmental assessment of geophysical exploration in the Gulf of Mexico supports the conclusion that there is no documented evidence of a measurable impact to benthic communities from streamer surveys, vertical seismic profile surveys or remote sensing surveys (MMS 2004). Vertical seismic profile impulses may cause mortality in plankton and ichthyoplankton near the source, but the spatial (metres) and temporal (two to three days per well) scales are considered to result in not significant residual environmental effects.

7.3.2.6 Atmospheric Emissions

Air emissions are not expected to interact with or affect the aspects of the marine ecosystem being assessed in this VEC and therefore this activity is not assessed further.

7.3.2.7 Well Abandonment / Suspension

During well abandonment/suspension, any physical disturbance to the seafloor would be limited to the areas already disturbed during drilling. The immediate area of the wellhead will remain permanently altered. Noise would be temporary and localized.

7.3.3 Mitigation

The following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on Marine Ecosystems have been identified:

- use of water-based drilling muds wherever possible;
- use of non-toxic or low toxicity chemicals and muds, and treating synthetic oil-contaminated cuttings as per the OWTG;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible;
- adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment; and
- proper equipment inspection / maintenance practices to be in place to minimize emissions and discharges.

7.3.4 Residual Environmental Effect

A summary of potential environmental effects on the Marine Ecosystem is provided in Table 7.9. Given that predicted effects are short-term, localized and reversible, the residual environmental effects on Marine Ecosystems are predicted to be not significant. Note that an irreversible change in benthic habitat is predicted for the immediate location of the wellhead, but this effect is localized.

Table 7.9 Potential Environmental Effects Assessment Summary – Marine Ecosystem

Project Components / Activities	Potential Interactions/ Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Presence of Platform	Physical disturbance (A)	Proper equipment inspection / maintenance practices	1	1	6	2	R	1
Drill Mud and Cuttings	Smothering, contamination (A)	Use of water-based drilling muds wherever possible; use of non-toxic or low toxicity chemicals and muds, and treating SBM cuttings as per the OWTG	1	1	6	3	R	1

Project Components / Activities	**Potential Interactions/ Environmental Effects (positive (P) or adverse (A))**	**Mitigation**	**Potential Environmental Effects Summary**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological and Socio-Economic Context**
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	Nutrient enrichment, contamination (A)	Transport of solid waste to shore; Adherence to the Pollution Prevention Regulations and OWTG	1	1	6	2	R	1
VSP / Drilling Noise	Mortality (A)	Adherence to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*	1	1	6	1	R	1
Well Abandonment / Suspension	Physical Disturbance (A)	Well abandonment to follow industry standard practices, in accordance with C-NLOPB regulations	1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

Geographic Extent
1 = <1 km radius
2 = 1-10 km radius
3 = 11-100 km radius
4 = 101-1,000 km radius
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6 = >10,000 km radius

Frequency
1 = <11 events/yr
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4 = 101-200events/yr
5 = >200 events/yr
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Duration
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

7.4 Marine Fish, Shellfish and Habitat

Marine Fish, Shellfish and Habitat includes the physical (e.g., substrate, temperature, water depth), chemical (e.g., nutrients), and biological (e.g., benthic invertebrates, marine plants) attributes of the environment that are required by marine fish to carry out life cycle processes (e.g., spawning, rearing, feeding, overwintering, migration). Several commercial species of fish and shellfish have spawning, feeding and nursery habitats within the Gulf. Environmental effects of the routine Project activities on fish and fish habitat resulting from an exploration well are assessed in this section. Marine Fish, Shellfish and Habitat is selected as a VEC because of the potential for direct interaction with the Project. Specifically, it was selected as a VEC because of:

- specific regulatory requirements of the *Fisheries Act*;
- the direct interaction between marine habitat and routine Project activities; and
- the ecological, recreational and commercial importance of marine habitat to the public.

The environmental impact assessment focuses on relevant aspects of fish, shellfish and fish habitat. Potential interactions with routine Project activities include:

- environmental effects associated with the presence of drilling platform and related lights;
- environmental effects associated with discharge of drill mud and cuttings;
- environmental effects associated with the discharge of waste and wastewater; and
- environmental effects of sound from all routine exploration drilling activities (including support vessels and VSP profiling).

A detailed list of the potential interactions between the Project and Marine Fish, Shellfish and Habitat is provided in Table 7.1. In this section, the potential effects of routine Project activities are evaluated. Species of Marine Fish listed under SARA or considered at risk by COSEWIC are assessed within the Species at Risk VEC (Section 7.2). The effects of accidental events are assessed in Chapter 8. Cumulative environmental effects in consideration with other projects and/or activities are assessed in Chapter 9.

7.4.1 Residual Environmental Effects Significance Criteria

A significant adverse environmental effect is defined as one that affects fish and/or shellfish populations, or a portion thereof, in such a way as to cause a decline or change in abundance and/or distribution of the population over one or more generations. Natural recruitment (reproduction and in-migration from unaffected areas) may not re-establish the population to its original (i.e., pre-Project) level within several generations or avoidance of the area becomes permanent.

For potential environmental effects on fish habitat, a significant adverse residual environmental effect would be one that results in an unmitigated or non-compensated net loss of fish habitat as required in a *Fisheries Act* harmful alteration, disruption or destruction authorization (HADD).

An adverse environmental effect that does not meet the above criteria is considered to be not significant.

A positive effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for fish and/or shellfish.

7.4.2 Effects Assessment

7.4.2.1 Presence of Platform

Existing knowledge related to the effects of the presence of the drill platform, safety zone, lights and flaring have been discussed in Section 7.4.1, including information applicable to fish, shellfish and fish habitat. As stated earlier, the presence of the drill platform may result in an artificial reef effect, where the drill platform provides shelter for species of fish and shellfish, especially juveniles. In the short-term, this could alter the local abundance and distribution of fish, thereby concentrating food sources that may attract marine mammals, sea turtles and marine birds to the drill platform. The FEZ may also serve as a refuge for some fish species, including commercially fished species.

There is some evidence that lights on the water may attract some fish species, including pelagic migratory fish species. This could make species more vulnerable to predation by marine mammals and marine birds that might also be attracted by the vessel lighting. Studies from the Pacific Coast report changes in juvenile herring and sand lance distribution at night, in artificially lighted areas (Nightingale and Simenstad 2002). Predators of these species may also have been attracted by the increase in juveniles under the lights (Nightingale and Simenstad 2002).

Since the rig would be present for 25 to 50 days, the above effects would be localized, short-term and reversible. No significance residual adverse environmental effects are predicted.

7.4.2.2 Drill Muds and Cuttings

Existing knowledge related to the effects of drill muds and cuttings are discussed in detail in Section 7.1.2, including toxicity of WBMs and SBMs and the results of field studies conducted on the fate of drill muds and cuttings in the environment. As described in Section 7.1.2.4, field studies (Neff 2010) found no evidence of ecologically significant bioaccumulation of metals and petroleum hydrocarbons by marine organisms residing or deployed in cages near WBMs discharges and no evidence of toxicity effects associated with WBMs constituents. Ecological effects are due to physical disturbances of water column and the benthic environment (a startle response and avoidance of the area of deposition may be elicited in motile benthic species and smothering of sessile organisms). The effects of SBM discharges are considered to be limited to the benthic environment. Therefore, additional information on the effects of drill muds and cuttings on shellfish is provided below.

The deposition of WBMs (and SBMs) may result in physical smothering of benthic organisms. The initial deposition of cuttings may also impact bottom-dwelling animals by altering the sediment particle size distribution of the substrate (OGP 2003). Since SBMs are biodegradable organic compounds, their presence with the cuttings on the sediments may increase the oxygen demand in the sediments. The organic enrichment of sediment can lead to anoxic/anaerobic conditions as biodegradation of the organic material occurs. Anoxic conditions may also result from burial of organic matter by sediment redistribution. If anoxia is induced, benthic organisms that require oxygen for survival may not be able to compete with bacteria for oxygen. As a consequence, rapid biodegradation of SBMs may indirectly result in sediment toxicity (OGP 2003). Furthermore, if the concentration of hydrogen sulphide becomes elevated in the sediments, it may also impact benthic populations. As a result of these factors, benthic populations may be altered in the affected sediments until the SBMs have undergone sufficient degradation to mitigate the organic enrichment and organisms are able to recolonize the sediments.

A number of field and monitoring studies have been conducted that assessed the degradation rates of SBMs and the recovery rates of benthos (Jensen et al. 1999; Neff et al. 2000; OGP 2003; Roberts and Nguyen 2006). Ester-based fluids generally biodegrade rapidly and the benthos is mostly recovered within 11 months. Studies on olefin-based fluids have been conducted under a wide variety of conditions with varying results but degradation and benthic recovery may take from several months to several years depending upon a wide variety of factors. In general, benthos may require as many as three to five years to fully recover after discharge of SBMs (Neff et al. 2000).

The potential risk of drill cuttings discharges settling onto the seabed is the temporary effects of physical burial of benthic fauna (Daan and Mulder 1993). The effect of burial mainly depends on the mobility of organisms in the sediment matrix and on the settling rate of particles. Sedentary organisms, which have no or very limited abilities to move, such as attached barnacles or mussels, are very sensitive. Other species with a low capability to move through the sediment, such as certain bivalve species, may eventually suffer from low oxygen concentrations in the sediment (Essink 1999). Most species present in muddy sediments or in high-energy, dynamic sediments are, however, well adapted to changes in their substrate. Especially species with burying behaviour, experience hardly any effect (Bijkerk 1988, in Kjeilen-Eilertsen et al. 2004).

Although changes in benthic density and diversity from drilling muds have been detected within 1,000 m of drill sites, most of these effects are found within the 50 to 500 m range and are of short duration (Hurley and Ellis 2004). Additives to WBMs are selected for use in accordance with the Offshore Chemical Selection Guidelines (NEB et al. 2009), which ensures that the additives selected have an acceptable risk to the environment. Metals from WBMs and cuttings have not been demonstrated to cause biological effects (CAPP 2001a; Hurley and Ellis 2004).

Research indicates that sessile organisms are likely to be smothered in areas where cuttings are greater than 1 cm thick (Bakke et al. 1989). Since most sessile benthic species have short generation times, benthic communities are expected to recover within one year after drilling (Hurley and Ellis 2004; Neff 2005). Sessile epifauna such as bryozoans, barnacles, brittlestars and urchins will be smothered at various depths. Infauna such as most polychaetes, amphipods and clams are burrowing species and can be expected to resurface from a covering of several centimetres.

The direct footprint of exploratory or production drilling for oil and natural gas has the potential to damage or destroy cold-water corals and sponges, if sited atop or in close proximity to cold-water coral or sponge communities. Physical damage in the form of breakage and dislodgement of organisms and hard substrate, and/or crushing of cold-water corals and sponges can result from anchoring of support and transport vessels, anchoring of semi-submersible drilling units, platform installation and chains associated with moorings (Cimberg et al. 1981; Raimondi et al. 1997; Freiwald et al. 2004; Lophelia 2010). Discharges of drill cuttings, drilling mud and chemicals could smother, stress or physically damage the corals and their inhabitants (Freiwald et al. 2004; Lophelia 2010).

Any drill cutting and drilling mud released near cold-water corals and sponges has the potential to damage these organisms as a result of burial or smothering or due to increased levels of suspended sediments in the waters surrounding a drilling site. Relatively coarse-grained sediments and barite crystals trapped in coral polyps approximately 500 m down-current from a drilling site in the Træna Deep have been observed (Lepland and Mortensen 2008). Corals use a number of mechanisms to remove sediments; ciliary movements, mucus production, tissue expansion and movements of tentacles and sediment ingestion (Stafford-Smith and Ormond 1992; Riegl 1995). These are all energetically costly mechanisms and the energy investment may ultimately affect processes such as growth, reproduction and resistance to disease (Krone and Biggs 1980; Dallmeyer et al. 1982; Riegl and Branch 1995).

Several field and laboratory studies have been conducted on possible effects of sedimentation and drilling mud in corals. The majority of these studies have focused on sediment exposure and most of the studies species were tropical corals. There have been relatively few studies published on cold water corals, such as *Lophelia pertusa* (Gass 2006; Gass and Roberts 2006; Lepland and Mortensen 2008; Brooke et al. 2009). Polyp mortality and increased mucus production / secretion seem to be the most reported effects / responses.

Results from laboratory studies have suggested an apparent weight loss of sea scallop somatic and reproductive tissues when exposed to ParaDrill IA (SBM type typically used for drill programs on the Grand Banks) at concentrations of 1.5 mg/L; however, the effects were reversed after exposure ceased and little effect was noted at lower concentrations (Armsworthy et al. 2005). The authors also concluded that the fine particles of bentonite and barite found in drill mud is most likely the primary cause of effects on scallop tissue growth. Hamoutene et al. (2004) exposed lobsters to the SBM (IPAR) over a 20-day period and concluded that there was little or no potential for negative effects.

While the drill plan is not to use SBMs unless technical challenges determine that the use of SBMs is required to safely complete the planned well, information of SBMs are provided as a contingency. The primary effect of WBMs will be the smothering of benthos near the drill site. Effects will range from eliciting a startle response (avoidance of the area of deposition) in motile benthic fish and shellfish to smothering of sessile invertebrates. Effects will localized to within 500 m of the drill site and if SBMs are used, the benthic environment is expected to recover within three to five years. No significant residual effects are predicted.

7.4.2.3 Routine Discharges

The effects related to routine discharges have been discussed in Section 7.1.3. Routine discharges will be of limited duration and frequency over the drilling period and will comply with applicable regulations. Any discharge with potential for toxicity to the marine environment is regulated and monitored for compliance, so the risk of contamination of biota is limited. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria. The effects of this relatively small amount of waste and wastewater on Marine Fish, Shellfish and Fish Habitat are considered not significant.

7.4.2.4 Support Vessels

Potential interactions between support vessels and this VEC are related to noise generated by the vessels. This interaction is assessed in Section 7.4.2.5. The effects of ship lights would be the same as for the platform, assessed in Section 7.4.2.1.

7.4.2.5 Drilling Noise / Vertical Seismic Profiles

Sound likely to be generated by Project activities (including drilling and VSP surveys) and the likely biological effects of this sound is presented in detail in Section 7.1.5 and related subsections. Specifically, existing knowledge regarding the biological effects of sound on fish and shellfish is presented in Section 7.1.5.3.

Most available literature indicates that the effects of noise on fish are transitory and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible effects on individuals and populations.

Noise from a seismic source array used in VSP or geohazard surveys may cause mortality of fish and shellfish eggs and larvae within tens of meters, if they come near the source. Physical effects on fish may occur within a few hundred meters of this magnitude sound source, but no mortality of fish or shellfish is expected. Fish will likely be startled and avoid the area temporarily within a few kilometers.

Other sources of noise during the Project will be less in magnitude and each of limited duration, with little potential for overlap. Due to the spatial limits of mortality and potential physical effects, and due to the temporary nature of behavioural effects, noise is considered a not significant environmental effect on Marine Fish, Shellfish and Fish Habitat.

7.4.2.6 Atmospheric Emissions

Potential interactions between atmospheric emissions and marine fish, shellfish and habitat will be limited and therefore further assessment is not warranted.

7.4.2.7 Well Abandonment / Suspension

During well abandonment / suspension, any physical disturbance to the benthic environment would be limited to the areas already disturbed during drilling. Noise would be temporary and localized. No significant adverse effects on fish and shellfish populations are expected. Permanent alteration of habitat would be localized to the immediate area of the wellhead.

7.4.3 Mitigation

In addition to the above commitments and based on the potential interactions identified and existing knowledge regarding these interactions, the following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on Fish, Shellfish and Habitat have been identified:

- use of water-based drilling muds wherever possible;
- use of non-toxic or low toxicity chemicals and muds, and treating synthetic oil-contaminated cuttings as per the OWTG;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible;
- adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment; and
- proper equipment inspection / maintenance practices to be in place to minimize emissions and discharges.

7.4.4 Residual Environmental Effect

The assessment of potential environmental effects on Marine Fish, Shellfish and Marine Habitat focused on key Project components, including presence of the MODU and support vessel(s), drill muds and cuttings, routine marine discharges and Project-related noise. A key Project-specific consideration of the effects assessment is the short duration of the proposed activities (i.e., 20 to 50 days). Given that predicted effects are short-term, localized and reversible, the residual environmental effects on Marine Fish, Shellfish and Habitat are predicted to be not significant. Note that an irreversible change in fish habitat is predicted for the immediate location of the wellhead, but this effect is localized. A summary of potential environmental effects on Marine Fish and Fish Habitat is provided in Table 7.10.

Table 7.10 Potential Environmental Effects Assessment Summary – Marine Fish and Fish Habitat

Project Components/ Activities	**Potential Interactions / Environmental Effects (positive (P) or adverse (A))**	**Mitigation**	**Potential Environmental Effects Summary**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological and Socio-Economic Context**
Presence of Drilling Platform (including safety zone, lights, flaring)	Behavioural effects (A) Artificial reef effect, increased food and shelter (P)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1
Drill Mud and Cuttings	Direct mortality caused by smothering (A) Loss of habitat (A) Contamination (A)	Use of WBMs where feasible; Treatment of mud and compliance with OWTG	1	1	6	4	R	1
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	Nutrient enrichment (A / P); Contamination (A)	Solid waste transported to shore; Adherence to MARPOL 73/78 and *Pollution Prevention Regulations* Compliance with OWTG	1	1	6	2	R	1
Support Vessels (supply boat and helicopter)	Fish Attraction or Avoidance (A)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1
VSP Survey / Drilling Noise	Mortality (eggs and larvae) (A) Behavioural and physiological effects (A)	Adherence to DFO's *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*	1	1	6	1	R	1
Well Abandonment / Suspension	Avoidance (A)		1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

7.5 Marine Birds

Marine birds were selected as a VEC because of the potential interactions with Project activities that could affect their habitat, behaviour, breeding success and ecological role. Marine birds are protected under the *Migratory Bird Convention Act*, administered by Environment Canada. Marine birds are also considered a VEC because of regulatory concern (C-NLOPB 2011b) and their sensitivity to oil in the marine environment. The following families of marine birds occur within the Study Area and could potentially be affected: Procellariidae (fulmars and shearwaters), Hydrobaridae (storm-petrels), Sulidae (gannets), Phalaropodinae (phararopes), Laridae (gulls, terns, kittiwakes, jaegers, skuas) and Alcidae (dovekie, murres, razorbills, puffins).

Pelagic seabirds in particular spend the majority of their lives on the open ocean, only coming to shore to breed, and are therefore most likely to be affected by Project activities. As this assessment also considers helicopter and survey vessel traffic associated with this Project, there is potential for Project interaction with nearshore birds.

While the Study Area extends to the coastal areas of western Newfoundland, this area was selected to encompass the transit routes of helicopters and supply vessels (any support vessels that may come from St. John's, NL, will use the recognized shipping lane through the Laurentian Channel). The zones of influence of other routine Project activities are generally limited to the Project Area. The key concern with respect to coastal areas and marine birds will therefore be disturbance to vulnerable seabird nesting sites by passing ships or helicopters. Due to a general lack of suitable nesting sites along the west coast of Newfoundland, there are only six colonies along the western shore of Newfoundland, four of which are found at the mouth of the Humber River. There are also several tern colonies. These will be considered in this assessment.

In this section, the potential effects of routine Project activities on marine birds are evaluated. Species of marine birds listed under SARA or considered at risk by COSEWIC are assessed within the Species at Risk VEC (Section 7.2). The effects of accidental events on marine birds are assessed in Chapter 8. Cumulative environmental effects in consideration with other projects and/or activities are assessed in Chapter 9.

7.5.1 Residual Environmental Effects Significant Criteria

A significant adverse residual environmental effect on Marine Birds is one that affects marine bird populations (e.g., direct mortality, change in migratory patterns, habitat avoidance) in a way that causes a decline in abundance or change in distribution of population(s) of indicator / representative species within the Study Area. Natural recruitment may not re-establish the population(s) to its original level within one generation.

A not significant adverse environmental effect is defined as an adverse effect that does not meet the above criteria.

A positive effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Marine Birds.

7.5.2 Effects Assessment

7.5.2.1 Presence of Platform

Existing knowledge related to marine birds and lighting on the platform is provided in Section 7.1.1. Birds may be attracted to rigs due to the increased presence of fish in the vicinity of the rig or to vessel lighting, particularly night flying birds such as storm-petrels. Birds may become disoriented and fly into vessel lights or infrastructure, injuring themselves and therefore being stranded. While the drill rig could attract marine birds to the area, its presence is expected to have negligible effects on gulls and other species that may be attracted to the Project site. There is an increased risk of predation by these species on smaller birds such as storm petrels; however, no significant change in regional bird populations are expected due to the presence of the drilling rig for a short period.

While all vessels and offshore structures have navigation and warning lights that may attract marine birds, lighting on supply vessels and drilling rigs may attract birds more readily than other vessels as the illuminated areas will be larger and more intense. Storm-petrels are particularly susceptible to light attraction because of their nocturnal feeding habits. For this Project, lighting will be used as required for navigational purposes, on the back deck for safe operations and equipment monitoring. Since lighting is required at night for safety purposes, mitigation will include routine checks for stranded birds and implementation of appropriate procedures for release that will minimize the effects of vessel lighting on birds in the Study Area.

There may be some short-duration flaring by the drill rig during testing, if it occurs. Marine birds attracted to flares may result in mortalities, but while gas flaring produces light that may attract birds, heat and noise generated by the flare may also deter birds from the immediate area, minimizing potential effects.

As all of the above effects will be short-term and with appropriate mitigation in place, the residual adverse environmental effect is the predicted to be not significant.

7.5.2.2 Drill Muds and Cuttings

As drill muds and cuttings are discarded and accumulate at the seafloor, no interactions with or effects on marine birds are anticipated.

