Labrador – Island Transmission Link

Marine Fish and Fish Habitat in the Strait of Belle Isle: Information Review and Compilation

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LC EV 035

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Project No.
021 012

November 10th, 2010

EXECUTIVE SUMMARY

Nalcor Energy is proposing to develop the *Labrador – Island Transmission Link* (the Project), a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula. In preparation for, and support of, the Project's environmental assessment, this *Marine Fish and Fish Habitat: Information Review and Compilation* has been completed with the objective to gather, summarize and present existing and available information on fish and fish habitat in the Strait of Belle Isle.

The Study Area was regional in nature, and comprised the overall extent of the Strait of Belle Isle, from Port au Choix on the west coast of Newfoundland to the tip of the Northern Peninsula and from Baie Jacques Cartier, Quebec to Chateau Bay, Labrador, encompassing an area of approximately 10,000 km^2.

A major source of information for this study was Fisheries and Oceans Canada (DFO). Other information sources consulted included Environment Canada, Newfoundland and Labrador Departments of Fisheries and Aquaculture, Environment and Conservation, Labrador and Aboriginal Affairs, and Natural Resources. Universities, institutions, and other organizations were also contacted including: Memorial University of Newfoundland and Labrador (MUN), Marine Institute and the Oceans Science Centre, Bedford Institute of Oceanography, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Atlantic Salmon Federation, and Atlantic Canada Conservation Data Centre (ACCDC). An annotated bibliography including relevant papers, reports, data sources and personal communications is included as an appendix to this report.

A review of the physical environment aspects of the Strait of Belle Isle was conducted and included discussion of climate and weather, physical (bathymetry, currents, tides, waves, ice conditions) and chemical (salinity, temperature) oceanography, surficial geology and substrates, as well as coastal environments and habitats. Components of the biological environment within the Study Area were also reviewed and discussed; including information on plankton, benthic invertebrates, and algae. Plankton information included data on chlorophyll '*a*', phytoplankton (marine algae), zooplankton (marine invertebrates), eggs and larvae of macro invertebrates, and ichthyoplankton (eggs and larvae of fish).

A review of information of marine finfish within the Strait of Belle Isle was based on their location in the water column: demersal fish (groundfish), living close to the bottom with distributions influenced by temperature, depth and physical and biological aspects of the habitat, and pelagic fish, living and feeding higher in the water column closer to the water surface. Invertebrates of commercial value or interest, (i.e., shellfish) are discussed separately from non-commercial invertebrates. Species listed under the *Species At Risk Act (SARA*), or those that have been assessed by the COSEWIC, are discussed as species of special conservation concern. Selected species are discussed in detail based on overall distribution, role in the ecosystem, and consideration of recreational, commercial and economic importance.

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1.0 INTRODUCTION

Nalcor Energy is proposing to develop the *Labrador – Island Transmission Link*, a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula.

The environmental assessment (EA) process for the Project was initiated in January 2009 and is in progress. An Environmental Impact Statement (EIS) is being prepared by Nalcor Energy, which will be submitted for review by governments, Aboriginal and stakeholder groups and the public.

In preparation for and support of the environmental assessment of the Project, this *Marine Fish and Fish Habitat Study* has been completed with the objective to gather, summarize and present existing and available information on fish and fish habitat in the Strait of Belle Isle (see Study Area, Figure 1.1). This information is intended to supplement that collected through marine surveys and other studies conducted in the Strait of Belle Isle by Nalcor Energy and reported elsewhere.

1.1 Project Overview

The proposed Labrador – Island Transmission Link (the Project) involves the construction and operation of transmission infrastructure within and between Labrador and the Island of Newfoundland. The Project will include the installation and operation of submarine power cables across the Strait of Belle Isle between Labrador and insular Newfoundland.

The proposed transmission system, as currently planned, will include the following key components:

- an ac-dc converter station at Gull Island in Central Labrador, on the north side of the Churchill River adjacent to the switchyard for the Lower Churchill Hydroelectric Generation Project;
- an HVdc transmission line extending from Gull Island across southeastern Labrador to the Strait of Belle Isle. This overhead transmission line will be approximately 400 km in length with a cleared right-of-way averaging 60 m wide, and will consist of single galvanized steel lattice towers;
- cable crossings of the Strait of Belle Isle with associated infrastructure, including cables placed under the seafloor through various means to provide the required cable protection;
- an HVdc transmission line (similar to that described above) extending from the Strait of Belle Isle across the Island of Newfoundland to the Avalon Peninsula, for a distance of approximately 700 km;
- a dc-ac converter station at Soldiers Pond on the Island of Newfoundland's Avalon Peninsula; and
- electrodes in Labrador and on the Island, with overhead lines connecting them to their respective converter stations.

Project planning and design are currently at a stage of having identified a 2 km wide corridor for the on-land portions of the proposed HVdc transmission line and 500 m wide corridors for the proposed Strait of Belle Isle cable crossings, as well as various alternative corridor segments in particular areas (Figure 1.1). Potential (alternative) on-land corridors and study areas have also been identified for the proposed electrodes, although the nature, type and location of these electrodes are the subject of ongoing analysis and engineering.

In terms of the proposed Strait of Belle Isle cable crossings, the HVdc transmission line will extend from Central Labrador to a crossing point on the Labrador side of the Strait of Belle Isle. Cables will extend under and across the Strait and make landfall on the northwestern side of the Island of Newfoundland's Northern Peninsula. A number of methods will likely be used to protect the cables across the Strait of Belle Isle. Primarily, the currently identified corridors (Figure 1.1) make use of natural sea-bed features to shelter the cables in valleys and trenches to minimize the possibility of iceberg contact or interaction with fishing activity. In order to access these natural deep valleys and other seafloor topography and to provide further required protection, various cable protection techniques are under consideration, including tunneling and rock trenching. Rock placement and the laying of concrete mattresses over the cables are also being evaluated for specific areas.