7.5.2.3 Routine Discharges

There are several types of discharges that marine birds may interact with during drilling of the well. The release of any blowout preventer fluid by a drill rig will have minimal effects on marine birds because low-toxicity glycol-water mixes will be used and the periodic near-bottom releases will be low volume. Drilling will require seawater, most of which will be chlorinated for anti-fouling purposes and used as cooling water. Minimal effects of cooling water on marine birds are expected due to low use concentrations, large dilution factors and the small area of any thermal effect.

Other waste materials, such as deck drainage and bilge waters, may negatively affect marine bird health due to the presence of residual hydrocarbons. The attraction of gulls to platforms as a result of discharges of sanitary and domestic waste may increase the potential for predation of smaller marine birds such as Leach's Storm Petrels.

Limited amounts of hydrocarbons may enter the marine environment as a result of routine discharges (e.g., deck drainage, gray water, black water). Ship operations will adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). Any MODU discharges will comply with the OWTG. Hydrocarbon concentrations associated with these discharges are not generally associated with formation of a surface slick. They are therefore not likely to have a measurable effect on marine birds. The waste generated by the Project will be limited due to the length of the drilling program and will be brought back to shore.

Given the short duration of the drilling program and compliance with applicable regulations and guidelines related to discharges, residual environmental effects on marine birds are predicted to be not significant.

7.5.2.4 Support Vessels

Support vessels may affect Marine Birds through discharges, lighting, the physical presence of the structure and noise. Marine birds in the Study Area are habituated to vessel activity and some birds such as gull species and Northern Fulmar are actually attracted to ships and often stay with them for extended periods (Montevecchi et al. 1999; Wahl and Heinemann 1979; Brown 1986). Direct effects to Marine Birds are not anticipated because these species are highly mobile and can avoid vessels by flying or diving. Energy expended during these events would be minimal and have no physiological effect on the birds.

With respect to helicopter traffic, research has shown that seabirds react most strongly to low-level flights and the effects of these responses tend to be short-lived. Helicopter overflights at 300 m failed to cause a visible reaction among moulting sea ducks in the North Sea, while overflights at 100 m resulted in short-term avoidance reactions (Ward and Sharp 1974). As with their response to vessel traffic, seabirds may habituate to air traffic over time.

Helicopters servicing the Project will avoid major colonies and will fly at a minimum of 600 m above sea surface whenever possible. Disturbance to marine birds on the water surface will be negligible when aircraft are 600 m above the sea surface. When taking off and landing on platforms, marine birds in the vicinity may be disturbed. However, birds will likely become habituated to the activity and potential residual adverse effects are considered not significant.

Supply vessels travelling from Newfoundland to the Project site will follow established shipping lanes, particularly in proximity to shore and the potential for disturbance to colonies will be minimal.

7.5.2.5 Drilling Noise / Vertical Seismic Profiles

Sources of noise associated with the Project VSP surveys, drilling activities, and marine and air traffic. The atmospheric noise generated by this Project is of little concern for seabirds, the loudest source being from a helicopter, which will likely be avoided by seabirds. The most intense sound source from this Project would occur during a potential VSP survey. The VSP array is not as intense and is more localized compared to a 2-D or 3-D seismic survey, so the potential effects would also be less. Section 7.1.5.3 describes existing knowledge related to marine birds and seismic noise.

Exiting knowledge indicates that marine birds diving in close proximity to a loud underwater sound could be injured. Only the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot and Atlantic Puffin) spend measurable time underwater during forage dives. Most species of seabirds that may be present in the Study Area spend only a few seconds underwater during a foraging dive; therefore, there would be minimal opportunity for exposure. It is thought that the presence of an on-coming supply vessel may potentially alert alcids (and other seabirds on the water), thereby flushing animals from the area (prior to being exposed to any sounds or occurring in close proximity to operating VSP airguns.

Given the short-term and localized nature of the potential effects, the potential for any injury to birds would be minimal. The residual environmental effects are predicted to be not significant.

7.5.2.6 Atmospheric Emissions

There is ample assimilative capacity for emissions resulting from Project activities because of the strong average winds at the site. There will be negligible environmental effects to air quality beyond the safety exclusion zone. Given the short term nature of this Project and the limited numbers of individuals that may be affected, no residual adverse significant environmental effects are predicted.

7.5.2.7 Well Abandonment / Suspension

During well abandonment / suspension, any noise would be similar to the noise associated with drilling. No significant adverse environmental effects are predicted on marine birds as a result of this activity. Noise would be temporary and localized.

7.5.3 Mitigation

Based on the potential interactions identified and existing knowledge regarding these interactions, the following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on Marine Birds have been identified:

- avoidance of seabird colonies by the MODU support vessel(s) and helicopters;
- routine checks for stranded birds and implementation of appropriate procedures for release that will minimize the effects of vessel lighting on birds;
- adherence to "The Leach's Storm-Petrel: General Information and Handling Instructions" in the event that this species becomes stranded on the survey vessel (which involves the pre-submission of a permit application to the CWS);
- a pelagic marine bird monitoring program will be implemented according to the protocols developed by CWS and Corridor will include a trained observer among their staff;

- Corridor will have a Bird Handling Permit and will comply with the requirements for documenting and reporting any stranded birds (or bird mortalities) to the CWS during the 20 to 50 day drilling program.
- compliance with the *Migratory Birds Convention Act* and regulations;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible; and
- equipment will be designed to meet regulatory requirements for emissions and regular maintenance plans will allow equipment to operate as efficiently as possible.

7.5.4 Residual Environmental Effects

A summary of the potential environmental effects on Marine Birds is provided in Table 7.11. Effects on Marine Birds are anticipated to be short-term, localized and reversible at a population level. Appropriate mitigation will be in place including routine checks for stranded birds. Therefore, the effects of routine Project activities on Marine Birds are predicted to be not significant.

Table 7.11 Potential Environmental Effects Assessment Summary – Marine Birds

Project Components/ Activities	Potential Interactions/ Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Presence of Drilling Platform (including safety zone, lights, flaring)	Attraction to vessel resulting in stranding, injury or mortality (A);	Routine checks for stranded birds and appropriate handling procedures; Adherence to MARPOL 73/78 and OWTG	1	1	6	2	R	1
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	Attraction to vessel (A); Contamination (A); Oiling of Feathers (A)	Adhere to Annex I of the International Convention for the Prevention of Pollution from Ships and OWTG; Equipment inspections and communication	1	1	6	2	R	1
Support Vessels (supply boat and helicopter)	Attraction to vessel resulting in stranding, injury or mortality (A); Disturbance due to overflights (A)	Routine checks for stranded birds and appropriate handling procedures; Bird observations by a qualified observer(s); Avoidance of seabird colonies	1	1	6	2	R	1
VSP Survey / Drilling Noise	Disturbance (A); Behavioural or physiological effects (A)	Adherence to DFO's *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*	1	1	6	2	R	1
Routine Air Emissions	Contamination (A)	Equipment will be designed to meet regulatory requirements for emissions and regular maintenance plans will allow equipment to operate as efficiently as possible.	1	1	6	2	R	1
Well Abandonment / Suspension	Disturbance (A)		1	1	6	1	R	1

Project Components/ Activities	Potential Interactions/ Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

7.6 Marine Mammals and Sea Turtles

Marine mammals and sea turtles were selected as a VEC for several reasons. They play a critical role in the marine ecosystem, the significance of which is manifested in regulatory protection, scientific study and public concern. Specifically, marine mammals were selected as a VEC because of:

- specific regulatory requirements of the *Fisheries Act* and SARA;
- requirements of the Project-specific Scoping Document (C-NLOPB 2011a);
- the direct interaction between marine mammals and routine Project activities, as well as accidents and malfunctions; and
- the ecological, recreational and commercial importance of marine mammals to the public.

The environmental impact assessment focuses on relevant aspects of marine mammals and sea turtles and potential interactions with routine Project activities, which include:

- effects associated with the presence of drilling platform and related lights;
- effects of noise from all routine activities (including VSPs and abandonment);
- effect from collisions with vessels;
- effects associated with discharge of drill mud and cuttings; and
- effects associated with the discharge of waste and wastewater.

The assessment of marine mammals includes baleen whales (Mysticetes), toothed whales (Odontocetes), dolphins (Delphinids), and seals (Pinnipeds). Species of marine mammals and sea turtles listed under SARA or considered at risk by COSEWIC, are assessed separately as Species at Risk (Section 7.2). Those species that are not considered at risk and may interact with the Project are considered within this VEC. The effects of all accidental events except collision between marine mammals / sea turtles and vessels are assessed in Chapter 8. Cumulative environmental effects on marine mammals in consideration with other Projects and/or activities are assessed in Chapter 9.

7.6.1 Residual Environmental Effects Significance Criteria

A significant adverse environmental effect is defined as one that affects a marine mammal or sea turtle population or portion thereof or their associated habitat in such a way as to cause a decline or change in abundance and/or distribution of the population over one or more generations. Natural recruitment (reproduction and in-migration from unaffected areas) may not re-establish the population to its original (i.e., pre-Project) level within several generations or avoidance of the area becomes permanent.

A not significant adverse environmental effect is defined as an adverse effect that does not meet the above criteria.

A positive effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Marine Mammals and Sea Turtles.

7.6.2 Effects Assessment

7.6.2.1 Presence of Platform

Marine mammals and sea turtles would most likely avoid the immediate area around drilling activities due to physical activities and underwater sound generated by equipment. It is possible that marine mammals may be attracted to subsea structures if the artificial reef effect occurs and availability of prey increases.

The potential interaction between the presence of the platform and marine mammals / sea turtles is limited. The MODU is not expected to present any physical obstruction as marine mammals / sea turtles will avoid collision with stationary structures of this size (the risk of collision with vessels is assessed separately below in Section 7.6.2.4). The limited potential of attraction may be offset by a more likely avoidance of noise from the structure. The residual adverse environmental effects are therefore assessed as not significant.

7.6.2.2 Drill Muds and Cuttings

The potential effect of drill mud and cuttings on marine mammals and sea turtles is essentially limited to the degree that their food supply is affected. Contamination of the marine mammals and sea turtle food supply is of limited concern. Baleen whales feed on plankton and on small schooling fish, like capelin, from the water column. Toothed whales (i.e., dolphins) feed primarily on fish and squid, some of which may be benthic species. Seals are known to feed on fish from the water column as well as from benthic habitats. The area where benthic species are potentially affected is limited to within 500 m of the well being drilled, so drill cuttings are unlikely to affect marine mammal prey or the food chain for sea turtles.

7.6.2.3 Routine Discharges

Marine mammals may not be directly or indirectly affected by the waste discharges from the rig because they are likely to avoid the noise from rigs and therefore the associated discharges. Any contact with the rig discharges will likely be short-term. All drilling discharges will meet the OWTG which were established to protect the environment. Rig discharges are expected to be temporary, non-bioaccumulating, non-toxic in nature, and subject to high dilution in the open ocean. Thus, measurable effects on marine mammals are not expected as a result of this Project. The residual adverse environmental effect of waste and wastewater from routine Project activities on marine mammals and sea turtles is predicted to be not significant.

7.6.2.4 Supply Vessels

Collisions of vessels with marine mammals during routine Project activities are considered unlikely, but possible. Habituation is possible when the same boats regularly visit a site (Bonner 1982). The current level of commercial and industrial activity within the area may have habituated repeat visitors.

When approached by a vessel, whales usually dive or make changes in swimming speed or direction (Watkins 1986), but the reaction can be quite variable between species and even within a species. There are several biotic and abiotic factors which may influence the reaction, such as whether or not the animal is feeding or the speed and size of the approaching vessel.

There is limited information pertaining to the potential effects of vessel traffic on sea turtles. Studies, as described in Section 7.1.4, suggest that some sea turtles exhibit behavioural changes and/or avoidance within an area of unknown size near a supply vessel. However, avoidance of approaching supply vessels is sufficiently limited and small-scale such that sea turtles are often seen from operating supply vessels. Therefore, the most likely effect on sea turtles is that they will temporarily avoid an area due to noise, with the spatial extent of any such temporary disturbance from an approaching vessel likely being small.

As indicated by the existing knowledge presented in Section 7.1.4, toothed whales and pinnipeds are rarely struck by vessels as they are fast swimming and agile, enabling them to avoid approaching vessels. The most commonly struck of all marine mammals are the baleen whales, which are large, slow-moving animals often unable to react fast enough to avoid approaching vessels, particularly vessels traveling at more than 14 knots. If a mammal is in the path of a vessel, every safe effort will be made by the vessel operator to avoid collision, if the mammals has not moved upon approach. By nature of the slow and steady movement of each vessel during this Project, and the practice of avoiding concentrations of marine mammals, the risk of collision is low.

It is probable that any behavioural changes in baleen whales, toothed whales, pinnipeds and sea turtles (including species at risk) triggered by a MODU and its support vessels will be temporary. The proposed surveys(s) are of short duration and will occur over a relatively small area within the Project Area boundary. Thus, disturbance from vessel traffic is expected to be low.

Helicopter traffic noise may elicit diving behaviour in many marine species. Minke whales have changed course or gone into a slow dive in response to helicopters flying at an altitude of 230 m (Leatherwood et al. 1982) and seals may also dive in response to low-flying aircraft. However, the effect is temporary.

Given the temporary and reversible nature of any disturbance and behavioural effects and the mitigation in place to avoid the potential for collisions, the environmental effect of vessel and helicopter traffic on marine mammals and sea turtles is predicted to be not significant.

7.6.2.5 Drilling Noise / Vertical Seismic Profiles

Existing knowledge related the effects of noise on marine mammals and sea turtles is described in detail in Section 7.1.5.3. Temporary avoidance of an area due to noise is the most likely effect from a drilling project on marine mammals and seas turtles. Most of the noise generated from this Project will be intermittent. However, the drilling unit emits some noise continuously during operation. A broadband received sound pressure level of 160 dB re 1 µPa (rms) or greater is currently the best estimate available to indicate potential concern for disruption of marine mammals behavioural patterns (NMFS 2000), however, noise levels below 160 dB re 1µPa have also been known to elicit behavioural disturbances in marine mammals (NRC 2005). The spatial extent of any such avoidance behaviour by most common species in the area (i.e., humpback and minke whales) can be expected to be 0.5 to 1 km.

The most likely activity of marine mammals in the Study Area is feeding, and some communications may occur between some whales during this activity. If mammals are discouraged from this area by noise or if their feeding efficiency is diminished as a result of masking, the effect would be of limited spatial extent and duration. Marine mammals will avoid an area of noise, especially if there are sudden changes in frequency or intensity. Marine mammals are generally more tolerant of stationary sources of noise than moving sources.

The effect of noise on marine mammals is considered highly reversible therefore, once the source is removed, marine mammals are expected to return to the area (Davis et al. 1987). Each activity, except supply vessels and personnel flights, will likely occur in sequence with little chance for more than one activity at a time. The Project Area offers no unique habitat or feeding areas for marine mammals. Similar alternate sites are available in the immediate area, so the fitness of any species of marine mammals will not be affected. The residual environmental effects on marine mammals are therefore predicted to be not significant.

The possible responses of sea turtles to sound associated with VSP surveys (seismic) and other exploratory drilling activities could include:

- avoiding the project area where seismic sounds (and other related exploratory drilling sounds) occur to the extent that turtles move to less preferred habitat (more likely to occur in near-shore shallow water areas during nesting, hatching or foraging as compared to the Old Harry Project Area, with 470 m water depth);
- avoiding only the immediate area around the active sound source (local avoidance of the source vessel but remain in the general area); and

- exhibiting no appreciable avoidance, although short-term behavioural reactions are likely.

Sea turtles might be excluded from the area for the duration of the VSP survey, or they might remain, but exhibit abnormal behavioural patterns such as lingering longer than normal at the surface where received sound levels are lower. Whether those that were displaced would return quickly after the VSP survey ended is unknown but monitoring evidence suggests this could occur (Holst et al. 2006; Hauser et al. 2008; Holst and Smultea 2008). The Project Area offers no unique habitat or feeding areas for sea turtles. Similar alternate sites are available in the immediate area, so the fitness of any species of sea turtles will not be affected. The residual environmental effects on sea turtles are therefore predicted to be not significant.

7.6.2.6 Atmospheric Emissions

Potential interactions between atmospheric emissions and marine mammals / sea turtles will be limited and therefore further assessment is not warranted.

7.6.2.7 Well Suspension / Abandonment

Noise generated during the removal of the wellhead will be of short duration and localized. It is unlikely that explosives will be required to remove the wellhead. The disturbance associated with well suspension and abandonment activities (primarily associated with noise generated during removal of the wellhead) will be of short duration and occur directly at the wellsite. The level of vessel traffic would be similar to that currently experienced in the area. The residual adverse environmental effects of well suspension / abandonment activities on marine mammals and sea turtles are predicted to be not significant.

7.6.3 Mitigation

Based on the potential interactions identified and existing knowledge regarding these interactions, the following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on Marine Mammals and Sea Turtles have been identified:

- use of a Marine Mammal Observer;
- adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible; and
- equipment will be designed to meet regulatory requirements for emissions and regular maintenance plans will allow equipment to operate as efficiently as possible.

7.6.4 Residual Environmental Effects

A summary of the potential environmental effects on Marine Mammals and Sea Turtles is provided in Table 7.12. Residual effects on marine mammals and sea turtles will be greatly influenced by the short-term nature of the Project and reversibility of any physical and behavioural effects once sound sources are removed. With the mitigation in place to minimize potential for collision, the effect of routine Project activities on Marine Mammals and Sea Turtles are predicted to be not significant.

Table 7.12 Potential Environmental Effects Assessment Summary – Marine Mammals and Sea Turtles

Project Components/ Activities	Potential Interactions / Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Presence of Drilling Platform (including safety zone, lights, flaring)	Attraction due to reef effect or possible avoidance due to noise (A)	Observer(s) for marine mammals and sea turtles	1	2	6	2	R	1
Routine Discharges	Contamination of food sources (A)	Adhere to Annex I of the International Convention for the Prevention of Pollution from Ships and OWTG; Equipment inspections and communication	1	1	6	2	R	1
Support Vessels (supply boat and helicopter)	Disturbance / avoidance (A); Collision resulting in injury or mortality(A)	Observer(s) for marine mammals and sea turtles; Slow vessel speed	1	1	6	2	R	1
VSP Survey / Drilling Noise	Physical and/or behavioural effects (A); Avoidance (A)	Adherence to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*;	1	2	6	2	R	1
Well Suspension / Abandonment	Physical and/or behavioural effects (A); Disturbance / avoidance (A)		1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

7.7 Sensitive Areas

Sensitive Areas are often associated with rare or unique marine habitat features, habitat that supports sensitive life stages of valued marine resources, and/or critical habitat for species at risk. Sensitive areas were selected as a VEC due to their importance as unique or critical habitat for various species or species assemblages. Sensitive areas are important socially, culturally, aesthetically, ecologically and scientifically.

As per the Scoping Document (Appendix A), Sensitive Areas in the Study Area include any EBSAs identified within the Gulf (and some consider the Gulf as a whole a sensitive area). With the Study Area, this includes the following EBSAs: the southern fringe of the Laurentian Channel (the Study Area has a small overlap with the eastern fringe of this EBSA) and the west coast of Newfoundland which crosses the Study Area between the Project Area and the western coastline of Newfoundland. The Project Area overlaps with a potential redfish (a COSEWIC-designated species) mating area and the Study Area overlaps with a potential redfish larvae extrusion area and a cod (a COSEWIC-designated species) spawning area. These five areas are considered in this VEC.

As many of the sensitive areas being considered here were created in relation to Species at Risk and other marine resources, such as marine mammals and marine fish, this assessment is closely linked to the assessment of other VECs. The effects of accidental events on Sensitive Areas are assessed in Chapter 8. Cumulative environmental effects on Sensitive Areas in consideration with other Projects and/or activities are assessed in Chapter 9.

7.7.1 Residual Environmental Effects Significance Criteria

A significant adverse residual environmental effect on Sensitive Areas is one that alters the valued habitat of the identified Sensitive Areas physically, chemically or biologically, in quality or extent, to such a degree that there is a decline in abundance of key species or species at risk or a change in community structure, beyond which natural recruitment (reproduction and immigration from unaffected areas) would not return the population or community to its former level within several generations.

An adverse environmental effect that does not meet the above criteria is considered to be not significant.

7.7.2 Effects Assessment

While all five of the sensitive areas considered within this VEC overlap with the Study Area, not all of these areas will interact with all routine Project activities. Many Project activities and their potential zones of influence are localized within the Project Area. Within the following assessment, the specific Project activities that may interact with each sensitive area will be identified and assessed.

7.7.2.1 Presence of Platform

As potential effects related to the presence of the platform would be limited to the Project Area, this interaction is only a consideration for the potential redfish mating area (September-December), which could overlap with the Project both spatially and temporally.

While redfish are a benthic species, limiting their potential to be attracted by lights or flares on the rig, feeding is believed to occur at night, when redfish rise off the bottom and feed on pelagic organisms (primarily zooplankton) in the water column (Scott and Scott 1988). Fish and crustaceans become more important in the diet as redfish increase in size. Thus there is potential for redfish to be attracted to the rig and be affected by the lights at night.

Given the localized and temporary nature of this affect and the reversibility once the drilling platform is removed, this effect will not be measurable at the population level.

7.7.2.2 Drill Muds and Cuttings

Similar to the presence of the drilling platform, the biological effects of drill muds and cuttings is limited to the Project Area and therefore would only be a consideration for the potential redfish mating area (September-December), which could overlap with the Project both spatially and temporally. As discussed in Section 7.1.2, most microcosm and field studies (Neff 2010) on the effects of WBM cuttings have shown no or minimal short term effects on zooplankton communities, and minimal effects on benthic macro- and mega-faunal communities (effects are generally restricted to within 100 m). In comparing WBM and SBM discharges, the effects of SBM discharges are limited to benthic organisms.

For fish species, such as redfish, there would be minimal behavioural effects from cuttings discharges (i.e., startle effect), no potential for smothering and minimal potential for physiological effects. The residual environmental effects are predicted to be not significant.

7.7.2.3 Routine Discharges

The effects related to routine discharges have been discussed in Section 7.1.3. Routine discharges will be of limited duration and frequency over the drilling period and will comply with applicable regulations. Any discharge with potential for toxicity to the marine environment is regulated and monitored for compliance, so the risk of contamination of biota is limited. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria. The effects of this relatively small amount of waste and wastewater would be limited to the Project Area and therefore only a potential influence on the potential redfish mating area; the residual environmental effects are considered not significant.

7.7.2.4 Support Vessels

Potential interactions between support vessels and this VEC are related to noise and lights generated by the vessels. Because of vessel traffic to and from western Newfoundland, this activity could interact with the cod spawning area, potential redfish mating area and the West Coast of Newfoundland EBSA. The vessel traffic associated with this Project will occur over a short period and will consist of approximately two to three vessel trips per week. Vessel operations will adhere to Annex I of the International Convention for the Prevention of Pollution from Ships and the *Canada Shipping Act*. The temporary interactions associated with limited vessel traffic will not result in any residual adverse significant effects on any of the identified Sensitive Areas.

7.7.2.5 Drilling Noise / Vertical Seismic Profiles

Sound likely to be generated by Project activities (including drilling and VSP surveys) and the likely biological effects of this sound is presented in detail in Section 7.1.5 and related subsections. As the zones of influence of the noise produced by these activities are likely to be contained within the Project Area and immediate vicinity, this interaction is of most concern for the potential redfish mating area. Existing knowledge regarding the biological effects of sound on fish is presented in Section 7.1.5.3.

Most available literature indicates that the effects of noise on fish are transitory and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible effects on individuals and populations.

Noise from a seismic source array used in VSP may cause mortality of fish and shellfish eggs and larvae within tens of metres, if they come near the source. Physical effects on fish may occur within a few hundred metres of this magnitude sound source, but no mortality of fish or shellfish is expected. Fish will likely be startled and avoid the area temporarily within a few kilometers. This may result in temporary disturbances to redfish mating activity, and possible injury to fish in the immediate area. Given the localized and mostly temporary nature of these disturbances, no residual adverse environment effect on redfish mating is anticipated.

Other sources of noise during the Project will be less in magnitude and each of limited duration. Due to the spatial limits of mortality and potential physical effects, and due to the temporary nature of behavioural effects, noise is considered to have a not significant environmental effect on Sensitive Areas.

7.7.2.6 Atmospheric Emissions

Air emissions are not expected to interact with or affect this VEC and therefore this activity is not assessed further.

7.7.2.7 Well Abandonment / Suspension

The abandonment / suspension of the well will cause a permanent alteration in benthic habitat in the immediate area of the wellsite. This is not anticipated to result in any significant adverse residual effects on Sensitive Areas.

7.7.3 Mitigation

The following technically and economically feasible mitigation measures to reduce or eliminate potential adverse effects of the Project on Sensitive Areas have been identified:

- use of water-based drilling muds wherever possible;
- use of non-toxic or low toxicity chemicals and muds, and treating synthetic -based mud and cuttings as per the OWTG;
- all wastewater discharges to comply with the OWTG and ship operations will adhere to Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act*;
- solid waste transported to shore and recycled where possible;
- adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment; and
- proper equipment inspection / maintenance practices to be in place to minimize emissions and discharges.

7.7.4 Residual Environmental Effect

The assessment of potential environmental effects on Sensitive Areas focused on key Project components, including presence of the MODU and support vessel(s), drill muds and cuttings, routine marine discharges and Project-related noise. Most of the potential disturbances related to routine activities are limited to the Project Area and are therefore only a potential concern for the potential redfish mating areas. Interactions with other Sensitive Areas would be limited to supply vessel and helicopter traffic to and from Newfoundland.

Due to the short duration of the proposed Project (i.e., 20 to 50 days), small survey area (1 to 5 km^2) and the implementation of the proposed mitigation measures, the potential adverse environmental effects of the Project on the potential redfish mating area are predicted to be not significant. A summary of potential environmental effects on Sensitive Areas is provided in Table 7.13.

Table 7.13 Potential Environmental Effects Assessment Summary – Sensitive Areas

Project Components/ Activities	Potential Interactions / Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Presence of Drilling Platform (including safety zone, lights, flaring)	Behavioural effects (A) Artificial reef effect, increased food and shelter (P)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1

Project Components/ Activities	Potential Interactions / Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-Economic Context
Routine Discharges (e.g., deck discharge, bilge water, sanitary or domestic waste water)	Nutrient enrichment (A / P); Contamination (A)	Solid waste transported to shore; Adherence to MARPOL 73/78 and *Pollution Prevention Regulations* Compliance with OWTG	1	1	6	2	R	1
Support Vessels (supply boat and helicopter)	Fish Attraction or Avoidance (A)	Proper equipment inspection / maintenance practices	1	2	6	2	R	1
VSP Survey / Drilling Noise	Mortality (eggs and larvae), Behavioural and Physiological Effects (A)	Adherence to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*	1	1	6	1	R	1
Well Abandonment / Suspension	Avoidance (A)		1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

Geographic Extent
1 = <1 km radius
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Reversibility
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3 = High level of existing adverse activity

n/a = Not applicable

7.8 Commercial Fisheries and Other Users

Historically, the fishery has played an important role in the economy and social fabric of various communities that border the Gulf including those in Newfoundland and Labrador, and has helped to define much of the region's character. The fishery remains an integral component of the economy of the region as well as Newfoundland and Labrador. Research and sentinel fisheries are undertaken to monitor the status and health of underutilized species, species under moratoria and listed species at risk and for the purpose of this environmental assessment as considered part of commercial fisheries. Commercial fisheries was selected as a VEC because of the potential for direct interaction with the Project. Specifically, commercial fisheries was selected as a VEC because of:

- specific regulatory requirements of the *Fisheries Act*;
- the direct interaction between commercial fish and routine Project activities;

- the potential interaction between commercial fish and the Project as a result of accidents or malfunctions; and
- the commercial importance and historic relevancy of the commercial fisheries to the region.

The environmental impact assessment focuses on relevant aspects of Commercial Fish. Potential interactions, between commercial fish and routine Project activities include:

- environmental effects of sound from all routine exploration drilling activities (including support vessels and VSP profiling);
- conflict with harvesting activities and fishing gear;
- impacts on fish catchability;
- interference with DFO surveys;
- environmental effects associated with discharge of drill mud and cuttings;
- environmental effects associated with the discharge of waste and wastewater; and
- environmental effects associated with the presence of drilling platform and related lights.

As described in Section 5.8.2, the Project Area is adjacent to a major shipping route, with traffic density in the vicinity estimated at four to eight ships per day. As well, DFO carries out stock assessment surveys and research activities throughout the maritime marine environment, which may overlap with proposed Project activities. The effects of the Project on these other users will also be assessed.

The effects of all accidental events on Commercial Fisheries and Other Users are assessed in Chapter 8. Cumulative environmental effects in consideration with other Projects and/or activities are assessed in Chapter 9.

7.8.1 Residual Environmental Effects Significance Criteria

7.8.1.1 Commercial Fisheries

A significant adverse residual environmental effect on Commercial Fisheries is one that has a measurable and sustained adverse effect on commercial fishing incomes.

An adverse environmental effect that does not meet the above criteria is considered to be not significant.

A positive effect is defined as one that results in a measurable increase in fisher income.

7.8.1.2 Other Users

Other users include Aboriginal fisheries, recreational fisheries, aquaculture, seal and bird hunting, military use, marine traffic and tourism and recreation. Marine traffic and military use is the primary other user that could interact with the Project. Aboriginal and recreational fisheries, aquaculture, sealing and bird hunting and tourism and recreational are activities that normally occur Nearshore and are not expected to interact with the Project Area. Therefore, the focus with be on marine traffic and military use in this section. Other users are discussed under accidental events (Section 8.6.7).

A significant effect is one that has a detrimental effect on the use of the Cabot Strait by marine traffic and military use for a duration of time sufficient to affect a long-term change in the established traffic patterns.

An adverse environmental effect that does not meet the above criteria is considered to be not significant.

A positive effect is defined as one that enhances marine traffic and military use activities.

7.8.2 Effects Assessment

Fishers elsewhere in the world have expressed concerns with respect to offshore oil exploration and development. Lam (2001) provides a good review of fisheries-related issues in the United Kingdom over more than three decades of offshore oil and gas development. Issues and concerns relevant to this environmental assessment include loss of access, damage to gear and compensation for damage, and communication between the two industries. Similarly, issues identified off California (MMS 2001) have included space use conflicts and reduced catch due to seismic activity and related noise. Peterson (2004) draws on Canada east coast experience to describe potential interaction between seismic testing activities and fisheries on the west coast of Canada. Issues identified in that report include reduced fish catch and space use conflict. Numerous other such reports exist, all of which highlight the importance of communication between the fishing (including DFO, with respect to research activities) and oil industry, often through the establishment of formal liaison mechanisms to deal with specific issues.

7.8.2.1 Presence of the Drill Platform

A FEZ is a temporary exclusion zone typically established around a drilling platform for the duration of the 20- to 50-day drilling program; fishing is not permitted within a FEZ. Input into the development of the FEZ is solicited from stakeholders during public and fisheries consultation as part of the project-specific environmental assessment process. The FEZ around drilling operations is relatively small (0.5 km^2). If the drilling platform is an anchored rig (such as a semi-submersible), then the FEZ typically extends 500 m beyond the anchor points (which can extend up to approximately 1,000 m from the centre of the drilling platform). If the drilling platform is not anchored, then the FEZ is established 500 m from the edge of the platform. Information on the FEZ is usually provided via the Fisheries Broadcast and through the Notice to Shippers.

Because fishing will not be safe within the designated safety zones, the effect of exclusion has the potential to interact with commercial fisheries (including research and sentinel fisheries). However, since the zones will be located in areas where very little commercial fishing has occurred in recent years (as described in Section 5.8.1, no harvesting locations were recorded within the Project Area, with the closest harvest location being approximately 10 km to the southwest), the safety zone area is expected to have little operational or economic impact on fish harvesters.

If sites selected for DFO science surveys happen to be within an active safety zone, alternative sites can be used (DFO typically selects equivalent alternative sites, for example, for random stratified surveys).

7.8.2.2 Drill Muds and Cuttings

The effect of drill muds and cuttings on commercial fisheries would be limited to the extent to which these discharges affect fish resources in the area. As shown in Section 7.4.2.2, effects of drill muds and cutting on fish, shellfish and fish habitat will generally be limited to within 500 m of the wellsite with expected recovery within three to five years. Given the localized area of the effect and the current low level of harvesting in the Project Area, these discharges are predicted to have no residual adverse environmental effects on fish harvesters or other marine users.

7.8.2.3 Routine Discharges

Similar to the effect of drill muds and cuttings, routine discharges could affect commercial fisheries indirectly through effects on fisheries resources or directly through fouling of gear. All routine discharges from the MODU and supply vessel(s) will comply with the OWTG and will meet the *Pollution Prevention Regulations* of the *Canada Shipping Act*. All domestic waste will be transported to shore.

As routine discharges will be of limited duration and frequency over the drilling period, will comply with applicable regulations and will disperse rapidly in an open ocean environment, no measurable effects on fish resources are anticipated. With the FEZs in place, potential for fouling of gear is also limited. As such, the adverse residual effects on Commercial Fisheries and Other Users is predicted to be not significant.

7.8.2.4 Supply Vessels

Supply vessels associated with the Project could interfere with fish harvesting activities if they interfere with the operation of fishing vessels or fishing gear. Such conflicts are more likely to involve fixed fishing gear (e.g., crab pots), and might result in gear damage, gear loss, loss of catch and increased operational expenses for harvesters. While supply vessels ships pose minimal risk to fishing gear (no more than other ocean-going ships or other fishing vessels in the area), surveys such as VSP during drilling do pose more of a specific risk if the seismic equipment is towed through the water. Seismic survey/fishing gear conflicts do occur sometimes once or twice a year in Atlantic Canada, though not usually as the result of localized VSP surveys, which are very small scale (i.e., on the order of a few kilometres). As the Project Area is low in existing harvesting activity, conflicts are expected to be minimal.

In the event that DFO research activities or stock assessments are underway in the vicinity of the Project Area during the proposed exploration drilling program, interactions and potential effects could occur either as a result of behaviour responses, fishing interference or displacements (LGL 2005b). The DFO Science Advisory Schedule can be accessed online to determine if there are any DFO activities scheduled to overlap with the Project. This online resource included activities scheduled through the month of May 2011, but no later, at the time of writing this report. This online resource will be accessed to check for conflicts prior to the

Project and communication with DFO will be used to resolve any potential issues should they occur.

During the proposed exploration drilling program, it is expected that commercial traffic will be passing in the vicinity of the Project Area. Therefore, the mobilization and logistic support for an exploration drilling program may interact with marine traffic and military use in the Cabot Strait, which includes the Laurentian Channel. The incremental amount of vessel traffic as a result of this Project is anticipated to be negligible compared to existing vessel traffic in the area and interactions will be minimal.

Overall, the residual adverse environmental effect of potential conflicts with supply vessels is predicted to be not significant for Commercial Fisheries and Other Users.

7.8.2.5 Drilling Noise / Vertical Seismic Profiles

Sound and the effects of sound that are applicable to Commercial Fish are presented in detail in Sections 7.1.5.3. As described in this section, if one examines sounds based on a hierarchal effect, then the most intense sounds associated with the proposed undertaking would most likely be associated with the seismic sources used in the VSP survey, followed by the drill platform and related operations, support vessels and helicopters. Much of the information presented on sound in subsequent sections will be related to seismic sources, as seismic sound sources using a risk management process has the potential to produce the more pronounced responses as it will be the most probable source of the most intense sounds undertaken as part of the exploration activities. VSP surveys may be conducted as part of the exploration drilling program. VSP surveys use a seismic source will a lower intensity and duration than those associated with seismic surveys.

Fisheries industry representatives have registered concerns in the past that seismic survey sound sources, in particular, may scare finfish from their fishing locations, or discourage benthic species (such as snow crab) from entering fixed fishing gear. There are also scientific reports of decreases in finfish catch rates near seismic arrays. There is debate on the duration and geographic extent of the effect, however. Reports range from fish quickly returning to the area after source arrays were activated, to finfish catch rates several kilometers away taking days to return to normal (Løkkeborg 1991; Skalski et al. 1992; Engås et al. 1996). In any case, compared to a conventional 2-D or 3-D geophysical survey, a very small area would be affected by VSP sound, since the area where the activities would take place will be quite small (i.e., in the immediate area of the drilling location). Also, the VSP sound source is typically smaller, the noise generated is lower than typical seismic arrays and the surveys would occur over a quicker timeframe.

Given the nature of the surveys to be conducted, the limited effects on fish resources and the lack of harvesting activity within the immediate Project Area, the residual environmental effect of noise sources on Commercial Fisheries and Other Users is predicted to be not significant.

7.8.2.6 Atmospheric Emissions

Potential interactions between atmospheric emissions and Commercial Fisheries and Other Users will be limited and therefore further assessment is not warranted.

7.8.2.7 Well Suspension / Abandonment

Noise generated during the removal of the wellhead will be of short duration and localized. It is unlikely that explosives will be required to remove the wellhead. The disturbance associated with well suspension and abandonment activities (primarily associated with noise generated during removal of the wellhead) will be of short duration and occur directly at the wellsite. The level of vessel traffic would be similar to that currently experienced in the area.

If the wellhead is removed, the wellhead and associated equipment would be removed to at least 1 m BSF, so as not to pose any obstruction. If approval is granted for leaving a wellhead in place, several factors are considered, including the occurrence and type of fishery in the area, as well as water depth at the location of the wellhead. Thus, it would not be left in place if it is deemed to be a major obstacle for fishing activities.

The residual adverse environmental effects of well suspension / abandonment activities on Commercial Fisheries are predicted to be not significant.

7.8.3 Mitigation

7.8.3.1 Commercial Fisheries

The C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (CNLOPB 2011b) provide guidance aimed at minimizing any impacts of VSP on commercial fish harvesting. These Guidelines were developed based on best practices during previous years' surveys in Atlantic Canada, and on guidelines from other national jurisdictions. The relevant Guidelines state (Appendix 2, Environmental Mitigative Measures):

> *1.a) The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and the local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained.*
>
> *1.b) Where feasible, a soft-start approach – a gradual ramp-up of airguns - should be implemented prior to survey. Ramp up procedures should follow measures outlined below in Section 2(e)*
>
> *1.c) The operator should publish a Canadian Coast Guard "Notice to Mariners" and a "Notice to Fishers" via the CBC Radio program Fisheries Broadcast.*
>
> *1.d) Operators should implement a gear and/or vessel damage compensation program, to promptly settle claims for loss and/or damage that may be caused by survey operations. The scope of the compensation program should include replacement costs for lost or damaged gear and any additional financial loss that is demonstrated to be*

> *associated with the incident. The operator should report on the details of any compensation awarded under such a program.*
>
> *1.e) Procedures must be in place on the survey vessel (s) to ensure that any incidents of contact with fishing gear are clearly detected and documented (e.g., time, location of contact, loss of contact, and description of any identifying markings observed on affected gear). As per Section 4.2 of these Guidelines, any incident should be reported immediately to the 24-hour answering service at (709) 778-1400 or to the duty officer at (709) 682 4426.*

Corridor will also use qualified fishing observers / Fisheries Liaison Officer. These mitigative measures will be in place for any such surveys required for the Project.

Section 4.9 of the C-NLOPB's *Guidelines Respecting Drilling Programs in the Newfoundland Offshore Area* state: "the operator should provide for the advance notification of persons engaged in fishing activities in the proposed area of operations and the measures to be put in place to eliminate any potential mutual interference."

The locations of the FEZs will be well publicized and communicated to fishers and DFO, and Corridor will continue to communicate with fishers and DFO about fishing and survey activities in these areas. The general timing and locations of planned Project activities will be provided to fishers who may be operating in the vicinity of the Project Area via a Canadian Coast Guard "Notice to Mariners" and a CBC Radio Fisheries Broadcast "Notice to Fishers".

Harvesting locations for each species can vary between years, as well as within the same season, due to migration patterns, catch rates, quotas, resource issues, weather, technology, and fuel costs. Effective communication of all operations in the Project Area is imperative.

7.8.3.2 Other Users

Representative(s) from DFO will be contacted prior to commencement of the Project to confirm the presence or absence of DFO vessels in the vicinity of the Project Area during the 20- to 50-day exploration drilling program. Scheduling will be coordinated with DFO, as required, to avoid or minimize disruption to existing DFO research activities or stock assessments being carried out in the Old Harry Prospect Area.

7.8.4 Residual Environmental Effects

A summary of potential environmental effects on Commercial Fisheries and Other Users is provided in Table 7.14. With the above mitigations in place (including compensation if a conflict with gear were to occur), and in light of the localized nature of VSP surveys, their small footprint, short duration, and the lack of past harvesting activities in the Project Area, the residual environmental effects of the Project on Commercial Fisheries and Other Users is predicted to be not significant.

Table 7.14 Potential Environmental Effects Assessment Summary – Commercial Fisheries and Other Users

Project Components / Activities	**Potential Interactions/ Environmental Effects (positive (P) or adverse (A))**	**Mitigation**	**Potential Environmental Effects Summary**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological and Socio-Economic Context**
Presence of Drill Platform (including safety zone, lights, flares)	Change in fish catch (A); Interference with marine traffic and military use (A)	Coordination and communication with fishing industry and DFO; Use of a qualified observer(s) / Fisheries Liaison Officer; Awareness of shipping lanes; Notice to Shipping	1	2	6	2	R	1
Routine Discharges	Change in fish catch (A); Fouling of Gear (A)	Adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* and OWTG;	1	1	6	2	R	1
Supply Vessels (supply boat and helicopter)	Change in fish catch (A); Interference with marine traffic, military use, DFO surveys, and other users (A)	Coordination and communication with fishing industry and DFO; Use of a qualified observer(s) / Fisheries Liaison Officer; Awareness of shipping lanes; Notice to Shipping	1	1	6	2	R	1
VSP Surveys/ Drilling Noise	Change in fish catch (A); Interference with marine traffic and DFO Surveys (A)	Compliance with the C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines*; Use of a qualified observer(s) / Fisheries Liaison Officer; Awareness of shipping lanes; Notice to Shipping	1	2	6	2	R	1
Well Abandonment / Suspension	Interference with marine traffic, fishing gear and DFO Surveys (A)	Compliance with C-NLOPB requirements	1	1	1	1	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

8.0 ACCIDENTAL EVENTS

The two main types of accidental events that could occur during the proposed exploration drilling program are blowouts and “batch” spills. Blowouts are continuous spills lasting hours, days or weeks that could involve the discharge of natural gas and/or crude oil into the environment. Batch spills are instantaneous or short-duration discharges of petroleum hydrocarbons that could occur from accidental events on the drilling rig where fuel oil and other petroleum products are stored and handled.

Based on modelling conducted by SL Ross (2011; see Section 2.12 for summary), the maximum extent of an oil spill that originates at the wellsite could extend up to 20 km from the point of origin of the spill, which is approximately 50 km away from the closest Newfoundland coast, approximately 70 km from the closest Nova Scotia coast and approximately 75 km away from the closest Magdalen Islands coast (Figure 2.20). As the Study Area was delineated to incorporate supply vessel and helicopter routing to and from Newfoundland, there is also potential for a batch spill to originate from a supply vessel at any point along the route. The worst case-scenario would be a collision / sinking close to shore that resulted in the loss of oil and diesel fuel.

Estimates on the probability of these spills and the results of trajectory modelling are provided in Sections 8.2 and 2.12.3, respectively. The information in these sections is from supporting documents prepared by SL Ross Environmental Research Ltd. (SL Ross 2011). An assessment of the environmental effects of an accidental event on the VECs is provided in Section 8.3.