Engineering analyses are ongoing to assess these and other potential approaches and techniques for protection of the subsea cables. The eventual selection of particular approaches and methods for the submarine cable crossings is the subject of on-going analysis, and will be based on water depths, terrain and seabed geology, substrate characteristics, risk exposure, and overall technical and economic viability.

It is these proposed transmission corridors and components that were the subject of Nalcor Energy's environmental baseline study program. Project planning is in progress, and it is anticipated that the Project description will continue to evolve as engineering and design work continue. The environmental assessment of the Project will also identify and evaluate alternative means that are technically and economically feasible. In conjunction and concurrent with the environmental assessment process, Nalcor Energy will be continuing with its technical and environmental analyses of the corridors, in order to identify and select a specific routing for the Project. The eventual transmission routes and locations will be selected with consideration of technical, environmental and socioeconomic factors.

1.2 Study Purpose and Objectives

The objective of this study is to compile and review existing and available information on marine fish and fish habitat in the general area of the proposed submarine cable crossings of the Strait of Belle Isle associated with the Labrador - Island Transmission Link. This information will be used in support of the proposed Project's EIS. The study further supplements the information gathered in the 2008 and 2009 surveys for the marine flora, fauna and habitat in the cable crossing corridors within the Strait of Belle Isle (and reported separately by AMEC Earth and Environmental 2010), marine habitat interpretation and mapping (Fugro-Jacques Geosurveys 2010), as well as information gathered regarding marine fisheries (Canning and Pitt 2010) and other ongoing studies.

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FIGURE 1.1

Strait of Belle Isle Study Area: Potential Landing Sites and Corridors

2.0 APPROACH AND METHODS

This study provides regional and Project area environmental baseline information for marine fish and fish habitat in the Strait of Belle Isle by compiling and reviewing existing and available information from literature as well as data from relevant government and non-governmental agencies. Experts were consulted throughout this process to provide the study team with information and data relevant to the Study Area, and to supplement the information existing in the published literature.

2.1 Study Area

The Study Area for this information review and compilation exercise was regional in nature, and generally comprised the Strait of Belle Isle, from Port au Choix on the west coast of Newfoundland to the tip of the Northern Peninsula and from Baie Jacques Cartier, Quebec to Chateau Bay, Labrador, encompassing an area of 10,107 km^2. The Study Area is presented in Figure 2.1. Although the primary focus of the analysis and eventual EA is on the area of the proposed Strait of Belle Isle cable crossings themselves, this Study Area encompasses a larger, regional area comprising much of the Strait of Belle Isle, in recognition of the larger marine environment and ecological systems, as well as to provide appropriate regional context.