8.1 Relief Well Planning

Corridor will prepare a relief well strategy that will ensure the following items are addressed in the Approval to Drill process with the C-NLOPB:

- a relief well drilling rig contracting plan;
- suitable quantity and type of tangible items are readily available for deployment (e.g., wellheads, tubular); and
- suitable relief well locations will be pre-determined prior to initiation of operations at Old Harry; these locations will consider expected wind, wave and current directions as well as maintaining a safe distance from the blowing well.

8.2 Well Cap and Containment System

Corridor will adhere to industry standards as well as the C-NLOPB’s Guidelines and Regulations in place at the time of operations at Old Harry.

In conjunction with CAPP, the C-NLOPB, other Newfoundland operators and industry companies, Corridor will continue work to ensure that the most suitable cap and containment system available in Eastern Canada is also available for use on this well should the need arise.

8.3 Spill Response Technologies

The general awareness of drill rig personnel will be increased through training and safety meetings. Personnel will be encouraged to report potential problems and 'near miss' incidents in an attempt to avoid an occurrence that could result in a loss of containment or other release of petroleum or other hydrocarbons.

Standard Operating Procedures to reduce or eliminate the chance of a spill, even in the case of equipment failure, will be instituted for all hydrocarbon handling operations. Prior to drilling, practices for operating in poor weather and/or high sea state conditions will be established. Good communications and sound marine practices for all vessels will also improve the ability to prevent spills.

The emergency oil spill program should consider a range of offshore spill response options as well as training and Standard Operating Procedures. The decision when to use each of these is based on an evaluation of operating conditions, the anticipated characteristics of the hydrocarbon, the effectiveness of the option and effects on the environment. There are environmental and technological constraints to response and cleanup. High sea states and visibility are examples of typical environmental constraints, while technological constraints include pumping capacity of oil recovery devices and effectiveness of chemical dispersants. These kinds of limitations apply in all environments and jurisdictions.

Cleanup and recovery from an oil spill is difficult and depends upon many factors, including the type of oil spilled, the temperature of the water (affecting evaporation and biodegradation) and the types of shorelines and beaches that may be involved.

Some examples of methods for cleanup and recovery include the following:

- Surveillance, tracking and detection are critical. Information about the location, movement and characteristics of the oil spill must be considered. Selection and application of response technologies depends on the location and movement of the oil, surface layer thickness and the nature and extent of weathering. Technologies for surveillance, tracking and detection include tracking buoys (used to follow the movement of the oil slick in response to winds, surface currents and ice movements), satellite imagery, airborne reconnaissance, vessel reconnaissance, trajectory modelling and optical tracking.
- Mechanical recovery involves the physical containment of the oil within natural or artificial barriers and the subsequent removal of the oil from the surface. Containment barriers are used to intercept, control, contain and concentrate spreading oil. Recovery of oil contained or concentrated with boom or natural barriers is accomplished using a skimming or recovery system that removes oil and water from the surface.
- Natural dispersion and/or degradation is the natural weathering of hydrocarbon as it breaks into small droplets by wave action that are metabolized by micro-organisms.
- Mechanical dispersion is the mechanical breakup of small spills by the use of readily available tools such as vessels (propeller wash) and sprayed water.
- Chemical dispersion or dispersants are a group of chemicals sprayed or applied onto oil slicks to accelerate the process of natural dispersion. They are usually used in oil spill response when it is desirable to reduce the amount of floating oil to minimize damage to

shorelines, wildlife, and other sensitive resources. These must be authorized by the C-NLOPB before application.

- Controlled burning can effectively reduce the amount of oil in water, if done properly, but it can only be done in low wind, and can cause air pollution. *In situ* burning is undertaken by collecting and thickening the oil with a fire resistant boom, ignite it burning the oil in place in the water.
- Blowout control is an important response strategy, as it would be the primary method to control and minimize the environmental effects of a well blowout.

An Oil Spill Response Plan will be developed in advance of operations and submitted to the C-NLOPB for review and approval as part of the Operations Authorization application. This Plan will describe in detail the oil spill response strategies to be utilized in the unlikely event of an accidental release.

8.4 Spill Probabilities

Because the SL Ross (2011) study derives spill and blowout statistics for the Project from worldwide statistics, it is assumed that the practices and technologies that will be used by Corridor will be at least as safe as those used in other offshore oil and gas operations around the world and will be in accordance with the accepted practices of the international petroleum industry.

8.4.1 General Oil Pollution Record of the Offshore Oil and Gas Industry

Compared with other industries that have potential for discharging petroleum oil into the marine environment, the industry of exploring, developing and producing offshore oil and gas (the offshore E&P industry) has a very good record. A study on marine oil pollution by the US National Research Council (NRC 2002) indicates that accidental petroleum discharges from platforms contribute only 0.07 percent of the total petroleum input to the world's oceans (0.86 thousand tonnes per year versus 1,300 thousand tonnes per year - see Table 8.1).

Table 8.1 Best Estimate of Annual Releases [1990 to 1999] of Petroleum by Source

Petroleum Source	North America (in thousands of tonnes)	Worldwide (in thousands of tonnes)
Natural Seeps	**160**	**600**
Extraction of Petroleum	**3.0**	**38**
Platforms	0.16	0.86
Atmospheric Deposition	0.12	1.3
Produced waters	2.7	36
Transportation of Petroleum	**9.1**	**150**
Pipeline Spills	1.9	12
Tank Vessel Spills	5.3	100
Operational Discharges [Cargo Washings]	Na[A]	36
Coastal Facility Spills	1.9	4.9
Atmospheric Deposition	0.01	0.4

Petroleum Source	North America (in thousands of tonnes)	Worldwide (in thousands of tonnes)
Consumption of Petroleum	**84**	**480**
Land-Based [River and Runoff]	54	140
Recreational Marine Vessel	5.6	Nd[B]
Spills [Non-Tank Vessels]	1.2	7.1
Operational Discharges [Vessels 100 GT]	0.10	270
Operational Discharges [Vessels <100 GT]	0.12	Nd[C]
Atmospheric Deposition	21	52
Jettisoned Aircraft Fuel	1.5	7.5
TOTAL	260	1,300

Source: NRC 2002. This 2002 report is the third (and most recent) in a series of reports updated periodically by NRC.

[A] Cargo washing is not allowed in US waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in US waters.

[B] World-wide populations of recreational vessels were not available.

[C] Insufficient data was available to develop estimates for this class of vessels.

8.4.2 Historical Large Spills from Offshore Oil Well Blowouts

The main concern is the possibility of a well blowout occurring and discharging large quantities of oil into the marine environment. In Canada, only one small condensate blowout has occurred on the Scotian Shelf. In the US, only three oil-well blowouts (including the recent Macondo blowout in the Gulf of Mexico) involving oil spills larger than 50,000 barrels have occurred since offshore drilling began in the mid-1950s. One must therefore look beyond North America to find a reasonable database on very large and extremely large oil-well blowouts (see Table 8.2 for a definition of hydrocarbon spill sizes). All worldwide blowouts involving spills of more than 10,000 barrels each are provided in Table 8.3.

Table 8.2 Definition of Hydrocarbon Spill Sizes

Hydrocarbon Spill Type	Spill Size	
	bbl	m^3
Extremely Large	>150,000	>23,850
Very Large	>10,000	>1,590
Large	>1,000	>159
Small	<1	<0.159

Note: The top three categories are cumulative; for example, the large-spill category (>1,000 bbl) includes the very large and extremely large spills, and the very large category includes extremely large spills. This follows the approach used by BOEMRE statisticians upon which the “large” spill frequencies are derived.

Table 8.3 Historical Large Spills from Offshore Oil Well Blowouts

Area	Reported Spill Size (bbl)	Date	Operation Underway
US, Santa Barbara	77,000	1969	Production
US, S. Timbalier 26	53,000	1970	Wireline
US, Main Pass 41	30,000	1970	Production
Trinidad	10,000	1973	Development drilling
North Sea / Norway	158,000	1977	Workover
Mexico (*Ixtoc 1*)[A]	3,000,000	1979	Exploratory drilling
Nigeria	200,000	1980	Development drilling
Iran	100,000	1980	Development drilling
Saudi Arabia	60,000	1980	Exploratory drilling
Iran[B]	see note	1983	Production
Mexico	247,000	1986	Workover
Mexico	56,000	1987	Exploratory drilling
US, Timbalier Bay / Greenhill	11,500	1992	Production
Australia[C]	30,000	2009	Development drilling
US, GOM[C]	4,000,000	2010	Exploratory drilling

[A] Spill volume widely believed to be underestimated.
[B] The Iranian Norwuz oil-well blowouts in the Gulf of Arabia, which started in February 1983, were not caused by exploration or drilling accidents but were a result of military actions during the Iraq / Iran war.
[C] Currently under investigation. Spill volume is best estimate and may be subject to revision.

8.4.3 Spill Probabilities from Historical Statistics

Spill frequencies are best expressed in terms of a risk exposure factor such as number of wells drilled. As of May 2010, approximately 50,433 offshore exploration and delineation wells have been drilled (Deloitte Petroleum Services 2010). Therefore, based on two extremely large spills (>150,000 barrel) during offshore exploration drilling the historical frequency is 3.97×10^{-5} (2 / 50,433).

A similar calculation can be done for “very large” spills, that is, those larger than 10,000 barrels. Referring again to Table 8.2, it is seen that four exploration drilling blowouts have produced spills in the “very large” spill category (including Ixtoc 1 and Macondo), so the spill frequency for these becomes 7.93×10^{-5} spills per well drilled (4 / 50,433).

In the entire history of operations in Canadian waters, the US Outer Continental Shelf (OCS), and the North Sea, there have been no large (>1,000 barrel) spills during exploration drilling, other than those listed above including the recent Macondo incident. Only one exploration-drilling blowout that resulted in a large oil spill, other than the spills listed in Table 8.2 (again noting that the category of large spills includes very large spills and extremely large spills). This occurred in the offshore Ankleshwar field in Gujarat, India, in 1998. The operator was the state-owned Oil and Natural Gas Corporation and the spill size was 100,000 gallons or 2,380 barrels. If it is assumed that this was the only large-spill blowout to occur after the ones accounted for above (and this may be a weak assumption), then the spill frequency for large (>1,000 barrel) spills from exploration drilling becomes 5 / 50,433 = 9.91 x 10^{-5} spills per well drilled.

8.4.4 Blowout Frequency Trends

It must be noted that the above spill frequency calculations are based on the entire offshore experience from 1955 to the present. Most of the spills noted in Table 8.3 occurred over 20 years ago, and, as noted earlier, only one large spill from exploration operations (the recent Macondo incident in the US GOM) has ever occurred in North American or North Sea waters. There is an obvious trend over time toward fewer blowouts. Looking at only the drilling-related blowouts and comparing these against the number of wells drilled in the corresponding periods, the historical frequency can be calculated (Table 8.4). There is a clear downward trend from the 1970s to 1980s to 1990s, but then an increase in the most recent 10-year period.

Table 8.4 Large Offshore Drilling-related Blowouts, Historical Frequency by Decade

Period	Incidents	Wells Drilled Worldwide[A]	Frequency	Return Period
1971 to 1980	5	20,116	2.49 x 10^{-4}	One in 4,020
1981 to 1990	1	29,527	3.39 x 10^{-5}	One in 29,500
1991 to 2000	0	28,118	0	--
2001 to present	2	26,732	7.48 x 10^{-5}	One in 13,400

Source: Deloitte Petroleum Services. 2010. List of offshore petroleum wells to May 31, 2010. Report generated on request from Deloitte LLP. London, England.
[A] Includes all offshore wells.

8.4.5 Calculated Blowout Frequencies for the Old Harry Project

Based on a drilling program of one exploration well:

- Predicted annual frequency of extremely large oil spills (>150,000 barrel) from blowouts during an exploration drilling operation, based on an exposure of wells drilled is simply, for a base case of one well, (1 well drilled/year) x (3.97 x 10^{-5} spills/well drilled) = 3.97 x 10^{-5} spills per year. This represents an annual probability of one in 25,000. Another way of expressing this would be to say that, if this drilling rate of one well per year were to continue forever, one could expect an oil spill larger than 150,000 barrels once every 25,000 years.
- Predicted annual frequency of very large oil spills (>10,000 barrel) from exploration drilling blowouts based on an exposure of wells drilled is 7.93 x 10^{-5}, or a probability of one in 13,000.
- Predicted annual frequency of large oil spills (>1,000 barrel) from exploration drilling blowouts based on an exposure of one well drilled is 9.91 x 10^{-5}, or a probability of one in 10,000.

8.4.6 Exploration Drilling Blowouts Involving Primarily Gas

Gas blowouts from offshore wells that do not involve a discharge of liquid petroleum are generally believed to be harmless to the marine environment. However, such blowouts do represent a threat to human life and property because of the possibility of explosion and fire.

US OCS data representing the 30-year period from 1980 to 2010 are provided in Table 8.5. The drilling and blowout experience in operations off Newfoundland and Nova Scotia are summarized in Table 8.6. The total number of exploration wells drilled in the U.S. Federal OCS from 1980 to 2010 is not shown in Table 8.5, but it is derived from Deloitte (2010); the number is approximately 12,000. The number of blowouts from exploration drilling is shown to be 45; therefore, the blowout frequency is 45/12,000 or 3.75 x 10^{-3} blowouts per well drilled, or one blowout for every 267 wells drilled. Five of the blowouts involved oil spills, one of size 200 barrels, one was 100 barrels, one was 11 barrels, one was 5 barrels and the recent Macondo spill of 4 x 10^{6} barrels. The frequencies in Table 8.5 are consistent with the values derived from Table 8.6 (2.8 x 10^{-3} versus 3.75 x 10^{-3}). It is important to note that blowout frequencies in the North Sea and in the GOM declined significantly over the most recent years of the study period, as shown in Table 8.7.

Table 8.5 Blowouts and Spillage from U.S. Federal Offshore Wells, 1980 to 2010

Year	Well Starts	Drilling Blowouts				Non-drilling Blowouts								OCS Production
		Exploration		Development		Production		Workover		Completion		Total Blowouts		
		No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	MMbbl
1980s	11,071	19	0	21	0	7	0	19	113	6	60	72	173	3,407.3
1990s	8,765	17	300	16	0	2	0	5	0	3	0	44	302	4,292.4
2000s	8,390[A]	9	4 E6[B] + 16	9	1	8	378	7	12	1	0	29	380	5,389.64
Total	28,226	45	4 E6[B]	46	1	17	378	31	125	10	60	145	855	13,089.34

[A] Most recent three years estimated.
[B] Total includes 4,000,000 barrel Macondo spill plus 316 barrels in 44 other incidents.

Table 8.6 Exploration and Development Wells and Blowouts in the Eastern Canada

Region	No. of Exploratory Wells	No. of Development Wells	No. of Blowouts	Exploration Blowout Frequency	Overall Blowout Frequency
Newfoundland	198	164	0	0	0
Nova Scotia	154	53	1 (exploration)	6.5 x 10^{-3}	4.8 x 10^{-3}
TOTAL	352	217	1 (exploration)	2.8 x 10^{-3}	1.8 x 10^{-3}

Valid to January 2011 for Newfoundland, March 2010 for Nova Scotia.

Table 8.7 Exploration and Development Drilling Blowout Frequencies over Time

Time Period	Number of Blowouts	Number of Exploration and Development Wells Drilled	Blowout Frequency
18 years (1980 to 1997)	53	22,084	24.0 x 10^{-4}
10 years (1988 to 1997)	23	13,870	16.6 x 10^{-4}
5 years (1993 to 1997)	5	7,581	6.6 x 10^{-4}
3 years (1995 to 1997)	1	4,924	2.0 x 10^{-4}

Source: Scandpower 2000

A more recent analysis by Scandpower (2006), summarized in IAOGP (2010), confirms the reduced frequencies in recent years. The data, based on the 20-year record to 2005, indicate a subsea blowout frequency of 2.1×10^{-4}, based on two incidents in 9,744 wells drilled, which is comparable to the most recent three-year period included in the Scandpower (2000) report. A subsea blowout frequency of 2.1×10^{-4} is equivalent to a probability of one blowout for every 4,800 wells drilled. The more recent analysis also indicates a shallow gas blowout frequency of 2.8×10^{-3}, based on 26 incidents in 9,172 wells drilled.

8.4.7 Calculated Blowout Frequencies for the Old Harry Project

Considering again an exploration program of one well, the blowout frequency becomes 1 well x 2.1×10^{-4} blowout/well drilled = 2.1×10^{-4} blowout per year, or a one in 4,800 chance of a subsea blowout occurring over the drilling program.

8.4.8 Smaller Non-blowout Spills

Oil spills other than from blowouts can occur during drilling and production activities. These include spills of diesel oil or lubricating oil on the drilling installation, spills from transfer operations, spills of drilling muds, and spills from similar incidents involving the handling of oil that is needed to run operations. The overwhelming majority of these spills are very small.

As there have been very few large spills related to exploration and development in Canadian waters, US and world-wide statistics are used. However, there is a reasonably-sized database on small spill incidents in Newfoundland and Labrador waters. Spill statistics are maintained and reported by the C-NLOPB (2011c).

Offshore drilling in Newfoundland and Labrador waters commenced in 1966 with 362 wells drilled to date. Spill incident data, published by the C-NLOPB, is available from 1997 when production began (C-NLOPB 2011c). Since 1997, 219 wells have been drilled. The spill incidents involving 1 barrel or more of hydrocarbon during that period are listed in Table 8.8. These spills include spills of crude, diesel and other hydrocarbons resulting from production and loading operations. As noted above, there was one spill of greater than 1,000 barrel, in 2004.

Table 8.8 Frequency of Spills in the Ranges of 1 to 49.9 Barrels and 50 to 999 Barrels (Newfoundland and Labrador Waters, 1997 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 barrels	12
50 to 999 barrels	0

A disproportionate number (7 of 12) of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years (Table 8.9). For the years 2000 to 2010, some 183 wells were drilled.

Table 8.9 Frequency of Spills in the Ranges of 1 to 49.9 Barrels and 50 to 999 Barrels (Newfoundland and Labrador Waters, 2000 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 barrels	5
50 to 999 barrels	0

For the smallest size range, statistics from Newfoundland and Labrador operations can be used, but as there have been zero spills in the second category, US GOM statistics will be used. Based on this, the frequency of spills in the range of 1 to 49.9 barrel is 2.7 x 10^{-2} (5 / 183) per well drilled and for the range 50 to 999 barrel is 1.8 x 10^{-3} (104 incidents / 56,500 total wells).

The C-NLOPB also provides a statistical record of spills of greater than 1 L but less than 159 L (1 barrel), and of spills of 1 L and less (Table 8.10). As in the previous category of spill size, a disproportionate number of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of the record, 2000 to 2010. For these years (2000 to 2010), there were a total of 183 wells drilled, with 87 spills in the 1 to 159 L category, and 201 spills less than 1 L. Note that the totals in Table 8.10 indicate all spills from 1997 to 2010. The total number of recorded spills less than 159 L (1 barrel) results in a historical frequency of 1.69 spills per well drilled (141 + 230 / 219 wells).

Table 8.10 Record of Very Small Spills in Newfoundland Waters, 1997 to 2010

Year	Spills Greater Than 1 L and Less Than 159 L (1 barrel)		Spills of 1 L and Less	
	Number	Total Volume (L)	Number	Total volume (L)
1997	7	123	0	0
1998	20	640	3	1.6
1999	24	1,193	9	4.72
2000	2	62	2	1.1
2001	7	26	8	4.21
2002	5	16	19	5.2
2003	10	186	9	2.48
2004	21	193	30	8.97
2005	11	181	28	8.96
2006	5	20	27	9.24
2007	3	93	34	4.28
2008	12	337	22	2.89
2009	11	215.8	22	4.97
2010	3	20.3	17	4.21
Total	141	3,306.1	230	62.83

8.4.9 Calculated Frequencies for the Old Harry Project

Three spill size classifications are considered: spills of less than one barrel (termed very small spills for this report), small spills defined as spills between 1 and 50 barrels, and medium spills, 50 to 999 barrels.

8.4.9.1 Spills (Less Than 1 Barrel)

The statistics in Table 8.10 are used to derive an estimated spill frequency for this spill size range. Considering a base case of one well drilled:

- The predicted frequency of spills less than 1 barrel during drilling operations is 1.69 spills/well.

8.4.9.2 Small Spills (1 to 10 Barrel)

The statistics in Table 8.10 are used to derive an estimated spill frequency for this spill size range. Considering that one well will be drilled:

- The predicted frequency of spills of size 1 to 50 barrels during drilling operations is 2.7 x 10^{-2} spills/well, or one spill every 37 wells.

8.4.9.3 Medium Spills (50 to 999 Barrel)

No medium spills or larger spills have occurred in Newfoundland waters since records began in 1997, therefore, US data is used:

- Based on US OCS experience, the predicted frequency of medium spills (50 to 999 barrels) during exploration drilling is 1.8 x 10^{-3} spills/well, or one spill every 540 wells.

8.4.10 Summary of Spill Frequencies

The calculated oil spill frequencies for the Old Harry Project are summarized in Table 8.11. The highest frequencies are obviously for the smaller, operational spills. Spills less than one barrel in size may occur one to two times per well, based on recent petroleum development experience off Newfoundland. Although they may occur with some regularity, they are likely to be quite small, with a median volume of 4 L. Oil spills during exploration that are larger than one barrel but less than 50 barrels have about a 1-in-37 chance of occurring per well. Oil spills of all types in the 50 to 999 barrel range may have about a 1-in-540 chance of occurring per well, based on experience in the US OCS.

There is about a 1-in-4,800 chance per well of having any sort of subsea blowout. Shallow gas blowouts may occur and are up to 10 times more probable than ones that occur at depth, but these would involve only natural gas and not oil.