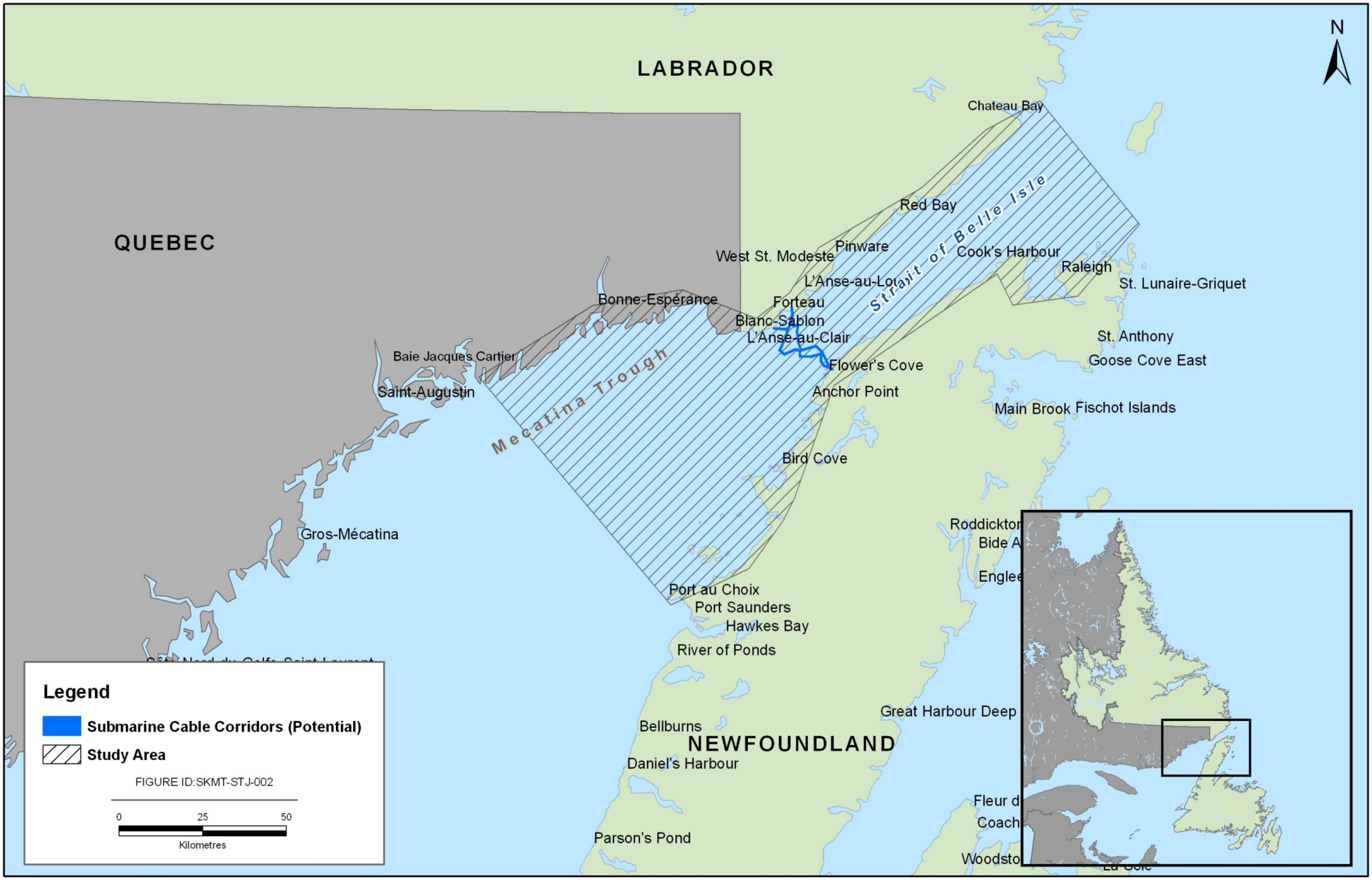

FIGURE 2.1

Strait of Belle Isle Study Area

2.2 Methods

The Study team has identified, acquired, compiled, reviewed, and presented available and existing information/data on marine fish and fish habitat in the Strait of Belle Isle. The study initially involved conducting a thorough inventory of available information related to the Strait of Belle Isle. Section 2.2.1 details the approach used, including key sources of information and data, as well as agencies, organizations and personal contacts to acquire the information and data. This section also outlines the considerations used to determine relevancy of information to the study. Any issues and challenges associated with this review are discussed.

2.2.1 **Information Sources**

It was initially determined that a major source of information was Fisheries and Oceans Canada (DFO). The Study Area includes geographical areas and fish stocks that are the responsibility of two DFO Regions: Newfoundland and Labrador Region and the Quebec Region. For example, the Atlantic cod (*Gadus morhua*) stocks in the Study Area are the responsibility of the Quebec Region, while American lobster (*Homarus americanus*) stocks are the responsibility of the Newfoundland and Labrador Region.

The various information/data sources that were examined through discussions with DFO, and through resources available on a variety of associated websites, include:

1. DFO Oceans, Habitat Management, and Species at Risk Branch – Newfoundland and Labrador Region;
2. DFO Science Branch - Newfoundland and Labrador Region and Quebec Region;
3. DFO Science Advisory Reports of the Canadian Science Advisory Secretariat (CSAS) regarding the Large Ocean Management Areas (e.g., GOSLIM);
4. DFO CSAS Publications including: Science Advisory Reports (SARs), Research Documents, Science Responses, Proceedings of Meetings and Workshops, Stock Status Reports, Ecosystem Status Reports, and Habitat Status Reports (available through the CSAS web site);
5. DFO Canadian Technical Report Series of the Journal of Fisheries and Aquatic Sciences;
6. DFO Research Vessel Surveys, Cruise Reports, and associated Database;
7. DFO Sentinel Fisheries Fixed Gear Database;
8. DFO Marine Environmental Data Service (MEDS) including the Integrated Science Data Management (ISDM) Databases;
9. DFO’s Oceanographic Database (within MEDS);
10. DFO Atlantic Zone Monitoring Program Database (AZMP);
11. DFO BioChem Database (biological and chemical oceanographic data);
12. DFO National Contaminants Information System (NCIS);
13. DFO Community-based Coastal Resource Inventory (CCRI) Database;

14. DFO Gulf of St. Lawrence Integrated Management (GOSLIM) Ecosystem Overview Report (EOR) and associated databases;
15. DFO Libraries and WAVES Database (database of holdings of DFO libraries);
16. DFO Canadian Hydrographic Service (CHS) Atlas of Tidal Currents; and
17. DFO CHS Nautical Charts.

In addition to the above information sources, the Study Team has also communicated with a variety of DFO staff to determine the availability of, and acquire access to, additional relevant information and data. A detailed listing of Personal Communications is provided in Section 5.0. In general, the following personnel within DFO were contacted:

- Scientists and species experts - Newfoundland and Labrador Region and Quebec Region;
- Section Heads within the Science Branch - Newfoundland and Labrador Region;
- Area Habitat Biologist (Western Newfoundland – Newfoundland and Labrador Region);
- Oceans Biologist/Gulf of St. Lawrence Integrated Management (GOSLIM) coordinator (Western Newfoundland - Newfoundland and Labrador Region);
- Species at Risk Coordinator - Newfoundland and Labrador Region;
- Biologist, Large Projects Office - Newfoundland and Labrador Region;
- Biologist - Coastal Resource Inventory Program - Newfoundland and Labrador Region; and
- CSAS Coordinator - Newfoundland and Labrador Region.

Other government agencies and organizations consulted include:

- Environment Canada;
    - Meteorological Service;
    - Canadian Ice Service; and
    - Canadian Wildlife Service.

Government of Newfoundland and Labrador

- Department of Fisheries and Aquaculture;
- Department of Environment and Conservation; and
- Department of Labrador and Aboriginal Affairs.

Universities, Institutions, and Organizations

- Atlantic Salmon Federation;

- Memorial University of Newfoundland and Labrador (MUN), including the Marine Institute and the Oceans Sciences Centre;
- Centre for Cold Ocean Research and Exploration (C-CORE);
- Bedford Institute of Oceanography;
- Atlantic Canada Conservation Data Centre (ACCDC); and
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status.

In addition to identifying the various information sources available directly from government agencies, universities, and institutions, the Study Team conducted both a physical and computerized search of published literature available through Memorial University of Newfoundland and Labrador. This included the following sources and databases:

- Aquatic Sciences and Fisheries Abstracts (ASFA);
- GEOSCAN;
- Newfoundland and Labrador Archives; and
- Google Scholar.