The chances of an extremely large (>150,000 barrels), very large (>10,000 barrels), and large (>1,000 barrels) oil well blowout from exploration drilling are very small: about a 1-in-25,000, 1-in-13,000 and 1-in-10,000 chance per well, respectively. These predictions are based on worldwide blowout data and are strongly influenced by blowouts that occurred in parts of the world where drilling regulations may be less rigorous.

Table 8.11 Predicted Number of Blowouts and Other Spills for Old Harry Project (assuming one well)

Event	Historical Frequency [illegible][A]	Probability
Subsea blowout during exploration drilling	2.1×10^{-4}	One every 4,800 wells
Exploration drilling blowout with oil spill >1,000 barrels	9.91×10^{-5}	One every 10,000 wells
Exploration drilling blowout with oil spill >10,000 barrels	7.93×10^{-5}	One every 13,000 wells
Exploration drilling blowout with oil spill >150,000 barrels	3.97×10^{-5}	One every 25,000 wells
Non-blowout oil spill, 50 to 999 barrels	1.8×10^{-3}	One every 540 wells
Non-blowout oil spill, 1 to 50 barrels	2.7×10^{-2}	One every 37 wells
Non-blowout oil spill, 1 L to 1.0 barrel	1.69	One every 0.59 wells

[A] Blowout spills (first four rows of data) are based on worldwide, US OCS and North Sea experience; Non-blowout - oil spills (last two rows of data) are based on Newfoundland experience, 2000 to 2010.

8.4.11 Spills of Synthetic-based Muds

The C-NLOPB records spills of SBM, and these are summarized in Table 8.12 for the years 1997 through 2010. In the largest such spill to date, in 2004, approximately 96,600 L (608 barrels) of SBM were spilled from the diverter line of the *GSF Grand Banks* at the White Rose location. The spill frequency is calculated based on the 219 wells spudded during this period.

Table 8.12 Spills of Synthetic-based Muds, 1997 to 2010

Spill Size Range	Number of Spills	Frequency, per well
>1 L	36	0.16
159 to 7,934 L (1 to 49.9 barrels)	18	0.082
7,935 to 159,000 L (50 to 999 barrels)	5	0.023
>159,000 L (1,000 barrels)	0	0

8.5 Nearshore Spills

The assessment of this Project includes helicopter and supply vessel transit to and from Newfoundland. Any support vessels that may come from St. John's, NL, will use the recognized shipping lane through the Laurentian Channel. Once the supply vessels leave the Project Area, they must adhere to general marine shipping rules and conventions, but there is a risk that an accident or collision could result in the release of hydrocarbons (likely diesel fuel and lubricants) into the marine environment. As the exact routing of these vessels has not yet been determined, it was not feasible to conduct modelling for these events. For the purposes of the assessment, it is assumed that the spill could occur anywhere within the Study Area and in a worst case-scenario, reach the shoreline. These potential effects are discussed here generically.

The United States Coast Guard (2005) published a fact sheet on small diesel fuel spills (approximately 1,900 to 19,000 L (500 to 5,000 gallons)), indicating that diesel fuel is a light, refined petroleum product and when spilled on water, most of the oil will evaporate or naturally disperse within a few days or less, seldom leaving any oil on the surface for responders to recover. It quickly spreads to a thin film; even when described as a heavy sheen, it is approximately 0.01 mm (0.0004 inches) thick. Due to low viscosity, it is readily dispersed into the water column; it does not sink and accumulate on the sea floor as pooled or free oil, but can be physically mixed into the water column by wave action, forming small droplets carried and kept in suspension by the currents.

Oil dispersed in the water column can adhere to fine-grained suspended sediments, which then settle out and are deposited on the sea floor (US Coast Guard 2005), with this process more likely to occur near river mouths and less likely in open marine settings. For small spills, it is not likely to result in measurable sediment contamination. Because of its low viscosity, when small spills strand on the shoreline, the oil tends to penetrate porous sediments quickly, but also to be washed off quickly by waves and tidal flushing. Thus, shoreline cleanup is usually not needed. It can be expected to be fully degraded by naturally occurring microbes within one to two months or less.

Within any shoreline type, environmental effects are expected to be proportional to the nature and amount of oil stranded. The level of environmental effects of oil spills on shorelines is closely related to the relative degree of exposure of the affected habitat (Hayes and Gundlach 1975; Gundlach and Hayes 1978; Gundlach et al. 1978; Michel et al. 1978). Two physical factors, wave energy flux and tidal-energy flux, primarily determine the degree of exposure for shorelines (NOAA 2002).

Shorelines can be classified as high, medium and low energy (NOAA 2002). High-energy shorelines are exposed year-round to large waves and/or strong tidal currents. They occur along the outermost coastline of a region that is subjected to dominant winds causing waves to strike the shoreline directly or by wave refraction. Medium-energy shorelines are subjected to seasonal patterns of influences resulting from storm frequencies and wave size (i.e., they are more sheltered than high-energy shorelines but storm events result in similar patterns as high energy shorelines on a seasonal cycle). Low-energy shorelines are sheltered from wave and tidal energy, except during unusual or infrequent events.

Inherent in the energy classifications are inferences to the persistence of stranded oil. High energy shorelines exhibit rapid natural removal, usually within days to weeks. Low energy shorelines are characterized by slow, natural removal, usually within years. Medium energy shorelines have stranded oil that will be removed when the next high-energy event occurs, which could be days or months after the spill.

The tidal-energy flux (NOAA 2002) is also important in determining the potential of oil-spill effects on coastal habitats, as strong tidal currents can remove stranded oil as well as build and move inter-tidal sand and/or gravel that bury oil.

Substrate types (NOAA 2002) are important considerations with respect to persistence and effects of oil on shoreline types. The substrate type distinctions of primary importance are between bedrock and unconsolidated sediment, as with unconsolidated sediment there is the potential for penetration and burial of oil. Penetration and burial are different, but these mechanisms lead to the increased persistence of oil and as a result may lead to long-term biological effects, as well as making cleanup more difficult and intrusive. Environmental effects are expected to be greater where the oil penetrates permeable substrates and tends to persist in sheltered habitats. Studies have shown that heavy oils can penetrate up to 1 m on gravel beaches. The oil from Old Harry is anticipated to be light (45to 56 ºAPI). Mixed sand and gravel beaches usually have heavy oil penetration of less than 50 cm.

Beaches may have different permeabilities depending upon grain size, with muddy sediment have the lowest permeability and the least amount of penetration. However, the infaunal burrows provide a mechanism for oil penetration into an often impermeable substrate.

Biological resources (NOAA 2002) along shorelines are most at risk from oil spills when:

- large numbers of individuals are concentrated in a relatively small area;
- marine or aquatic species come ashore during special life stages or activities, such as nesting, birthing, resting, or molting;
- early life stages or important reproductive activities occur in sheltered, near-shore environments where oil may tend to accumulate;
- a species is threatened, endangered, or rare; or
- a large percentage of the population is likely to be exposed to oil.

In high-energy environments (NOAA 2000), oil is generally held offshore by wave reflection, and any oil that is deposited is rapidly removed by wave action. Environmental effects to inter-tidal communities are expected be short term. In medium-energy environments, which are essentially an intermediate stage between high-energy and low-energy environments with tide pools, there is usually a small accumulation of soil sediment at high tide mark coexisting with gravel beaches. Depending upon the substrate type and energy / tidal flux, medium-energy environments often have varying species density and diversity. Barnacles, snails, mussels and macro-algae are present and may be dominant species.

The effects of oil in low-energy environments (NOAA 2000) may vary considerably, depending upon substrate type. Beach-type fauna will vary with sand beaches used by birds, turtles, crabs, amphipods and other sediment crustaceans. Tidal flats are often the most diverse productive type of low-energy environments, with large concentrations of bivalves, worms and other invertebrates. They are often critical habitat for feeding birds. If there is the presence of sea grasses, these low-energy environments may be important fish and shellfish nurseries. Under worst case scenarios, environmental effects in low-energy environments can be severe, with smothering and lethal toxicity associated with interstitial waters. Sea grass communities maybe become defoliated. Temporary declines in infauna may occur, which in turn may affect shorebirds, as low-energy environments are often critical forage habitats.

Several diesel oil spills have been studied in the past, focusing on the physical properties and movement of diesel, along with the biological effects of diesel in the marine environment (Hooper and Morgan 1999). Diesel has been found to have an immediate toxic effect on many intertidal organisms, including periwinkles, limpets, gastropods, amphipods and most meiofaunal organisms within several kilometres of the original spill (Pople et al. 1995; Stirling 1977; Wormald 1976; Cripps and Shears 1997). One such spill was found to have contaminated the water and shoreline with diesel within a 2 km radius of the original spill. Intertidal areas were most directly affected, but all components of the surrounding ecosystem were contaminated during the first weeks after the spill. Hydrocarbons were detected in tissues from birds, limpets, algae, calms, fish and crustaceans in harbours a couple of kilometres away up to one year after the incident (although continued chronic leakage from the ship was suggested as a possible source) (Kennicutt et al. 1991). Subtidally, there were no measurable effects of the *Bahia Paraiso* oil spill two months after the incident, nor was there any major contamination of the subtidal sediments (Hyland et al. 1994). Marine resources unable to avoid a spill, such as eggs and larvae, would be more at risk from the harmful physiological effects of a spill.

8.6 Spills of Whole Muds

SBMs are drilling muds that consist of a synthetic base fluid chemical that is in continuous phase with water as the dispersed phase (Neff et al. 2005). As such, SBMs are largely immiscible in water (Hart et al. 2007). When accidently released into seawater, SBM breaks into individual droplets. Due to the presence of barite in emulsion, SBMs are denser than seawater and will sink when released. Dispersal, size and fall velocity of droplets depend on the conditions of release and mixing during descent through the water column (Hart et al. 2007). The contrasting physical / chemical properties of WBM versus SBM emulsions leads to different responses to dilution in seawater and, subsequently, different behaviours in the marine environment. These differences are fundamental and are possibly best described in terms of a comparison of the general behaviour of WBM and SBM releases in seawater.

In the case of WBM, seawater dilutes an emulsion that is already water-based (JW 2004). As a result, individual particles in the emulsion are separated by larger and larger distances such that they can be eventually treated as independent particles falling under the force of gravity. After sufficient dilution, these particles simply ‘rain’ down toward the seabed. The particles may coalesce (flocculate) and their behaviour in the benthic boundary layer (overlying water column and uppermost centimetres of sediment) may be complex, but, in any case, the original properties of the emulsion are lost. In the case of WBM, the effect of dilution is invariably to break the emulsion.

SBM emulsions behave quite differently (JW 2004). While the initial phase of dilution follows the same overall physical processes as does WBM (mainly mixing during momentum loss and turbulent decent), the entrained seawater does not dilute the emulsion constituents homogeneously and does not “break” the emulsion. Instead, the emulsion forms droplets that retain the properties of the original emulsion. These droplets can subsequently coalesce under conditions of reduced turbulence to regenerate the original bulk emulsion. The regenerated emulsion may be wetter than the original, due to water adsorbed by excess emulsifiers or due to the swelling of the water pockets within the emulsion. If wet enough and subject to shearing over a sufficiently long period of time, a thickened mousse may form. However, only under conditions of very high shear will the emulsion break with the separation of the synthetic base fluid phase from the emulsified constituents. This circumstance would be a very rare event, but if it were to occur, the buoyant base fluid phase of the emulsion will tend to rise in the water column while the heavier particles would tend to floc and sink toward the sea floor. Only in this unlikely case would the weighting particles tend to behave like diluted WBM particles. Most releases likely involve formation of droplets or streams of the SBM emulsion. The main environmental parameters affecting SBM plume behaviour are density and current.

8.7 Environmental Effects Assessment

An accidental release of oil could affect marine fish habitat and marine ecosystems (especially a subsea blowout), marine fish and shellfish (and the resulting affect on commercial fisheries), marine birds (especially a surface blowout or batch spill), marine mammals and sea turtles that come into contact with a slick (although they can usually avoid a slick), species at risk (for same reasons as the not at-risk species) and sensitive areas.

The following assessment assumes that the Study Area / Affected Area for each of the VECs would be equivalent to the cumulative predicted zones of influence from the spill scenarios described in Section 2.12.3 (and illustrated in Figures 2.12, 2.13, 2.18 and 2.19 and reported in SL Ross (2011) for blowouts. As described in the introduction, there is also a possibility that spills of diesel fuel could occur from vessels enroute to site from Newfoundland (any support vessels that may come from St. John’s, NL, will use the recognized shipping lane through the Laurentian Channel.).

The same significance criteria are used as for routine Project activities (see Sections 7.2.1 to 7.8.1).

8.7.1 Species at Risk

The species at risk that may occur within the Study Area are identified in Tables 5.1 and 5.2 and include marine fish, marine birds, marine mammals and sea turtles.

8.7.1.1 Marine Fish Species at Risk

Fish have the potential to interact with material discharged during a spill event. Spilled substances can adhere to physical habitat structures or influence chemical habitat parameters (e.g., water quality). The risk of exposure of marine fish to an oil spill is dependent on the habitat they occupy and their behaviour (Yender et al. 2002):

- pelagic and benthic fish, occurring in relatively deep waters have low exposure risk because they are highly mobile and able to avoid oiled areas (Irwin 1997) and oil concentrations in the water column are usually low and declining;
- fish that spawn or occur in nearshore intertidal and subtidal zones and in shallow reef zones are at higher risk of exposure due to shoreline oiling;
- shellfish have a moderate risk of exposure because they have some mobility, but utilize benthic habitats in shallow nearshore and estuarine areas. Species that burrow into contaminated sediments are at higher risk of exposure;
- molluscs, especially bivalves, are at high risk of contamination because they are sessile and unable to avoid exposure. They can ingest dispersed oil and oil attached to suspended sediments.

All marine fish species at risk within the Study Area are finfish with low exposure risk. A hydrocarbon spill can affect local abundance and availability of phytoplankton and zooplankton to fish, but fish are not expected to remain within the area affected by the spill. If fish eat contaminated zooplankton, they will accumulate hydrocarbons themselves. However, fish are also able to metabolize hydrocarbons and there is no potential for bio-magnification (LGL 2005c).

Perhaps the species of greatest concern would be redfish as the Project Area overlaps a potential redfish mating area. Redfish typically mate in the fall; however, eggs are hatched within the female and are not extruded until the following April to July (Section 5.2.1.7). An oil spill would not affect redfish larvae, as the potential larvae extrusion area is outside (to the north, in the Cabot Strait) of the Study Area (Figure 5.56).

Effects of an oil spill resulting from an accidental release associated with this Project are therefore expected to be minimal and not significant on juvenile and adult fish species at risk.

8.7.1.2 Marine Bird Species at Risk

The oil spill modelling of the diesel and oil (condensate) spills at the wellsite (reported in SL Ross (2011) and summarized in Section 2.12.3) indicate that there would be no fuel remaining after 30 days and it would not reach any shorelines (Table 2.12). The only bird species at risk (Ivory Gull) which is expected to occur within the Project Area is an infrequent visitor and travels with the pack ice. As Corridor plans on drilling in an ice-free period only, there is a low probability that any Ivory Gull would be affected by an oil spill at the exploration well. Spills of diesel fuel from the supply vessels could interact with the coastline, and thus could affect piping plover, Barrow's Goldeneye and Harlequin Duck. This risk would be no different or greater than the risk associated with any other marine shipping activity in the Gulf.

Oil spills can affect marine bird species at risk in a number of ways. Nesting seabirds that have survived oil contamination generally exhibit decreased reproductive success. Breeding birds that ingest oil generally exhibit a decrease in fertilization (Holmes et al. 1978), egg laying and hatching (Hartung 1965; Ainley et al. 1981), chick growth (Szaro et al. 1978), and survival (Vangilder and Peterle 1980; Trivelpiece et al. 1984), as well as a reduction in mean eggshell thickness and strength (Stubblefield et al. 1995).

A spill that occurs during the reproductive period could cause mortality of young even if the adults survived the exposure to oil by affecting prey availability of species with low seasonal dietary variation (Velando et al. 2005), changes in normal parental behaviour (Eppley and Rubega 1990) or abandonment of nests (Butler et al. 1988).

There are possible changes in habitat use of oiled areas by both oiled and un-oiled birds, with the greatest decrease in use of contaminated habitats immediately following a spill occurring in species that feed on or close to shore and that either breed along the coast or are full-year residents (Wiens et al. 1996). Day et al. (1995) showed that species lacking clear evidence of recovery tended to be intertidal feeders and residents. However, they also found that other ecologically similar species did not show signs of initial impact or showed rapid recovery.

Exposure to oil causes thermal and buoyancy deficiencies that typically lead to the deaths of affected seabirds. External exposure to oil occurs when flying birds land in oil slicks, diving birds surface from beneath oil slicks, and swimming birds swim into slicks. Although some may survive these immediate effects, long-term physiological changes may eventually result in death (Ainley et al. 1981; Williams 1985; Frink and White 1990; Fry 1990). Reported effects vary with bird species, type of oil (Gorsline et al. 1981), weather conditions, time of year, and duration of the spill or blowout. Although oil spills at sea have the potential to kill tens of thousands of seabirds (Clark 1984; Piatt et al. 1990), some studies suggest that even very large spills may not have long-term effects on seabird populations (Clark 1984; Wiens 1995). Most mortality occurs during the initial phase of oil spills when large numbers of birds are exposed to floating oil (Hartung 1995). There is no clear correlation between the size of an oil spill and numbers of seabirds killed, because the density of birds in a spill area, wind velocity and direction, wave action, and distance to shore can have a greater bearing on mortality than the size of the spill (Burger 1993). A major spill that persists for several days near a nesting colony could kill a high proportion of pursuit-diving birds (e.g., murres) within the colony (Cairns and Elliot 1987). As stated above for diesel spills, most of the oil will evaporate or naturally disperse within a few days or less, limiting the potential for oiling of marine bird species at risk in the Study Area.

Oiled birds that escape death can ingest oil from excessive preening (Hunt 1957, in Hartung 1995). The preening leads to the ingestion of significant quantities of oil that, although apparently only partially absorbed (McEwan and Whitehead 1980) can cause lethal effects.

Birds exposed to oil are also at risk of starvation (Hartung 1995). For example, oiled Common Eiders generally deplete all of their fat reserves and much of their muscle protein (Gorman and Milne 1970). In addition, energy demands are higher because the metabolic rate of oiled birds increases to compensate for the heat loss caused by the reduced insulating capacity of their plumage. This can expedite starvation (Hartung 1967; McEwan and Koelink 1973).

It appears that direct, long-term sublethal toxic effects on seabirds are unlikely (Hartung 1995). The extent of bioaccumulation of the chemical components of oil in birds is limited because vertebrate species are capable of metabolizing them at rates that minimize bioaccumulation (Neff 1985, in Hartung 1995). Birds generally excrete much of the hydrocarbons within a short time period (McEwan and Whitehead 1980).

Piping plover are known to breed in western Newfoundland. As a shorebird, this species would be most at risk from spills that extend onto shore. As stated above, when small spills of diesel fuel strand on the shoreline, the oil tends to penetrate porous sediments quickly, but also to be washed off quickly by waves and tidal flushing. As diesel spill disperses rapidly, this would only be a concern for spills that originate close to shore from support vessels.

Harlequin Ducks breed and overwinter on the west coast of Newfoundland. Breeding sites are in inland rivers, then in later summer, birds return to the ocean and spend most of the year in coastal marine environments. Distribution maps for these species shows a greater occurrence on the southern and northern coasts of Newfoundland. While Harlequin duck may be affected by a spill, this species is expected to occur off the west coast in low densities and it is therefore unlikely for a localized spill of diesel fuel to affect more than a few birds in a worst-case scenario.

Barrow's Goldeneye is a diving duck that winters in marine habitats. During late fall, winter and early spring, the majority of the Eastern population occur in the St. Lawrence corridor, an area subject to heavy shipping activity. A provincial management plan considered that the risks to this species on the wintering grounds within Newfoundland from an oil spill would be minimal. As there are only a small number of birds documented at six sites (mostly off eastern and northern Newfoundland), any individual oil spill was considered to have a negligible overall effect on the Barrow's population (Schmelzer 2006).

Depending on the timing, location, and environmental conditions of any accidental events, there could be oiling of marine bird species at risk. Given the location of the Project and potential supply vessel route from Newfoundland (any support vessels that may come from St. John's, NL, will use the recognized shipping lane through the Laurentian Channel), it is unlikely that an accidental spill would affect a large number of birds or that the effects would be measurable at a population level. However, as even minute amounts of oil have the potential to affect marine birds, the residual environmental effect is predicted to be significant.

8.7.1.3 Marine Mammal Species at Risk

Marine mammals or turtles could ingest oil with water, contaminated food, or oil could be absorbed through the respiratory tract; absorbed oil could cause toxic effects (Geraci 1990). Inhalation of vapours from volatile fractions of oil from a spill or blowout could potentially irritate respiratory membranes and hydrocarbons could be absorbed into the bloodstream (Geraci 1990). Species like the humpback whale, right whale, beluga and harbour porpoise that feed in restricted areas may be at greater risk of ingesting oil (Würsig 1990). Absorbed oil can cause toxic effects such as minor kidney, liver, and brain lesions (Geraci and Smith 1976; Spraker et al. 1994). Some of the ingested oil is voided in vomit or feces, but some is absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982). In baleen whales, crude oil could coat the baleen and reduce filtration efficiency, but these effects are considered to be reversible (Geraci 1990).

Gross histologic lesions developed in loggerhead sea turtles experimentally exposed to oil, but most effects were apparently reversed by the tenth day after exposure (Bossart et al. 1995). Oil may also reduce lung diffusion capacity, decrease oxygen consumption or digestion efficiency, or damage nasal and eyelid tissue (Lutz et al. 1989).

Several species of cetaceans and seals have been documented behaving normally in the presence of oil (St. Aubin 1990; Harvey and Dahlheim 1994; Matkin et al. 1994). It is possible that cetaceans swim through oil because of an overriding behavioural motivation (for example, feeding). Studies of both captive and wild cetaceans indicate that they can detect oil spills. Captive bottlenose dolphins (*Tursiops truncatus*) avoided most oil conditions during daylight and darkness, but had difficulty detecting a thin sheen of oil (St. Aubin et al. 1985). Wild bottlenose dolphins exposed to the Mega Borg oil spill in 1990 appeared to detect, but did not consistently avoid contact with, most oil types (Smultea and Würsig 1995). It is unknown whether sea turtles can detect and avoid oil slicks. Gramentz (1988) reported that sea turtles did not avoid oil at sea, and sea turtles experimentally exposed to oil showed a limited ability to avoid oil (Vargo et al. 1986).

There is no clear evidence implicating oil spills with the mortality of cetaceans (Geraci 1990), although there was a significant decrease and lack of recovery in the population size of a fish-eating killer whale pod that uses the area of the Exxon Valdez oil spill (Dahlheim and Matkin 1994). Continued monitoring over sixteen years indicates that the killer whale pod had still not returned to its pre-spill population abundance, and the population's rate of increase was significantly less than other fish-eating pods in the area (Matkin et al. 2008).

Hall et al. (1983) observed seven live and three dead sea turtles following an oil well blowout in 1979; two of the carcasses had oil in the gut but no lesions, and there was no evidence of aspirated oil in the lungs. However, hydrocarbon residues were found in kidney, liver, and muscle tissue of all three dead turtles, and prolonged exposure to oil may have disrupted feeding behaviour and weakened the turtles.

Stressed individuals or those that could not escape a contaminated area would be most at risk to potentially deleterious effects. Animals exposed to heavy doses of oil for prolonged periods could experience mortality. It is difficult to predict with precision the effects of accidental events on biota, especially as they relate to the geographic extent of the effects. Numerous parameters (e.g., chemical composition of the hydrocarbon, behaviour of spilled substance at different times of year) influence hydrocarbon spill characteristics and there are many unknowns concerning specific effects on different marine mammal and sea turtle species at risk. Therefore, the emphasis will be on accident prevention at all phases of the Project.

Marine mammals and sea turtles are not considered to be at high risk from the effects of oil exposure, and it is probable that only small proportions of populations at risk would be in the Project Area or Study Area at any one time. Oil spill prevention measures, along with typical oil spill countermeasures (creating an oil spill response plan, training, preparation, an equipment inventory, and conducting emergency response drills) will serve to reduce the likelihood of an oil spill. Depending on the time of year, location of animals within the affected area, and type of oil spill or blowout, the effects of an accidental release on the health of cetaceans and sea turtles is predicted to be negligible to low. Based on modelling exercises, and on past monitoring experience with large spills with much worse scenarios than for this Project (e.g., Exxon Valdez, Arrow and others), any residual environmental effects on marine mammal or sea turtle species at risk in the Study Area are predicted to be not significant.

8.7.2 Marine Ecosystems

Based on modelling conducted by SL Ross (2011; see Section 2.12 for summary), there will be no interaction between a spill at the wellsite and coastal ecosystems (algal, eelgrass and saltmarsh communities) (Figure 2.20). A diesel spill from a vessel accident could potentially affect the coastline and this is discussed below.

There is also potential for interaction between a spill event at the wellsite and the marine ecosystems (benthic fauna and plankton). As condensate product from a surface spill would form a thin slick on the ocean surface and only disperse into the top 30 m of the water column

(Section 2.12.2.4), it is unlikely that there would be an interaction between a surface spill and deep-water corals and sponges. There is potential for interaction in the event of a subsea blowout. Oil released from an offshore blowout should quickly rise to the surface. As fluids erupt from the seabed, the turbulent flow breaks the crude oil up into small droplets. These droplets are then quickly carried to the surface by the water being pumped to the surface by the gas bubble plume. Drilling will occur in open water and because of the depths involved (greater than 400 m), there is a low likelihood of oil adhering to suspended sediments and being deposited on the bottom.

Effects of crude oil spills on plankton are brief, with zooplankton being more sensitive than phytoplankton. Zooplankon accumulate hydrocarbons in their bodies which may be metabolized and depurated (Trudel 1985). After a spill, accumulated hydrocarbons would be depurated within a few days after a return to clean water, and thus, there is limited potential for transfer of hydrocarbons up the food chain (Trudel 1985). There is a potential for transfer of hydrocarbons up the food chain in an environment subject to chronic inputs of hydrocarbons, but there is no potential for biomagnification.

Diesel oil (39 to 43 ° API), which has similar characteristics to the oil (condensate) expected at the Old Harry field, is much more toxic than heavy crude oil, but is shorter-lived in the open ocean than crude oil and there is great variability among species and some species are relatively insensitive. For example, the 96-h LC50 of crude oil for *Calanus hyperboreus*, a common cold water copepod, was 73,000 ppm (Foy 1982). Complete narcotization of copepods can occur after a 15-minute exposure to 1,800 ppm of aromatic heating oil (No. 2 fuel oil) and mortality can occur after a 6-hour exposure (Berdugo et al. 1979). Exposure to concentrations of 1,000 ppm of aromatic heating oil for three days had no apparent effect on mobility, but exposure for as little as 10 minutes shortened life span and total egg production (Berdugo et al. 1979). No. 2 fuel (33.7ºAPI) oil at concentrations of 250 to 1,000 ppm completely inhibited, or modified, copepod feeding behaviour, while concentrations of 70 ppm or lower may not affect feeding behaviour (Berman and Heinle 1980). Exposure to naphthalene at concentrations of 10 to 50 ppm for 10 days did not affect feeding behaviour or reproductive potential of copepods, although egg development was not examined (Berdugo et al. 1979).

Although individual zooplankton could be affected by a blowout or spill through mortality, sublethal effects, or hydrocarbon accumulation, the predicted maximum concentrations for batch and blowouts are well below those known to cause effects.

If a diesel spill were to occur in the nearshore environment, it could affect sensitive habitats such as eelgrass beds and kelp forests. Sea grasses are sensitive to hydrocarbon uptake and oiling. Direct contact with oil causes eelgrass plants to lose their leaves. As eelgrass leaves are rough and without a mucous layer like many seaweeds, oil will readily stick.

Direct oiling can occur where eelgrass beds occurs in very shallow water and form a canopy layer on the water surface, allowing oiling of the floating eelgrass tops. However, direct oiling is uncommon, with uptake of hydrocarbon from the water column being the main concern. Moderate hydrocarbon concentrations in the water column for a few hours or low concentrations for a few days will result in mortality of individual plants, with a bed of eelgrass possibly taking several years to recover from die-off resulting from oiling (Fingas 2001).

The effects of oil spills can be more pronounced for eelgrass beds growing in sheltered bays that are poorly flushed, as oil will tend to persist for longer periods resulting in chronic contamination (Dean and Jewett 2001). The timing of a spill will also influence the nature of the effects. In the spring, seed production and viability could be affected (Beak Consultants 1975), while a spill in late summer or winter when leaf sloughing is at its peak, may encounter mats of drift blades which will tend to catch and retain oil for later decomposition in the intertidal zone. Hatcher and Larkum (1982) also indicate that the surfactants applied to mitigate oil spills could have a permanent and more significant detrimental effect on eelgrass than the spill itself.

Studies of the effects of oil spills on eelgrass communities have been conducted in association with the *Exxon Valdez* oil spill in Prince William Sound, Alaska (Dean et al. 1998; Jewett and Dean 1997), and the Amoco Cadiz spill near Roscoff, France (Den Hartog and Jacobs 1980). The results of both case studies indicate that recovery of the eelgrass beds can occur within a couple of years, although there may be a longer effect for some components of the benthic communities. Thus, it is the associated faunal communities that tend to be more sensitive to hydrocarbon pollution than the eelgrass plants themselves. There is very little information on the effect of diesel oil on eelgrass in particular. Even though diesel can be more toxic than crude oil initially, these studies are useful in assessing the longer term effects of polycyclic aromatic hydrocarbons (PAHs) in the sediment of an eelgrass bed.

Bokn et al. (1993) discussed the effects of the water-accommodated fractions of diesel on rock shore populations. In a rocky littoral, diesel oil spills usually result in extensive animal mortalities, and variable, but less severe impacts on seaweeds (e.g., Blumer et al. 1971, Pople et al. 1990). Data for the Solbergstrand mesocosms suggest that animal populations were most affected by oil treatments and indicate that a chronic low-level exposure to water-accommodated fractions of diesel oil may have only limited direct effect on seaweed stocks (Bokn et al. 1993).

Should an accidental spill of diesel hydrocarbons occur in the nearshore environment as a result of this Project, experience from the sites of other spills indicates that there could be a change in the composition of mobile benthic communities associated with any contaminated eelgrass beds. While most components are likely to recover within several years following a spill, some taxa such as Amphipoda and some families of Polychaeta, may take longer to return.

Marine wetlands (e.g., salt marshes) are vulnerable to oil spills because their inherently low wave energy limits the effective physical removal of oil. They are flooded at high tide and their complex surface can trap large amounts of oil (Zhu et al. 2004). Oil spills can cause reduction in population and growth rate or abnormal growth and regrowth after initial impact, with effects depending on factors, including the type and amount of oil, the extent of oil coverage, the plant species, the season of the spill, the soil composition, and the flushing rate (Zhu et al. 2004). Oil generally remains longer in soils with higher organic matter, resulting in greater impact on resident plants. Heavy contamination by light oil can lead to widespread mortality, and plants may require a decade or more to recover. Plants are also more sensitive to oiling during the growing season than other periods (Pezeshki et al. 2000).

The risk of any diesel spill in association with this Project is low and no greater than from any other marine shipping activity in this region. Supply ships will follow standard shipping rules and conventions and pollution prevention measures will be in place. As discussed above, a diesel spill will disperse quickly in open waters and the above effects would be of most concern if a spill occurred in the vicinity of sheltered bays which also support sensitive habitats such as eelgrass beds or salt marshes. As worst-case scenario effects are predicted to be reversible and localized, the residual adverse environmental effect of an accidental spill on Marine Ecosystems is predicted to be not significant.

8.7.3 Marine Fish and Fish Habitat

Shellfish have limited potential to interact with material discharged during a spill event. Spilled substances can adhere to physical habitat structures or influence chemical habitat parameters (e.g., water quality). Shellfish (with the exception of northern shrimp) present in the Study Area inhabit the seabed for the majority of their life. Only the subsea blowout scenario has potential to interact with adult benthic shellfish. Shellfish past the egg and larval stage will likely actively avoid any hydrocarbon spill by swimming away and would not be affected (Irwin 1997).

Eggs and larvae are more subject to harmful physiological effects from a fuel spill because they cannot actively avoid the spill and they have not developed any detoxification mechanisms. Recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of the spawning area were lost (Rice 1985). When the survival of herring larvae was reduced by 58 percent as a result of the *Exxon Valdez* spill, no effect was detected at the population level (Hose et al. 1996). Thus, the effect of a localized spill on egg and larval survival would likely be undetectable from the high rate of natural mortality.

As described in Section 8.4.1.1, marine fish would likely avoid any slick that might form. Given the limited aerial extent of a modelled accidental event, the residual adverse environmental effect of an accidental spill on Marine Fish and Shellfish is predicted to be not significant on adult and juvenile fish and shellfish.

8.7.4 Marine Birds

The potential effects of oil on marine bird species at risk are discussed in Section 8.4.1.2, but is also applicable to non-listed species. It is clear that truly aquatic and marine species of birds are most vulnerable and most often affected by exposure to marine oil spills. Diving species such as Black Guillemot, murres, Atlantic Puffin, Dovekie, eiders, Long-tailed Duck, scoters, Red-breasted Merganser (*Mergus serrator*), and loons are considered to be the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999; Irons et al. 2000). Alcids, especially Common and Thick-billed Murres, often have the highest oiling rate of seabirds recovered from beaches along the south and east coasts of the Avalon Peninsula, Newfoundland (Wiese and Ryan 2003). Those were the only group of seabirds to show an annual increase over a 13-year period (2.7 percent) in the proportion of oiled to stranded birds (Wiese and Ryan 1999). There also appears to be a strong seasonal effect, as significantly higher proportions of alcids (along with other seabird groups) are oiled in winter versus summer (Wiese and Ryan 1999).

Other species such as Northern Fulmar, shearwaters, storm-petrels, gulls, and terns are vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water's surface. They are also vulnerable to the disturbance and habitat damage associated with oil spill cleanup (Lock et al. 1994). Shorebirds may be more affected by oil spills than has been suggested by carcass counts.

The 1984 blowout at the Uniacke G-72 well (near Sable Island) resulted in a spill of 240 m^3 (1,510 barrels) of condensate. A survey of an extensive area around the well after the well was capped (11 days after the blow-out) observed a total of seven oiled marine birds (three Dovekies and four murres), with no obvious oiling of gulls, kittiwakes and fulmars (Martec Ltd. 1984, in Hurley and Ellis 2004).

Some studies have suggested that oil pollution is unlikely to have major long-term effects on bird productivity or population dynamics (Clark 1984; Butler et al. 1988; Boersma et al. 1995; Erikson 1995; Stubblefield et al. 1995; White et al. 1995; Wiens 1995, 1996; Seiser et al. 2000).

On a broader geographical scale, estimates of the number of birds that die annually from operational spills range from 21,000 on the Atlantic coast of Canada, and 72,000 in all of Canada (Thomson et al. 1991), to 315,000 ±65,000 Common Murres, Thick-billed Murres and Dovekies annually in southeastern Newfoundland alone due to illegal oil discharges from ships (Wiese and Robertson 2004). Clark (1984) estimated that 150,000 to 450,000 birds die annually in the North Sea and North Atlantic from oil pollution from all sources.

The modelling results indicated that no slicks would reach a coastline from an above-sea spill in the Project Area (see Table 2.12). As a result, none of the coastal species would be affected by a spill at the well site. As described above for marine bird species at risk, an accidental spill of diesel fuel from a supply ship could occur anywhere along the route. The west coast of Newfoundland supports six vulnerable seabird colonies, with four of the six found at the mouth of the Humber River, the waterway leading to the Port of Corner Brook. The lack of seabird colonies is attributable to a general lack of suitable nesting sites and the relatively low productivity of the waters along this coast. There are also some relatively large tern colonies present along the west coast of Newfoundland.

Depending on the timing, location, and environmental conditions of any accidental events, there could be oiling of marine birds. Given the location of the Project and potential supply vessel route from Newfoundland (any support vessels that may come from St. John’s, NL, will use the recognized shipping lane through the Laurentian Channel), it is unlikely that an accidental spill would affect a large number of birds or that the effects would be measurable at a population level. However, as even minute amounts of oil have the potential to affect marine birds, the residual environmental effect is predicted to be significant.

8.7.5 Marine Mammals and Sea Turtles

The effects of hydrocarbon spills on marine mammal and sea turtle species at risk is described in Section 8.4.1.3 and would also be applicable to non-listed species. As described in this section, marine mammals and sea turtles would likely avoid any slick that might form.

Marine mammals and sea turtles are not considered to be at high risk from the effects of oil exposure, but some evidence implicates oil spills with seal mortality, particularly young seals.

For marine mammals and sea turtles, it is probable that only small proportions of populations are at risk at any one time in either the Project or Study Area. Oil spill prevention measures, along with typical oil spill countermeasures (creating an oil spill response plan, training, preparation, an equipment inventory, and conducting emergency response drills) will serve to reduce the number of animals exposed to oil in the unlikely event of a spill.

Depending on the time of year, location of animals within the affected area, and type of oil spill or blowout, the effects of an oil release on the health of cetaceans is predicted to range from negligible to low magnitude over varying geographic extents. Based on the modelling exercises, and on past monitoring experience with large spills with much worse scenarios than likely for this Project (e.g., Exxon Valdez, Arrow and others), it can be predicted with confidence that an oil spill associated with the Project will not result in any significant residual impacts to marine mammals or sea turtles in the Study Area.

8.7.6 Sensitive Areas

The Study Area overlaps with the following EBSAs: the southern fringe of the Laurentian Channel (the Study Area has a small overlap with the eastern fringe of this EBSA) and the west coast of Newfoundland which crosses the Study Area between the Project Area and the western coastline of Newfoundland. The Project Area also overlaps with a potential redfish (a COSEWIC-designated species) mating area and the Study Area overlaps with a potential redfish larvae extrusion area and a cod (a COSEWIC-designated species) spawning area.

The oil spill modelling indicates that the furthest extent of a blow-out or spill from the Project site would extend approximately 20 km from the well location (not much beyond the borders of EL 1105), overlapping with the redfish mating area. As stated in Section 8.4.1.1, life history of the redfish and the Project's distance from the potential redfish larvae extrusion area, would limit the extent of any effects of a spill of redfish eggs and larvae.

Spills of diesel fuel from a supply vessel could overlap a number of these Sensitive Areas depending on the final routing of the vessels. As stated earlier in Section 8.2, spills of diesel fuel in open water is expected to disperse rapidly. While diesel is more toxic than heavy crude oil, it is shorter-lived in the open ocean and there is great variability among species and some species are relatively insensitive. There is no greater risk of a spill from a supply vessel in transit than any other marine vessel activity. A spill of this nature would not have a long-term effect on any of the identified sensitive areas. Effects would be short-lived and relatively localized. No significant adverse residual effects are predicted.

8.7.7 Commercial Fisheries and Other Users

The 1984 blowout at the Uniacke G-72 well (near Sable Island) resulted in a spill of 240 m^3 (1,510 barrels) of condensate. No taint was observed in fish caught in the condensate drift zone (Gill et al. 1985, in Hurley and Ellis 2004). Diesel fuel is considered to result in a moderate to high risk of seafood contamination because of the relatively high content of low molecular weight, water-soluble aromatic hydrocarbons, which are semi-volatile and evaporate slowly (Yender et al. 2002). Dispersed droplets are also bio-available. Crude from the Old Harry Project is considered a light crude and would behave in a similar fashion to diesel.

An accidental spill could potentially affect Commercial Fisheries (including sentinel and research fisheries) and Other Users (Aboriginal fisheries, recreational fisheries, aquaculture, seal and bird hunting, military use, marine traffic and tourism and recreational activities). Accidental spills could result in fishing gear fouling and potential loss of income through reduced catch value or suspended fishing. However, the likelihood of such an event is extremely low. As well as described in Section 5.8.1, there is likely no commercial fishing occurring within the Project Area. Commercial fishers could be affected by a spill of diesel from a supply ship, with the likely effects depending on the location of the spill in relation to harvesting activities. As noted above, the risk of a spill from a supply ship would be no different than the risk of spills from any marine shipping activity. The loss of fuel during an accidental event is not expected to have an effect on other users. Given the low level of commercial harvesting activities within the Project Area and the mitigation which will be in place to compensate fishers for any loss or fouling of gear, the residual adverse environmental effect of an accidental release of diesel or oil (condensate) on commercial fisheries is rated not significant.

8.8 Summary

The potential environmental effects associated with an accidental event on species at risk, marine fish and fish habitat, marine birds, marine mammals and sea turtles, sensitive areas and commercial fisheries and other users are summarized in Table 8.13. As the likely effects of any accidental event are largely dependent on a number of variables including time of year, spilled material, amount of material spilled, the rankings in Table 8.13 represent the worst case scenario. With the exception of marine birds (including at-risk species), residual environmental effects are predicted to be not significant.

As described in Section 8.1.10, spills and blowouts are considered unlikely from exploration drilling activities, and Corridor's Emergency Response Plan and Oil Spill Response Plan (which will be based on Corridor's *Corporate Emergency Response Manual* (and experience of other offshore operators)) would ensure that any such effects are minimized. The drilling platform will have response equipment on board (and personnel trained in their use) and Corridor will enter into an agreement with the Eastern Canada Response Corporation for support in the unlikely event of an oil spill.

Table 8.13 Potential Environmental Effects Assessment Summary – Accidental Events

Project Components / Activities	Potential Interactions / Environmental Effects (positive (P) or adverse (A))	Mitigation	Potential Environmental Effects Summary					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological and Socio-economic Context
Species at Risk	Oiling (A) Avoidance of Habitat (A) Mortality (marine birds) (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	3	3	1	2	R	1
Marine Ecosystems	Contamination / Health Effects (A) Mortality (plankton) (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols	1	3	1	3	R	1
Marine Fish and Fish Habitat	Oiling (A) Avoidance of Habitat (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	1	3	1	2	R	1
Marine Birds	Oiling (A) Avoidance of Habitat (A) Mortality (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	2	3	1	2	R	1
Marine Mammals and Sea Turtles	Oiling (A) Avoidance of Habitat (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	1	3	1	2	R	1
Sensitive Areas	Avoidance of Habitat (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	1	3	1	2	R	1
Commercial Fisheries	Reduced fish catch (A) Suspended fishing (A) Tainting (real or perceived) (A)	Spill Response Plan Equipment inspections Adherence to pollution prevention protocols Drilling in Ice-free season only	1	3	1	2	R	1

KEY:

Magnitude Context
0 = Negligible (essentially no effect)
1 = Low effects
2 = Medium effects
3 = High

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

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

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

Reversibility
R = Reversible
I = Irreversible (Refers to population)

Ecological and Socio-economic Context
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

n/a = Not applicable

9.0 CUMULATIVE ENVIRONMENTAL EFFECTS ASSESSMENT

Potential cumulative environmental effects external to the Project include marine transportation (see Section 5.8.2.7), commercial fishing (see Section 5.8.1), oil and gas exploration including seismic activity and research surveys (see Sections 5.8.1.4 and 5.8.1.5). There is little potential for environmental effects resulting from the proposed exploration well to overlap with other existing exploration drilling programs either temporally or spatially. There is potential for seismic surveys to be conducted along western Newfoundland between 2012 and 2014. The recent (November 16, 2011) land sale resulted in the sale of the two parcels in Western Newfoundland (NL-11-01-01 (west of EL 1120) and NL-11-01-02 (west of EL 1097, EL 1098 and EL 1103)). DFO conducts annual multi-species research surveys in the Gulf, usually in August and September. During the exploration drilling program, it is expected that some commercial traffic will be passing in the vicinity of the Project Area. As well, commercial fishing vessels may be transiting in the vicinity of the Project Area. The increase in vessel traffic resulting from supply vessels will be minimal with respect to the traffic currently associated with marine traffic and fishing activities.