Other sources that were examined but determined to have limited or no relevant information for the study included:

- Offshore Labrador Biological Studies (OLABS) program reports (circa 1978-1982) – Mostly offshore studies;
- National Oceanic and Atmospheric Administration (NOAA) Strategic Environmental Assessment (SEA) of the Atlantic Coast – Limited information for the Study Area;
- Canada Newfoundland Labrador Offshore Petroleum Board's (CNLOPB) Strategic Environmental Assessment (SEA) of the Labrador Shelf Offshore Area - Mostly offshore but relevant literature sources were identified);
- Studies conducted by Hydro Quebec for the Romaine River Hydro Development EIS – Not relevant to the Study Area; and
- International Council for Exploration of the Sea Reports and publications – Publications restricted to offshore areas.

2.2.2 **Data Compilation and Analysis**

Information and data were compiled for the Study Area and reviewed for relevancy. An annotated bibliography (Appendix A) was produced and included relevant papers, reports, data sources and personal communications. Information sources that were relevant to the Study Area are included in the annotated bibliography, but not necessarily used and cited directly in the report. Information sources used in the report to provide general information about fish species or biology are not included in the annotated bibliography, as the latter only includes relevant information specific to the Study Area.

A key challenge in the compilation, review, and analysis of the identified information was the integration of information/data from a variety of sources ranging from peer reviewed scientific literature, to systematic surveys of physical and biological characteristics of the area, to anecdotal and qualitative data (e.g., the CCRI). The information that is available had been collected over several decades, over which scientific knowledge, methods, standards, and data collection platforms have changed. The data formats, quality and quantity were highly variable with some data available in raw format while other data are only available in summarized form. The classification schemes for key attributes (e.g., substrate size) were also variable between studies. Additionally, some on-line data sources are limited in the output, both as data and graphics, they could provide. Other data sources are discrete in their geographical coverage with data limited to the Gulf of St. Lawrence side of the Strait, or conversely the Labrador Sea side of the Strait, while much relevant information was localized to the corridors for the proposed submarine cable crossings.

2.3 Study Team

The study team was led by Larry LeDrew, Project Manager, with senior advice and report preparation provided by Dave Scruton and Tim Anderson. Suzanne Thompson conducted the literature review and participated in report preparation, while Grant Vivian prepared the maps and figures (Table 2.1).

Table 2.1 Study Team Roles and Responsibilities

Name	Role	Responsibilities
Larry LeDrew, M. Sc.	Project Manager	Project Management, Client liaison, report review
Dave Scruton, M. ES	Senior Scientist – Advisor	Report preparation and review
Tim Anderson B. Sc.	Senior Scientist – Advisor	Data compilation, analysis, report preparation and review
Suzanne Thompson, B. Sc.	Biologist – Researcher	Data compilation, analyses, interpretation and report preparation
Grant Vivian, B. Tech.	Geomatics Specialist	Geomatics and mapping support

3.0 RESULTS AND DISCUSSION

The following sections provide an overview of the results of the information review and compilation, including an outline of the major sources of information used for this study. A thorough description and discussion of the various components that comprise the marine habitat and fish in the Study Area are also detailed in this section.

3.1 Major Information Sources

The major sources of information used in this report include the Gulf of St. Lawrence Integrated Management Initiative (GOSLIM), the Community Coastal Resource Inventory (CCRI) and Research Survey and Sentinel Fisheries data, which are all the responsibility of DFO. These sources are outlined in Sections 3.1.1 through 3.1.3, respectively, including a description of the amount and nature of this information that was used in this study.

3.1.1 **Gulf of St. Lawrence Integrated Management Initiative**

The Gulf of St. Lawrence (including the Strait of Belle Isle) has been designated as a Large Ocean Management Area (LOMA) by DFO. LOMAs are delineated on an ecosystem basis and are established to advance collaborative management through an Integrated Management approach. A considerable amount of the information used in the preparation of this report was compiled and reviewed by the Gulf of St. Lawrence Integrated Management (GOSLIM) project (DFO 2006c, 2007a; Savenkoff et al. 2007).

During the establishment of the GOSLIM, a zonal workshop was undertaken in 2006 (DFO 2006c) to identify Ecologically and Biologically Significant Areas (EBSAs) within the GOSLIM. This process required the identification of important areas in terms of the ecological functions they fulfill and/or their structural properties. Three criteria are used to determine ecological and biological significance: (i) uniqueness, (ii) aggregation, and (iii) fitness consequences (Savenkoff et al. 2007).

Eight thematic layers were identified, examined separately and then combined to determine EBSAs within the GOSLIM region:

- topography and physical processes;
- primary production;
- secondary production;
- meroplankton (fish and invertebrate larvae);
- benthic invertebrates (e.g., molluscs, crustaceans, anthozoa);
- pelagic fish;
- demersal fish; and
- pinnipeds and cetaceans.

During this exercise, the Strait of Belle Isle was identified as an Important Area (IA) for the following four thematic layers:

- *primary production* - important for Labrador Shelf waters entering through the Strait, tidal mixing and upwelling;
- *benthic invertebrates* - high abundance of limited species (Circumpolar Eualid - *Eualus gaimardii* and Greenland lebbeid –*Lebbeus groenlandicus*);
- *pelagic fish* - high concentration of capelin, and high feeding concentration of spiny dogfish (*Squalus acanthias)*, Atlantic herring (*Clupea harengus*), and sandlance (*Ammodytes sp.)*, as well as spawning for herring; and
- *pinnipeds and cetaceans* - high biomass and aggregation of piscivorous marine mammals and feeding area for large cetaceans (Savenkoff et al. 2007).

These IAs are discussed in further detail in this report where relevant information exists.