A summary of the potential cumulative environmental effects on species at risk, marine ecosystems, marine fish and shellfish, marine birds, marine mammals and sea turtles, sensitive areas and commercial fisheries and other users is described in the following sections.

9.1 Species at Risk

By definition of their nature or life history, species at risk often have lower tolerance to disturbance or are less resilient than non-listed species. For most species at risk, various anthropogenic activities have been identified as major threats to the recovery of the population. For most marine fish species, direct and indirect fishing, both historically and current, are identified as one of the key threats. Marine mammals are vulnerable to ship strikes and marine pollution. The latter is also a major consideration for marine birds.

The potential for cumulative effects on these species is essentially the same as the potential cumulative effects on non-listed species, although it is acknowledged that due to the status of these populations, they may be more vulnerable to even limited Project effects compared to more stable populations. In general, the proposed Project's contribution to any cumulative effects is limited in comparison to the influences on these species throughout their range that have caused these species to reach their current population levels.

A key consideration for this Project is that its environmental effects are localized, short-term and reversible. This limits the potential for temporal and spatial overlap with other projects and activities and therefore, the potential for cumulative environmental effects. As described in Section 7.1.5, noise associated with the Project would cause most species to avoid the immediate Project Area, limiting any further exposure to Project effects. If there was a lack of alternate habitat in the area due to other activities, this would be a concern. However, during this period, there would likely be only commercial vessel traffic in the area. As shown in Section 5.8.1, the level of commercial harvesting activities in the vicinity of the Project Area is low and this trend is expected to continue into the proposed exploration period. Due to both logistical conflicts and validity of research results, any other seismic surveys or research surveys would need to be co-ordinated to avoid temporal and spatial overlap, thereby negating the potential for cumulative effects.

Given the mitigation measures in place, the limited nature of the Project's residual effects and the nature of the other projects and activities in the area, the cumulative environmental effects of the Project in combination with other projects and activities on species at risk are rated as not significant.

9.2 Marine Ecosystem

As described in Section 7, the majority of Project-related effects are limited geographically to the Project Area. The exception is vessel and helicopter traffic and any associated accidental events. Within the Project Area, the Marine Ecosystem VEC includes consideration of plankton and coral. As stated in Section 5.3.3, sea pens are present but not common in the Project Area and deep-water corals and sponges are not considered likely in this area. While corals can be affected by commercial fishing practices, there is limited activity in the Project Area and vicinity. The residual environmental effects of the Project on coral are predicted to be not significant and given the limited potential for both corals and fishing activity in the Project Area, no cumulative effects are predicted.

Plankton within the Project Area can be affected by seismic noise, but the noise associated with a VSP survey is short-term and of less strength than that associated with 2D and 3D surveys. There is potential for cumulative effects if other surveys were to occur in the same area, but this potential is limited by the logistical need to maintain temporal and geographic separation between any surveys. As indicated in Section 7.3.2.5, mortality in plankton and ichthyoplankton caused by a VSP would occur near the source, but the spatial (metres) and temporal (two to three days per well) scales would be so limited that the effects are considered non-significant and any potential cumulative effects would also be negligible.

Coastal ecosystems, including algal, eelgrass and saltmarsh communities, can be susceptible to both marine and on-land development and activities. While coastal areas in western Newfoundland are likely subject to cumulative pressures, the contribution of this Project to these effects is limited to a small amount of vessel traffic over less than a two month period (i.e., two to three vessel trips/week). Vessel traffic has limited potential for interaction with these resources, as it will be required to follow standard shipping routes, rules and conventions.

The cumulative effects of the Project on Marine Ecosystems in the Study Area are predicted to be not significant.

9.3 Marine Fish, Shell Fish and Habitat

Sources of cumulative effects on marine fish, shellfish and habitat in the Study Area include marine shipping, commercial harvesting and seismic and research surveys. Overfishing, habitat degradation, pollution and natural variability of the population cause adverse effects to fish species and habitat. Fishing pressure and subsequent bottom dragging techniques are significant stresses on some fish resources. Bottom dragging fish gear impacts fish habitat by removing plants, corals, sessile food items, overturning rocks, levelling rock outcrops and re-suspending sediments, ultimately homogenizing the habitat. While commercial fisheries can have an impact on marine invertebrates and fish, the current level of commercial exploitation within the Project Area is limited and DFO's fisheries management is intended to keep populations at sustainable levels.

As stated in Section 7, the majority of Project effects will be limited to the immediate vicinity of the wellsite. Fish may either be attracted by the artificial reef effect or be temporarily displaced by noise. The effects of drill mud and cuttings deposition in the area immediately adjacent to a well lessen considerably one to two years after drilling cessation (Kingston 1987; Gray et al. 1990). Fish habitat, as measured by changes in benthic community structure around single exploration wells, returned to baseline conditions within one year after cessation of drilling (Hurley and Ellis 2004).

All predicted effects on marine fish, shell fish and habitat are temporary and reversible. This limits the potential for these effects to act in a cumulative fashion with any other project and activities. Commercial harvesting levels in the Project Area are negligible, further limiting any potential for cumulative effects.

Areas along major shipping routes, such as the Project Area, are potentially subject to chronic oiling from bilge pumping and de-ballasting by vessel traffic, resulting in resident (non-migratory) biota having accumulated hydrocarbons; however, in a non-coastal area such as the Project Area, resident species within an area affected by a spill would be benthic for the most part (e.g., scallop, clams, sculpins) and the least likely to have accumulated hydrocarbons from chronic oil pollution.

Discharges from the Project will comply with the OWTG and ship operations will comply with Annex 1 of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) and *Pollution Prevention Regulations* of the *Canada Shipping Act.* Overall, the cumulative environmental effects of the Project in combination with other projects and activities on Marine Fish and Shellfish are rated not significant.

9.4 Marine Birds

Other oil and gas exploration programs, commercial fishing, research surveys and commercial shipping may result in cumulative environmental effects on seabirds. Marine birds may also be affected by projects and activities that occur outside the Study Area, but within their migratory ranges. As well, changes in prey and predator populations may affect marine bird populations.

Vessel traffic may affect marine birds through vessel lighting, oily discharges and sound. Chronic routine discharges, such as deck drainage and ballast and accidental releases of hydrocarbons, can expose birds to oil. Chronic releases may be equally or more important to long-term population dynamics of seabirds. All routine drilling platform discharges and supply vessel discharges will comply with the OWTG.

The incremental amount of vessel traffic as a result of this Project will be negligible compared to existing vessel traffic in the area. Routine Project activities are predicted to have minor, temporary and reversible environmental effects on marine birds; therefore, the cumulative environmental effects of Project activities on Marine Birds within the Study Area are predicted to be not significant.

9.5 Marine Mammals and Sea Turtles

Marine mammals may be vulnerable to cumulative effects from the Project in combination with marine transportation, commercial fishing and other seismic and research surveys. The main effects of the Project on marine mammals are associated with noise disturbances, potential for injury and mortality due to vessel collisions and contamination or change in distribution of food source.

While other seismic programs may occur in the Project Area, activities will not overlap spatially and temporally, as this may interfere with data collection. Given the localized nature of the surveys associated with this Project, the zone of influence is spatially limited. In addition, all surveys conducted within the Project Area would be required to comply with the C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011b), thereby reducing the potential for cumulative effects from this activity.

Marine mammal reaction to the Project is likely temporary avoidance behaviour. Richardson et al. (1995) predicted a radius response to noise during development and production activities for baleen and odontocetes to be less than 100 m. Vessel traffic associated with the proposed Project would contribute to only a slight increase over current levels. No cumulative effects are expected with helicopter traffic due to the localized and temporary disturbance.

Marine mammals may be vulnerable to vessel collisions. Most marine mammal-vessel collisions occur near the surface where acoustical reflection and propagation can limit the ability of marine mammals to hear and locate approaching vessels (Gerstein et al. 2005). Injuries on stranded ship-struck marine mammals suggest that large vessels are the principal source of injury with most marine mammals not observed prior to the collision or at the last moment. Limited data suggest that vessels speeds below 26 km/hr (14 knots) may be beneficial in reducing marine mammal vessel collisions (Laist et al. 2001). The typical speed of vessels within the Project Area may assist in the avoidance of marine mammal collisions.

Based on the speed of the vessel movement associated with offshore activities and the limited incremental number of vessels associated with the Project, the predicted cumulative adverse effect on marine mammals is not significant.

Sea turtles feeding in the Study Area may be affected by entanglement in and ingestion of debris. Entanglements in fishing lines, lobster pot lines, nets and other fishing gear have been reported. Sea turtles either ingest baited hooks or become entangled or hooked externally or both (Witzell 1999; Smith 2001). Sea turtles have also been in trawling gear in other parts of the Atlantic, Pacific and Gulf of Mexico (Magnuson et al. 1990). There is no known directed take of sea turtles in Canadian waters. The take of sea turtles at sea or on nesting beaches in other areas is seen as a threat to all species of sea turtles. Few studies have been undertaken on the effects of anthropogenic noise on sea turtles; however, it is assumed that noise from the various offshore sources could result in temporary disturbance to individuals. Although the effects of noise from this Project are not expected to be significant, it will add to cumulative noise and disturbance levels that sea turtles are exposed to in the Study Area. Sea turtle densities are low in the area and there is no evidence to suggest that the Project's oil and gas activities and increased support vessel traffic will add measurably to cumulative impacts on sea turtles.

9.6 Sensitive Areas

The Study Area overlaps with the following EBSAs: the southern fringe of the Laurentian Channel (the Study Area has a small overlap with the eastern fringe of this EBSA) and the west coast of Newfoundland which crosses the Study Area between the Project Area and the western coastline of Newfoundland. The Project Area also overlaps with a potential redfish (a COSEWIC-designated species) mating area and the Study Area overlaps with a potential redfish larvae extrusion area and a cod (a COSEWIC-designated species) spawning area.

As described in Section 7.7, potential Project effects on all of these areas, except for the potential redfish mating area, would be limited to the additional supply vessel traffic, which represents a short-term, slight increase in the existing levels of marine traffic in the Study Area. The potential for Project-related cumulative environmental effects on the various species that may use these Sensitive Areas is considered and assessed in the respective VECs above. None of the potential effects related to supply vessel traffic would result in a long-term or permanent change in habitat quality or quantity within the Sensitive Areas. Therefore, there is no potential for the Project to result in significant cumulative effects to these areas.

With respect to the potential redfish mating area, the Project will not cause any long-term or irreversible effects to fish habitat in the Project Area. There may be short-term and localized disturbances to mating activities which could act in a cumulative manner with other sources of disturbance in the area, but these are not considered to be at a level to result in significant cumulative environmental effects on this Sensitive Area or this species.

9.7 Commercial Fisheries

Cumulative environmental effects on commercial fisheries are related to the space-use conflicts and sound associated with other users of the offshore resources. Drilling MODU support vessel activity is a minor component of total marine transportation in the vicinity of the Study Area. The additional vessel activity from support of the exploration drilling program is negligible compared to the existing vessels in the area. As well, as discussed in Section 5.8.1, no commercial fishing efforts have overlapped with the Study Area during the years assessed (2004 to 2009).

In general, a drilling program will constitute a minor incremental contribution to the overall sound generated by other such sources and space-user conflict, and will be of short duration in local areas. Based on current knowledge, and especially with the proposed mitigation procedures in place, the proposed Project is not expected to result in or contribute to any significant cumulative environmental effects on commercial fisheries.

9.8 Summary

Based on the short-term and localized nature of the predicted environmental effects of routine Project activities and the limited occurrence of other projects and activities in the Project Area, there are no significant cumulative environmental effects predicted for any of the assessed VECs.

10.0 RESIDUAL ADVERSE ENVIRONMENTAL EFFECTS SUMMARY

Short-term residual Given the short duration (20 to 50 days) and limited geographic extent (1 to 5 km^2) of a typical exploration drilling program proposed to occur within the Project Area and with the application of mitigation measures, the residual environmental effects of routine activities of the Project, including cumulative environmental effects, is predicted to be not significant. In the unlikely event of an accidental release of hydrocarbons, short-term residual adverse environmental effects could result from the Project.

A summary of the residual adverse environmental effects for Species at Risk, Marine Fish, Shellfish and Habitat, Marine Birds, Marine Mammals and Sea Turtles, Sensitive Areas and Commercial Fisheries and Other Users is presented in Table 10.1.

Table 10.1 Residual Adverse Environmental Effects

VEC		Project Activities							Accidental Event (surface or subsea oil spill)
		Presence of Drilling Platform	Drill Muds and Cuttings	Routine Discharges	Support Vessels	VSP Survey / Drilling Noise	Routine Air Emissions	Well Abandonment / Suspension	
Species at Risk	Significance	NS	NS	NS	NS	NS	NS	NS	S^A
	Level of Confidence	3	3	3	3	3	3	3	3
	Likelihood*								1
Sensitive Areas Marine Ecosystems	Significance	NS	NS	NS	n/a	NS	n/a	NS	NS
	Level of Confidence	3	3	3		3		3	3
	Likelihood*								
Marine Fish and Fish Habitat	Significance	NS	NS	NS	NS	NS	NS	NS	NS
	Level of Confidence	3	3	3	3	3	3	3	3
	Likelihood*								
Marine Birds	Significance	NS	n/a	NS	NS	NS	NS	NS	S
	Level of Confidence	3		3	3	3	3	3	3
	Likelihood*								1
Marine Mammals and Sea Turtles	Significance	NS	n/a	NS	NS	NS	n/a	NS	NS
	Level of Confidence	3		3	3	3		3	3
	Likelihood*								
Sensitive Areas	Significance	NS	n/a	NS	NS	NS	n/a	n/a	NS
	Level of Confidence	3		3	3	3			2
	Likelihood*								
Commercial Fisheries and Other Users	Significance	NS	NS	NS	NS	NS	NS	n/a	NS
	Level of Confidence	3	3	3	3	3	3		3
	Likelihood*								

Key:

Significance:	Level of Confidence:	Likelihood*:
S = Significant Adverse Effect	1 = Low	1 = Low Probability
NS = Not Significant Adverse Effect	2 = Medium	2 = Medium Probability
P = Positive Effect	3 = High	3 =High Probability

* Likelihood defined only for effects that are evaluated as significant (CEA Agency 1994)

n/a = Not Applicable
A refers specifically to marine bird Species at Risk

11.0 FOLLOW-UP AND MONITORING

A follow-up program is discretionary, not mandatory, for a screening-level environmental assessment. Potential follow-up and monitoring that could be applied to this Project include the following:

- There is no follow-up and monitoring recommended for marine fish (at-risk and not-at-risk), shellfish and fish habitat.
- Routine checks will be done for stranded birds that may have been attracted to vessel lighting.
- Corridor will use a Marine Mammal Observer during the drilling program.
- In the unlikely event of an oil spill, an EEM program will be designed as part of Corridor's Emergency Response Plan.
- During the VSP program, a qualified observer will be used, whom will be capable of liaising with the fishing industry.
- Any fluid losses will be reported to the C-NLOPB and the Canadian Coast Guard and any seabird mortalities will be recorded by the on-board observer(s).

12.0 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The effects of the environment on an exploration drilling program are considered during the planning and environmental assessment stages of program development. Effects of the physical environment on the Project include those caused by wind, ice, waves, and currents (discussed in Chapter 4). These effects may differ somewhat by equipment type, with bottom-founded equipment stable under all conditions whereas floating systems are subject to heaving due to wave action. Successful exploration drilling programs have been executed in offshore Newfoundland waters for more than two decades. The potential effects of the environment on the program include:

- meteorology and oceanography (extreme conditions may affect schedule and program operations);
- sea ice and icebergs (drilling will be conducted during ice-free periods);
- superstructure icing; and
- biofouling.

12.1 Potential Effects of the Physical Environment on the Project

Weather, ice and icing, and wave conditions affect every offshore oil and gas project in eastern Canadian waters. These effects will be mitigated by using rigs, vessels and equipment that are certified by the appropriate authorities (e.g., DNV, Transport Canada, Coast Guard, C-NLOPB, and others) for use in eastern Canadian waters, by detailed project planning, by design in accordance with recognized and appropriate national and international standards, by operational scheduling, and by state-of-the-art forecasting. The residual effects of physical environmental factors have the potential to be adverse on the Project because they can cause delays, damage to equipment and thus economic losses, or because they can be a contributing factor to accidents. Accidental effects are discussed in detail in Chapter 8.

Wind and wave conditions result in most environmental constraints on exploration drilling programs. Sea ice should have no effect on the Project given the Project time frame (during open waters). There is a potential that spring / early summer sea ice may cause some delays.

Ice accumulations (superstructure icing) may cause delays while operations are slowed or suspended and ice accumulation is avoided or removed. Any delays are anticipated to be relatively short-lived, particularly with respect to the short duration of the Project’s timeline. The effects of ice on the Project will be minimal because most of the Project Area is often free of sea ice and subject to relatively few icebergs most of the year. Any potential effects on the Project from icebergs can be mitigated by the Ice Management Plan and project scheduling such that residual effects will be minimal.

has been no seismic activity reported in the Study Area in approximately 400 years and the Project is in Zone 1, which is the lowest seismic zone. Therefore, there is little risk of seismic activity in the Project Area.

Vessels operating in Canadian waters in late fall and winter are likely to experience some degree of icing. Icing can hinder shipboard activity and, in extreme cases, it can seriously impair vessel operations and stability. The accumulation of ice on a ship's superstructure can raise the centre of gravity, lower the speed and produce difficulty in manoeuvring (DFO 1999a).

Icing on vessels and related structures can result from freshwater moisture such as fog, freezing rain, drizzle and wet snow, or from salt-water including freezing spray and wave wash. Of the various forms of superstructure icing, freezing spray is the most common, and is the most severe cause of ice build-up. It occurs when the air temperature falls below the freezing temperature of sea-water and when sea-surface temperatures are below 6°C (DFO 1999a).

In the Gulf, freezing spray is the most frequently reported cause of vessel icing and may be encountered any time from November to April, although it is most frequently reported from December to February. During January, potential spray icing conditions are encountered more than 50 percent of the time (DFO 1999a). Freezing spray conditions in the Gulf are usually produced as a result of intense winter storms situated off the Canadian east coast. These storms may result in a strong northwesterly flow of cold Arctic air over the Gulf area, which produces snow showers and squalls over open water. During spray icing events, the air temperature is typically around -10°C with 55.6 km/hr (30-knot) northwesterly winds and 2 to 3 m waves (DFO 1999a).

Mitigation measures applied to potential effects of the physical environment on the Project include the following:

- Ice Management Plan;
- Project scheduling;
- Use of rigs, vessels and equipment that are all certified by the appropriate authorities;
- Detailed Project planning;
- Design in accordance with recognized and appropriate national and international standards;
- Monitoring government and industry 24-hour forecasts; and
- an Exploration well will be drilled during an ice-free period.

With this mitigation in place and given the timing of the Project, effects of the physical environment on the Project are, therefore, unlikely.

12.2 Potential Effects of the Biological Environment on the Project

Effects of the biological environment on the Project are unlikely with biofouling being the main potential effect. Biofouling may affect rig stability and encourage corrosion by establishing itself on exposed support structures or hulls and may also have a similar effect on the interior of pipes as well as water intakes and outlets and tankage used for waste water storage and treatment, and possibly drill mud tankage.

Mitigation measures applied to potential effects of the biological environment on the Project include the following:

- Use of rigs, vessels and equipment that are all certified by the appropriate authorities;
- Detailed project planning;
- Design in accordance with recognized and appropriate national and international standards; and
- Preventative maintenance programs instituted by the drill platform and vessel owners.

With the appropriate mitigation in place, effects of the biological environment on the Project are predicted to be unlikely.

13.0 ENVIRONMENTAL MANAGEMENT

Corridor will act as the Program Operator for the exploration well. Corridor's policies and procedures would apply as well as those of the exploration MODU contractor and other subcontractors. If Corridor enters into a partnership with another company, that company's policies and procedures will be compared with Corridor's and those policies and procedures that provide the best level of safety, health and environmental protection will be implemented. These policies and procedures will be bridged so that there is clear direction on the requirements for the Project. Such policies and procedures will include:

- fisheries liaison / interaction policies and procedures, such as routine advisories, where appropriate and continued participation with One Ocean;
- use of a qualified observer(s), whom will be capable of liaising with the fishing industry during the VSP surveys;
- species at risk and other marine mammal, sea turtle and marine bird monitoring through the use of a qualified observer(s) during drilling activities, including VSP surveys;
- waste management;
- spill response;
- compensation of affected parties, including fisheries interests, for accidental damage resulting from Project activities, in keeping with the *Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity* (C-NLOPB 2002); and
- Project-specific Quality, Health Safety and Environment (QHSE) Plan – note that this document will be prepared in advance of the Program and it will serve to link Corridor's Corporate plans (QHSE Management System Overview (2009), Corporate Environmental Management Manual (2009) and Corporate Emergency Response Manual (2011)) to those of the MODU contractor and any support vessels subcontractor(s). The plan will outline the specific HSE arrangements for the exploration drilling program.

Corridor is committed to conducting all Project activities in an environmentally responsible manner and promoting employee, contractor and public awareness of environmental issues. Corridor has and will continue to integrate environmental considerations into early decision making in order to identify and wherever practical, mitigate potentially negative consequences of their proposed activities. Corridor intends to implement progressive industry standards, codes and practices, and government policies and guidelines for environmental protection in assessing, planning, constructing and operating all proposed projects as well as preventing and minimizing waste and emissions through throughout the life cycle of their Project.