3.1.2 **Community Coastal Resource Inventory**

A key source of information for this study was the DFO led Community Coastal Resource Inventory (CCRI). There have been three inventories relevant to the Study Area:

- Northern Peninsula East Coastal Resource Inventory
- Northern Peninsula West Coastal Resource Inventory
- Labrador Straits Coastal Resource Inventory

These compilations were intended as a tool to support integrated coastal zone management, environmental assessment, sensitivity mapping, sustainable economic development planning and other potential resource developments. The inventories were compiled in partnerships between government agencies (primarily DFO, Environment Canada, Newfoundland and Labrador Department of Fisheries and Aquaculture) and Local Development Associations. Review of the information determined that there were considerable data of relevance to the study including: fish species distributions and possible spawning areas (groundfish, pelagics, shellfish), locations of aquatic plants, aquaculture sites, shoreline classification, and ice coverage.

It is important to highlight that much of the information contained in these inventories are derived from local ecological knowledge, collected through interviews, and therefore are considered anecdotal in nature. Owing to the anecdotal and qualitative origin of this information, the CCRI based data is discussed separately from other information sources that are based on more scientific surveys and studies. The data in these inventories have been compiled within a GIS and a digital atlas, containing various thematic layers. Selected environmental and fisheries information from these inventories has been mapped and discussed in the ensuing sections.

3.1.3 DFO Research Survey and Sentinel Fisheries Data

Another key information source has been scientific data on catches of specific commercial and other important fish species as provided by DFO (DFO 2010d). These data are from two independent databases: (i) scientific (research vessel) surveys (mobile gear only) and (ii) sentinel fisheries (using fixed gear and mobile gear) surveys, both collected over the past 10 years (1999 to 2009).

Locations of catches for all species are provided in Figure 3.1 to provide an indication of the spatial distribution of effort, and associated information, from these surveys. Four-panel summary distribution maps were generated to indicate the distribution of fish species for both mobile gear and fixed gear. Mobile gear maps included data from both scientific surveys and sentinel fisheries (mobile gear) catches. Fixed gear maps include the sentinel fisheries data only as collected from fixed gear fisheries, as described below. These maps separate both the fixed gear and mobile gear data into two time periods, 1999 to 2003 and 2004 to 2009, and within each panel the catches are further subdivided by year.

The scientific surveys conducted in the Gulf of St. Lawrence by DFO consisted of rigorous, scientific sampling conducted from four research vessels: the Canadian Coast Guard Ship (CCGS) Alfred Needler, the CCGS Teleost, the Lady Hammond and the Gadus. In the Study Area, the Needler and the Teleost were used for sampling. It is important to note that each vessel used different fishing gear and applied a different fishing protocol. The CCGS Alfred Needler used a URI type bottom trawl and the CCGS Teleost was equipped with a Campelen 1800 shrimp trawl (DFO 2010d). The sampling stations were determined by applying a random stratified sampling protocol. The sampling area did not include the shallow, coastal zone (less than 36 m) and has changed over the years.

The sentinel fisheries surveys included both fixed and mobile gears. The fixed gears included gillnet, fixed longline (J-hooks and circle hooks), traps, manual jiggers, and covered pots. The mobile gear used in the sentinel fishery included a rock hopper trawl 300 (with and without liner). A Rock Hopper 980 Shrimp Trawl (without grid and with window) was also used in April of 2006 (DFO 2010d).

These two data sources are very complimentary in that the sentinel fixed gear effort data are concentrated on the inshore zone, while the scientific survey data, based largely on systematic surveys using mid-water and bottom trawls, have been conducted in the offshore zone (greater than 36 m). It should be noted that there is a longer time series for the research vessel surveys, however this review has focused on the last 10 years of information, consistent with the time series of sentinel fisheries data.

These data sources are very useful to provide information on the distribution of individual species based on catch information. DFO has cautioned that these data are limited in relation to assessing relative abundances due to a lack of data from “zero” catches, as well as difficulty interpreting information from different vessels and/or gear types (i.e., differences in catchability). These data also provide good coverage on an inter-annual basis, but provide less complete coverage on a monthly/seasonal basis. The CCGS Alfred Needler conducted sampling programs in the Strait of Belle Isle from 1999 to 2005, while the CCGS Teleost sampled between 2004 and 2009. Both surveys were conducted during the summer, in August. Sentinel fisheries occur between June and October, however many of the catches occur during the summer months (DFO 2010d).