14.0 SUMMARY AND CONCLUSION

This environmental assessment presents information on the exploration drilling program, as proposed by Corridor, and the results of the environmental effects assessment. The proposed program would be conducted offshore over the Old Harry prospect in the Gulf in Newfoundland waters. The VECs selected for this assessment were:

- Species at Risk;
- Marine Fish, Shellfish, and Habitat;
- Marine Birds;
- Marine Mammals and Sea Turtles;
- Sensitive Areas; and
- Commercial Fisheries and Other Users.

In the unlikely event of an accidental release of hydrocarbons, significant environmental effects are predicted to occur for marine birds (both at risk and not at risk species). With respect to routine activities associated with drilling one exploration well, the results of the Environmental Assessment predict that no significant adverse environmental effects, including cumulative environmental effects, will occur as a result of the Project.

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APPENDIX A

Corridor Resources Inc. Old Harry Prospect Exploration Drilling Scoping Document

Corridor Resources Inc. Exploratory Drilling Program on the Old Harry Prospect, Exploration Licence 1105

Scoping Document

Prepared by:
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1 Purpose

This document provides scoping information for the environmental assessment of the proposed exploration drilling program (the Project) in the Gulf of Saint Lawrence on EL 1105 over the period 2012 through 2014. Corridor Resources Inc. (Corridor) is the project proponent. A Project Description was submitted to the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) on February 21, 2011. The proposed project is located offshore western Newfoundland, approximately 80 kilometres west-northwest of Cape Anguille, Newfoundland and Labrador.

Included in this document is a description of the scope of the project that will be assessed, the factors to be considered in the assessment, and the scope of those factors.

The document has been developed by the C-NLOPB in consultation with the federal and provincial fisheries and environment departments, and the public.

2 CEA Act Regulatory Considerations

The Project will require authorizations pursuant to Section 138 (1) (b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 134(1) (b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*.

The C-NLOPB has determined, in accordance with paragraph 3(1)(a) of the *Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements* (FCR), that an environmental assessment (EA) of the project under Section 5 of the *Canadian Environmental Assessment Act* (CEA Act) is required.

Pursuant to paragraph 12.4 (2) of the CEA Act, the C-NLOPB will be assuming the role of the Federal Environmental Assessment Coordinator (FEAC) for this screening and in this role will be responsible for coordinating the review activities by the expert government departments and agencies that participate in the review.

The C-NLOPB intends that the environmental assessment submitted with any supporting documents, as may be necessary, will fulfill the requirements for a Screening. The C-NLOPB, therefore, pursuant to paragraph 17(1) of the CEA Act, formally delegate the responsibility for preparation of an acceptable Screening environmental assessment report to Corridor Resources Inc., the project proponent. The C-NLOPB will prepare the Screening Report, which will include the determination of significance.

3 Scope of the Project

The project to be assessed consists of the following components.

3.1 Drilling of a single exploration well, inclusive of routine activities such as pre-setting of anchors, vertical seismic profiling (VSP), geotechnical borehole drilling, and seabed sampling (coring, grabs, ROV surveying).

3.2 Operation of support craft associated with the above activities, including but not limited to mobile offshore drilling units (MODU), anchor handling tug supply (AHTS) vessels, supply/standby vessels, and helicopters.

3.3 Drilling activities are likely to commence in 2012, are scheduled to last between 20 to 50 days, and may occur year-round depending on ice conditions. Well testing activities, if conducted, will require several additional weeks. Depending on the type of drilling unit used (*i.e.*, semi-submersible, drill ship), drilling activities may occur throughout the year up to 2014. The well will either be suspended or abandoned by the end of 2014.

4 Factors to be Considered

The environmental assessment shall include a consideration of the following factors in accordance with Section 16 of the CEA Act.

4.1 The purpose of the project.

4.2 The environmental effects[1] of the Project, including those due to malfunctions or accidents that may occur in connection with the Project, and any change to the Project that may be caused by the environment.

4.3 Cumulative environmental effects of the Project that are likely to result from the project in combination with other projects or activities that have been or will be carried out.

4.4 The significance of the environmental effects described in 4.2 and 4.3.

4.5 Comments from the public that are received in accordance with the CEA Act and the regulations.

4.6 Measures, including contingency and compensation measures as appropriate, that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project.

4.7 The significance of adverse environmental effects following the employment of mitigative measures, including the feasibility of additional or augmented mitigative measures.

4.8 The need for, and the requirements of, any follow-up program in respect of the Project consistent with the requirements of the CEA Act and the *Species at Risk Act* (SARA).

4.9 Report on consultations undertaken by Corridor Resources with interested parties who may be affected by program activities and/or the public respecting any of the matters described above.

5 Scope of the Factors to be Considered

Corridor will prepare and submit to the C-NLOPB an EA for the physical activities as described in the project description "*Project Description for the Drilling of an*

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[1] The term "environmental effects" is defined in Section 2 of the *CEA Act*, and Section 137 of the *Species at Risk Act*.

Exploration Well on the Old Harry Prospect – EL 1105" (Corridor Resources Inc. February 2011), and as described above.

In preparing its EA, the Proponent shall consult with potentially affected groups and individuals, in consideration of comments submitted during the public consultation period for the February 25, 2011 draft scoping document. The EA will describe the results of these consultations and how they are to be addressed; address the factors listed in Section 4; and address the issues identified in Section 5.2..

Program activities are proposed for the Old Harry area, which has been studied in recent environmental assessments and the Western Newfoundland Strategic Environmental Assessment (LGL 2005) and Amendment (LGL 2007). For the purposes of the present assessment, the information provided in these environmental assessment documents for offshore oil and gas activities in this area can be used and/or referenced as supporting information, where applicable.

If the "valued ecosystem component" (VEC) approach is used to focus its analysis, a definition of each VEC (including components or subsets thereof) identified for the purposes of environmental assessment, and the rationale for its selection, shall be provided.

The scope of the factors to be considered in the environmental assessment includes the components identified in Section 5.2, "Summary of Potential Issues", setting out the specific matters to be considered in assessing the environmental effects of the project and in developing environmental plans for the project and the defined "Boundaries" (see below). Considerations relating to definition of "significance" of environmental effects are provided in the following sections.

Discussion of the biological and physical environments should consider the data available for the project and Affected area. Where data gaps exist, the EA should clearly identify the lack of data available.

5.1. Boundaries

The EA will consider the potential effects of the proposed drilling program activities within spatial and temporal boundaries that encompass the periods and areas during and within which the project may potentially interact with, and have an effect on, one or more VEC. These boundaries may vary with each VEC and the factors considered, and should reflect a consideration of:

- the proposed schedule/timing of the drilling program and its additional activities;
- the natural variation of a VEC or subset thereof;
- the timing of sensitive life cycle phases in relation to the scheduling of proposed physical activities;
- interrelationships/interactions between and within VECs;
- the time required for recovery from an effect and/or return to a pre-effect condition, including the estimated proportion, level, or amount of recovery; and

- the area within which a VEC functions and within which a project effect may be felt.

The Proponent shall clearly define and provide the rationale for the spatial and temporal boundaries used. The EA report shall clearly describe the spatial boundaries (i.e. Affected Area, Project Area), and shall include figures, maps and the corner-point coordinates.

Boundaries should be flexible and adaptive to enable adjustment or alteration based on field data and/or modeling results. The Affected Area and associated boundaries will be described based on consideration of potential areas of effects as determined by modeling (spill trajectory and cuttings dispersion), the scientific literature, and project-environment interactions (including transportation corridors). A suggested categorization of spatial boundaries follows.

5.1.1. Spatial Boundaries

Defining the spatial boundaries should take into consideration the potential for project activities, including accidental hydrocarbon spill events, which could affect sensitive areas, including coastlines.

Project Area
The area in which Project activities are to occur.

Affected Area
The area which could potentially be affected by project activities beyond the "Project Area".

Regional Area
The area extending beyond the "Affected Area" boundary. The "Regional Area" boundary will also vary with the component being considered (e.g., boundaries suggested by bathymetric and/or oceanographic considerations).

5.1.2. Temporal Boundaries.

The temporal scope should describe the timing of project activities. Scheduling of project activities should consider the timing of sensitive life cycle phases of the VECs in relation to physical activities.

5.2. Summary of Potential Issues

The EA report for the proposed drilling program should contain descriptions of the physical and biological environments, as identified below. Where applicable, information may be summarized from existing environmental assessment reports. However, where new information is available, (e.g., fisheries data) the new information should be provided. Where information is summarized from existing environmental assessment reports, the environmental assessment reports should be properly referenced and the EA report should specifically reference the section of the completed EA report summarized.

The EA will contain descriptions and definitions of EA methodologies employed in the assessment of effects. Where information is summarized from existing EA reports, the sections referenced should be clearly indicated. Effects of relevant project activities on those VECs most likely to be in the Affected Area will be assessed. Discussion of cumulative effects within the Project and with other relevant marine projects will be included. Issues to be considered in the EA will include, but not be limited to, the following.

5.2.1. Physical Environment

Provide a summary description of the following:

- Meteorological and oceanographic characteristics in the Affected Area, including extreme conditions;
- Circulation and the factors influencing it;
- Summary of sea ice and iceberg conditions, including iceberg scour of the seabed;
- Overview of physical environmental monitoring, observation and forecasting programs that will be in place during the project;
- Magnitude and frequency of earthquakes;
- Evidence for and consequences of climate change for meteorology and oceanography;
- Summary of natural hazards affecting the seafloor (e.g., submarine landsliding) including events occurring outside the affected area that may affect the affected area;
- Ice management/mitigation procedures to be implemented, and any change to the Project that may be caused by the environment; and
- Effects of the environment on the Project (e.g., vessel and drilling platform icing, helicopter icing, turbulence, and cloud ceiling heights), including cumulative effects. The effects assessment should pay specific attention to effects of environmental factors on deep water rigsand mitigations that may be implemented to reduce these effects.

Marine Resources

5.2.2 Marine and/or Migratory Birds using the Affected Area

Provide a summary description of the following:

- Spatial and temporal species distributions (observation/monitoring data collected during ongoing petroleum activities should be included);
- Species habitat, feeding, breeding, and migratory characteristics of relevance to the Affected Area;
- Physical displacement as a result of vessel presence (e.g. disruption of foraging activities);
- Exposure to contaminants from accidental spills (e.g., fuel, oils) and operational discharges (e.g., deck drainage, grey water, black water);
- Attraction of birds to vessel lighting and flares and potential effects and mitigations;
- Noise disturbance from equipment including both direct effects (physiological), or indirect effects (foraging behaviour or prey species);
- Attraction of, and increase in, predator species as a result of waste disposal practices (i.e., sanitary and food waste);
- Procedures for handling birds that may become stranded on drill rigs or support vessels;

- Means by which bird mortalities associated with project operations may be documented and assessed;
- Means by which potentially significant effects upon birds may be mitigated through design and/or operational procedures;
- Effects of hydrocarbon spills from accidental events; and
- Environmental effects due to the Project, including cumulative effects (e.g., hunting, fishing (long line by-catch), shipping).

5.2.3 Marine Ecosystem

Provide a summary description of the following:

- Description of coral communities likely present in the Affected Area, and potential for coral communities to exist based on local habitat conditions;
- Characterization, including quantification to the degree possible, of the spatial area of seabed that is predicted to be affected by drill cuttings and other discharges, and subsea structures and the extent of impact on benthic communities (e.g., fish, shellfish, corals);
- Water column biota and their productivity including seasonality;
- Description of plankton communities, in particular zooplankton accumulation and aggregation zones that can be important for higher trophic level species (e.g., fish, marine mammals);
- Characterization of potential effects of the project on pelagic community and mitigation options;
- Means by which potentially significant effects upon benthic communities, (eg. corals and kelp forests), may be mitigated through design and/or operational procedures;
- Effects of hydrocarbon spills from accidental events; and
- Assessment of effects, including cumulative effects (e.g., bioaccumulation).

5.2.4 Marine Fish and Fish Habitat

Provide a summary description of the following:

- Distribution and abundance of marine fish and invertebrate species utilizing the Affected Area with consideration of critical life stages (e.g., spawning areas, overwintering, juvenile distribution, migration);
- Description, to the extent possible, of location, type, diversity and areal extent of marine fish habitat in the Affected Area. In particular, those indirectly or directly supporting traditional, aboriginal, historical, present or potential fishing activity, and including any essential habitats(e.g. spawning, feeding, overwintering);
- Description of benthic and pelagic habitat in the region and the affected area;
- Critical seasons and timing of habitat occupation;
- The means by which potentially significant effects upon fish and fish habitat (including critical life stages) may be mitigated through design, scheduling, and/or operational procedures;
- Effects of hydrocarbon spills from accidental events; and
- Environmental effects due to the Project, including cumulative effects.

5.2.5 Marine Mammals and Sea Turtles

Provide a summary description of the following:

- Spatial and temporal descriptions (observation and monitoring data collected during exploration activities operated by Corridor Resources should be discussed);
- Description of marine mammal and sea turtle lifestyles/life histories relevant to Affected Area;
- Means by which potentially significant effects upon marine mammals and sea turtles (including critical life stages) may be mitigated through design, scheduling, and/or operational procedures;
- Effects of hydrocarbon spills from accidental events; and
- Environmental effects due to the Project, including cumulative effects.

5.2.6 Species at Risk (SAR):

Provide a summary description of the following:

- A description, to the extent possible, of SAR and their habitat as listed in Schedule 1 of the *Species at Risk Act (SARA)*, and those under consideration by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in the Affected Area, including fish, marine mammals, sea turtles and seabird species. It is advised that the SARA Registry and COSEWIC website be referred to for the most recent information;
- A description of critical habitat (as defined under SARA), if applicable, to the Affected Area;
- Monitoring and mitigation, consistent with recovery strategies/action plans (endangered/threatened) and management plans (special concern);
- A summary statement stating whether project effects are expected to contravene the prohibitions of SARA (Sections 32 (1), 33, 58(1));
- Means by which adverse effects upon SAR and their critical habitat may be mitigated through design, scheduling, and/or operational procedures;
- Effects of hydrocarbon spills from accidental events; and
- Assessment of effects (adverse and significant) on species and critical habitat, including cumulative effects summary statement stating whether project effects are expected to contravene the prohibitions of SARA (Sections 32 (1), 33, 58 (1).

5.2.7 Sensitive Areas

The information should include:

- A description, to the extent possible, of any "Sensitive" Areas in the Affected Area, including coastal areas, deemed important or essential habitat to support any of the marine resources identified;
- Effects of hydrocarbon spills from accidental events;
- Environmental effects due to the project, including cumulative effects, on those "Sensitive" Areas identified; and
- Means by which adverse effects upon "Sensitive" Areas may be mitigated through design, scheduling, and/or operational procedures.

Marine Use

5.2.8 Noise/Acoustic Environment

Provide a description of the following:

- Noise and acoustic issues in the marine environment that may be generated from drilling operations (drill rig, thrusters-equipped vessels, VSP, and geohazard/wellsite

survey programs) and abandonment (wellhead severance), including the geographical extent of elevated noise levels;
- Disturbance/displacement of VECs and SAR associated with drilling activities;
- Means by which potentially significant effects may be mitigated through design and/or operational procedures; and
- Assessment of effects of noise/disturbance on the VECs and SAR, including cumulative effects.

5.2.9 Presence of Structures and/or Operations:

Provide a description of the following:
- Size and location of temporary or project-life exclusion zones;
- Description of project-related traffic (e.g., support aircraft and vessels), including routings, volumes, scheduling and vessel types;
- Effects upon access to fishing grounds;
- Means by which potentially significant effects may be mitigated through design, scheduling and/or operational procedures; and
- Effects of physical presence of structures upon access to fishing grounds, fish research surveys and upon general marine traffic/navigation; including cumulative effects.

5.2.10 Discharges and Emissions

Provide a description of planned project discharges to the marine environment, including:
- Drilling muds, fluids, and cuttings, bilge water, grey water, black water, cooling water, deck drainage, blow out preventer fluid, ballast water;
- Characterization, quantification and modelling of expected discharges and the timing of discharges, including a description of the trajectory models employed; and
- Environmental effects of discharges, including cumulative effects.

5.2.11 Air Quality

Provide a description of the following:
- Annual estimates of rates and quantities of emissions (e.g. as reported through Environment Canada's National Pollutant Release Inventory and the Board's *Offshore Waste Treatment Guidelines*), and a description of potential means for their reduction and reporting;
- Implications for health and safety of workers that may be exposed to them;
- Implications for health and safety of other marine users (e.g., fishers) that may be exposed;
- Implications for health and safety of coastal communities;
- Mitigation and monitoring; and
- Assessment of effects, including cumulative effects.

5.2.12 Commercial Fisheries

Provide a description of commercial fisheries in the Affected Area. The most recent data should be included, if available. The information should include:
- A description of fishery activities (including traditional, existing and potential commercial, recreational and aboriginal/subsistence and foreign fisheries) in the Affected Area;

- Consideration of underutilized species and species under moratoria that may be found in the Affected Area as determined by analyses of past DFO research surveys and Industry GEAC survey data, with emphasis on those species being considered for future potential fisheries, and species under moratoria;
- An analysis of the effects of Project operations and accidental events upon the foregoing;
- Fisheries liaison/interaction policies and procedures;
- Program(s) for compensation of affected parties, including fisheries interests, for accidental damage resulting from project activities;
- Effects of hydrocarbon spills from accidental events;
- Means by which adverse effects upon commercial fisheries may be mitigated through design and/or operational procedures; and
- Environmental effects of the Project, including cumulative effects.

5.2.13 Accidental Events

The discussion should not be limited to crude oil or condensate, but should consider accidental releases of drilling fluids, drilling muds, and other hydrocarbons. The information should include:

- Quantification of blowout risk;
- Quantification of risk of petroleum/chemical spills of all volumes associated with the Project;
- Discussion of the potential for spill events from drilling activities to enter the marine environment;
- Modelled physical fate of hydrocarbon spills, including descriptions of models and/or analyses that are employed and the physical data (e.g. circulation) upon which they are based;
- The effect of the physical environment on spills (e.g., ice)
- Description of the marine area likely to be affected by hydrocarbons from a spill event that enters the marine environment;
- Mitigations to reduce or prevent such events from occurring;
- Contingency plans, including relief wells and subsea intervention to shut in or cap well, to be implemented in the event of an accidental release;
- Description of activities associated with emergency response (e.g., dispersant use, burning or cleaning operations); and
- Environmental effects of any accidental events on all VECs identified, including those listed above. Cumulative effects should be included.

5.2.14 Environmental Management

Provide a general overall description of Corridor Resources' environmental management system and its components. It should include, but not be limited to:

- Pollution prevention policies and procedures;
- Fisheries liaison/interaction policies and procedures;
- Program(s) for compensation of affected parties, including fisheries interests, for accidental damage resulting from project activities; and
- Emergency response plan(s).

5.2.15 Biological and Follow-up Monitoring

Discuss the need for and requirements of a follow-up program (as defined in Section 2 of CEAA) and pursuant to the SARA. The discussion should also include any requirement for compensation monitoring (compensation is considered mitigation).

Detailed description of the monitoring and observation procedures to be implemented regarding marine mammals, sea turtles, and seabirds (observation protocols should be consistent with those described in Appendix 2 of the C-NLOPB "*Geophysical, Geological, Environmental and Geotechnical Program Guidelines*" (2011)).

5.2.16 Abandonment/Decommissioning

Plans for abandonment and/or decommissioning of the Project area and associated facilities following termination of drilling, including any anticipated requirement for post-abandonment monitoring.

5.3 Significance of Adverse Environmental Effects

The Proponent shall clearly describe the criteria by which it proposes to define the "significance" of any residual adverse effects that are predicted by the EA. This definition should be consistent with the May 2007 CEAA reference guide "*Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects*", and be relevant to consideration of each VEC (including components or subsets thereof) that is identified. SARA species shall be assessed independent of non-SARA species. The effects assessment methodology should clearly describe how data gaps are considered in the determination of significance of effects.

5.4 Cumulative Effects

The assessment of cumulative environmental effects should be consistent with the principles described in the February 1999 CEAA "*Cumulative Effects Assessment Practitioners Guide*" and in the November 2007 CEAA operational policy statement "*Addressing Cumulative Environmental Effects under the Canadian Environmental Assessment Act*". It should include a consideration of environmental effects that are likely to result from the proposed project in combination with other projects or activities that have been or will be carried out. These include, but are not limited to:

- Proposed and potential oil and gas activities under EA review (listed on the C-NLOPB Public registry at www.cnlopb.nl.ca);
- Seismic activities;
- Marine management and protected areas;
- Commercial tourist activities;
- Fishing activities, including Aboriginal fisheries; and
- Marine transportation.

6 Projected Timelines for the Environmental Assessment Process

The following are estimated timelines for completing the EA process. The timelines are offered based on experience with recent environmental assessments of similar project activities and do not include proponent time.

ACTIVITY	TARGET	RESPONSIBILITY
Proponent submits EA to C-NLOPB	-	N.A.
C-NLOPB assess completeness of EA and requests further information from proponent [*if required*]	2 weeks	C-NLOPB
Proponent submits additional information [if required]		*Proponent*
C-NLOPB files EA documents with Independent Reviewer	0.5 weeks	C-NLOPB
Technical review of EA	8 weeks	C-NLOPB, Government Agencies, Public
Compile comments on EA and provide to Proponent	2 weeks	C-NLOPB
Submission of EA Addendum/Response to EA Comments		*Proponent*
Review of EA Addendum/Response Document	3 weeks	C-NLOPB & Government Agencies
Preparation of Draft Screening Report	3 weeks following submission of Independent Reviewer's report	C-NLOPB
Review of Draft Screening Report	4 weeks	Public
Finalize Screening Report (Determination of Significance of Project Effects)	2 weeks	C-NLOPB