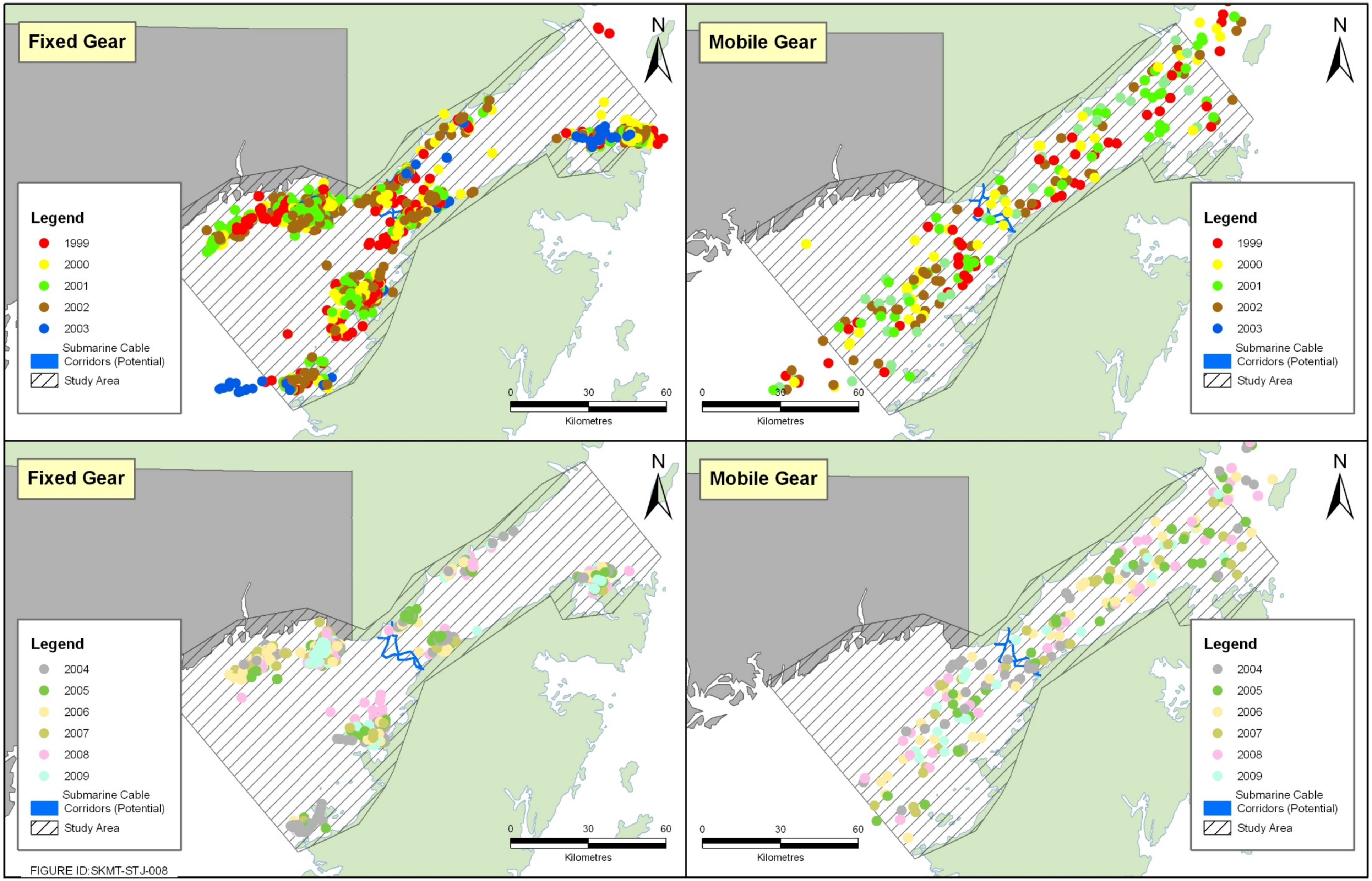

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FIGURE 3.1

Sentinel Fisheries Data and DFO Scientific Surveys - All Species (1999 to 2009)

3.2 Marine Habitat

The following sections give an overview of marine habitats (physical and biological aspects) in the Strait of Belle Isle. This includes components of the physical oceanographic processes in the Strait, as well as primary production and information on benthic invertebrates.

3.2.1 **Physical Environment**

The physical environment aspects of the Strait of Belle Isle include the physical and chemical oceanography, bathymetry, ice conditions, surficial geology, as well as the coastal environments.

3.2.1.1 Climate and Weather

Environment Canada has weather stations in the vicinity of the Strait of Belle Isle, including at Flower's Cove and Plum Point in Newfoundland and Blanc-Sablon in Quebec. Information for weather and climate in the vicinity of the Strait of Belle Isle was taken from climate statistics from these stations (see Environment Canada 2010a). Data from each of the three Environment Canada weather stations is plotted to compare temperature and precipitation amounts (Figures 3.2 and 3.3). Monthly climate averages for all of the Strait of Belle Isle are displayed in Table 3.1. Calculations include results from all three weather stations within the Strait of Belle Isle for the years 1971 to 2010, inclusive.

Weather in the Strait of Belle Isle area is highly influenced by storm tracks, wind direction and the presence of sea ice. During summer, low pressure systems often track across the southern portion of Labrador or the Lower North Shore of Quebec, then north of Newfoundland. Under these conditions, a moist southwest flow will develop, and where the dew point temperature is higher than the sea surface temperature, fog will develop in the Strait and spread onshore to the Lower North Shore of Quebec and the western side of the Northern Peninsula. Precipitation during the summer is generally in the form of showers. Daily average temperatures during the summer are in the vicinity of 12˚C, with maximums near 16˚C. Summer rainfall amounts average around 300 mm.

During winter, low pressure systems are more intense due to temperature contrast across North America. Low pressure systems affecting Newfoundland take two major tracks: (i) systems will pass south or southeast of Newfoundland which leaves the Strait on the cold, western side of the flow with most precipitation coming as snow, and (ii) low tracking through the Gulf of St. Lawrence through the Strait, or the Lower North Shore of Quebec, resulting in a mixture of rain, snow, freezing rain with high winds and generally higher precipitation amounts. In winter, on average daily temperatures are near -10˚C, with approximately 20 days which reach an overnight low of -20˚C. Overnight temperatures may fall as low as -30˚C in this region from late December through early March, however the region is not generally as cold as inland Labrador. Measurable snowfall is usually in the area by mid to late October and can be observed as late as early June. Annual snowfall amounts in the Straits are generally near 400 mm.

Monthly total precipitation (rainfall and snowfall) amounts for the three Environment Canada weather stations in the Strait of Belle Isle area are displayed in Figure 3.2, based on available climate statistics from 1971 to 2010. Precipitation amounts are generally similar between stations, and are distributed evenly between months, with the highest precipitation amounts usually occurring in summer and early winter. Total annual precipitation averages 1096 mm for the Strait of Belle Isle region.

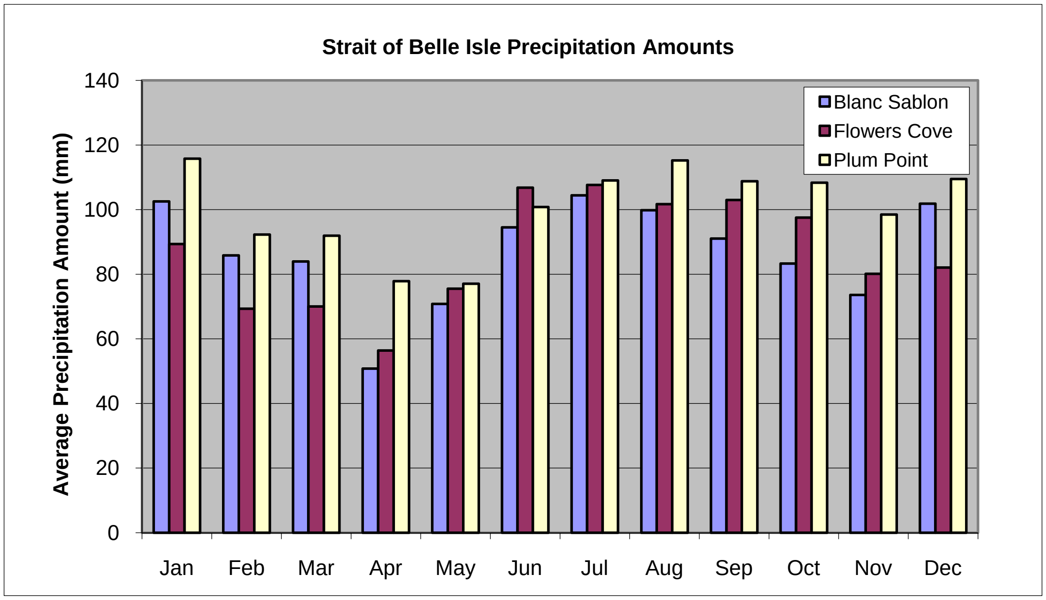


Figure 3.2 Individual Station Monthly Average Precipitation Amounts (Environment Canada 2010a).

Daily average temperatures (displayed monthly) for the three Environment Canada weather stations in the Strait of Belle Isle are illustrated in Figure 3.3, based on climate statistics from 1971 to 2010. Average temperatures are generally similar between stations, with highest temperatures usually occurring in July and August. The average temperature for the year is 1.3˚C for the Strait of Belle Isle region.

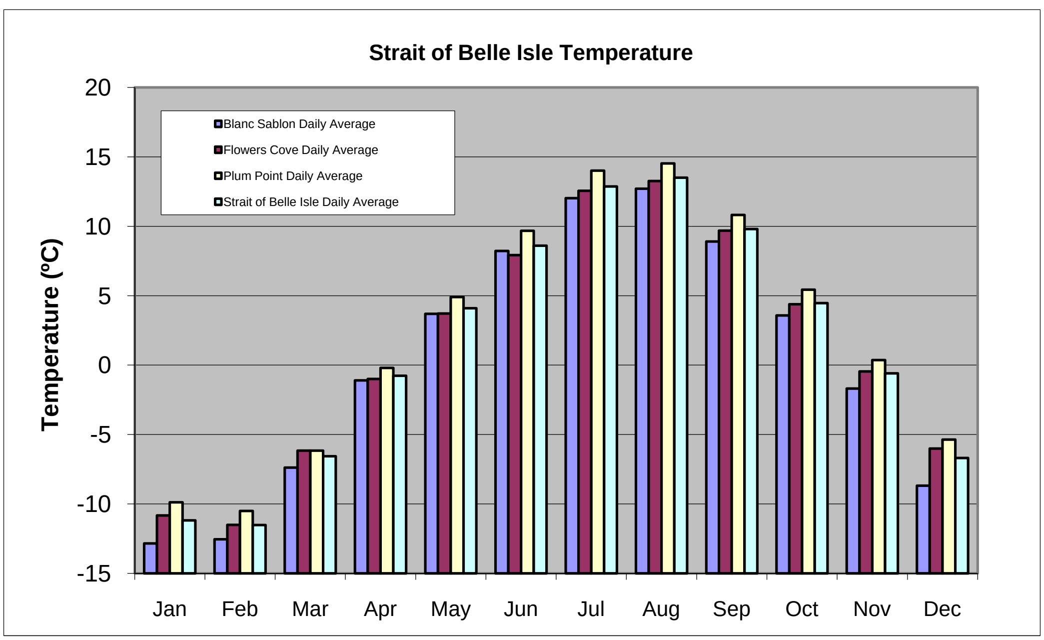


Figure 3.3 Individual Station Monthly Average Temperature (Environment Canada 2010a)

Table 3.1 Monthly Climate Averages for the Strait of Belle Isle (Environment Canada 2010a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (˚C):													
Daily Average	-11.2	-11.5	-6.6	-0.8	4.1	8.6	12.9	13.5	9.8	4.5	-0.6	-6.7	1.3
Daily Maximum	-6.7	-7.1	-2.5	2.6	7.9	12.6	16.7	17.1	13.4	7.6	2.5	-2.9	5.1
Daily Minimum	-16.7	-16.6	-11.1	-4.4	-0.2	4.0	8.4	9.2	5.4	0.6	-4.6	-11.6	-3.1
Precipitation:													
Rainfall (mm)	15.7	12.0	19.0	29.5	66.2	99.8	107.0	104.8	105.3	90.2	59.2	30.2	738.8
Snowfall (cm)	87.2	71.9	63.3	32.1	8.3	1.0	0.0	0.0	0.0	6.3	24.9	67.6	362.6
Precipitation (mm)	102.6	82.5	82.0	61.7	74.5	100.7	107.0	105.6	100.9	96.4	84.1	97.8	1095.7

3.2.1.2 Wind Statistics

Directional statistics on wind were calculated from wind data provided from MSC50, a wind and wave hindcast of hourly data of the North Atlantic Ocean, as provided by the Meteorological Services Canada (Swail et al. 2006). The dataset used for this analysis was from the MSC50 node # 18071 (51.4 N, 56.8 W), and covered the years 1954 to 2009, inclusive, and include consideration of iced-over periods. Wind roses were developed for the entire dataset seasonally, and includes fall (October through December), winter (January through March), spring (April through June) and summer (July through August). Wind roses are provided in Figure 3.4.

A review of these statistics indicated that winds are frequently aligned with the Strait, with a predominant southwest (from) wind direction. On average, the predominant flow is from the west or northwest during winter months, while predominantly southwest winds are expected during the spring (Figure 3.4) . Wind roses for summer and fall show that the majority of winds during the summer originate from the southwest, then begin to veer to predominantly westerly winds in the fall.

Wind speeds are on average comparable strength in spring and summer, approximately 5 to 10 m/s. These speeds increase markedly, on average, in the fall. At this node, wind reaches maximum speeds of approximately 25 m/s; however this occurs less than 1 percent of the time in the fall and winter.

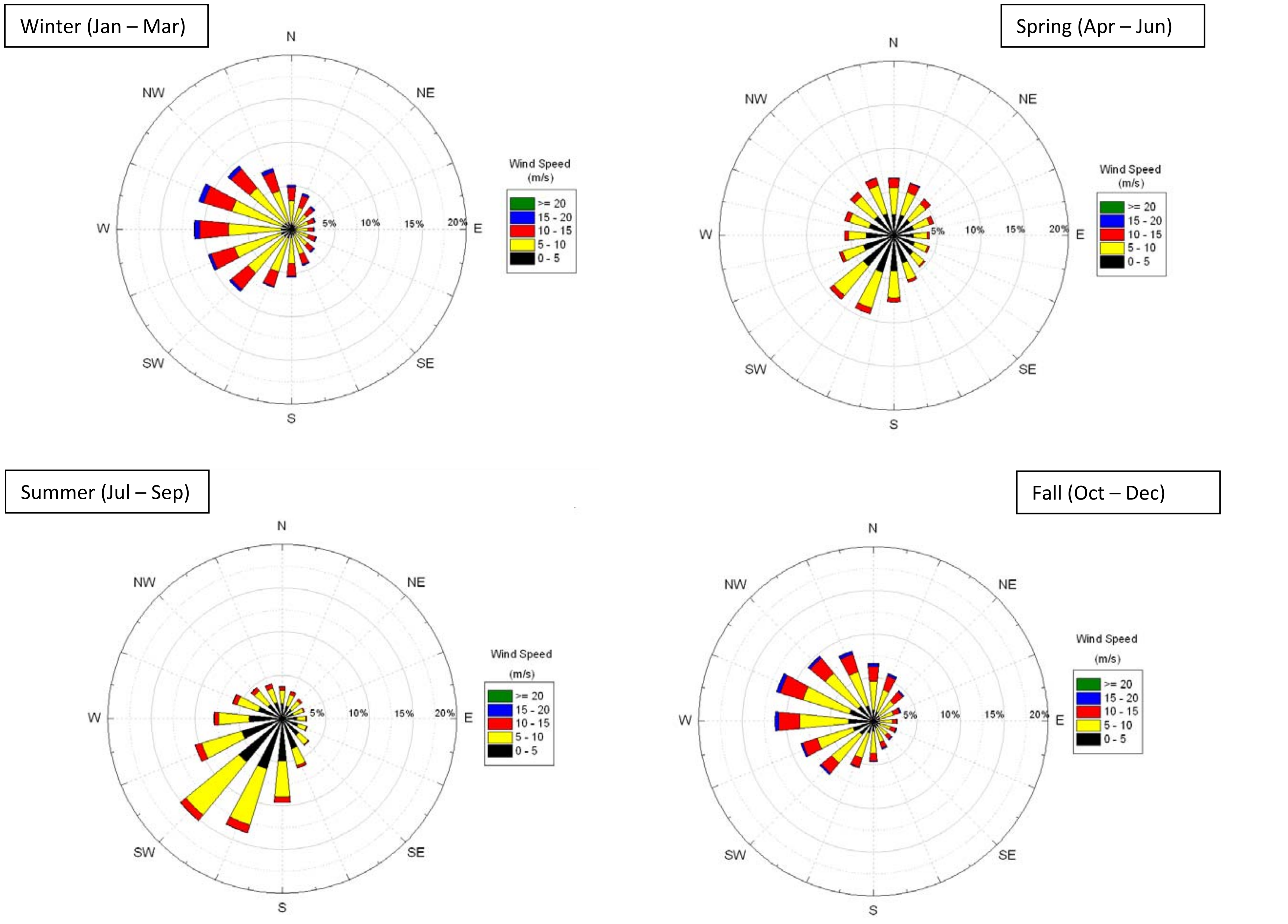


Figure 3.4 Seasonal Wind Roses for the Strait of Belle Isle Area (MSC50 Node 18071)

3.2.2 Physical and Chemical Oceanography

Physical factors in the ocean, such as currents, tidal mixing and upwelling, can significantly influence biological processes. For example, upwelling and vertical mixing in the ocean can create vertical flux of nutrients, creating areas that are highly productive biologically.

The area in the vicinity of the Strait of Belle Isle and coast of the Quebec Lower North Shore has been identified as important for such productivity. High nutrient levels are brought in from the Labrador shelf waters entering through the Strait of Belle Isle, as well as tidal mixing and upwelling in the region bringing nutrients to the surface. These processes have resulted in the Strait of Belle Isle and the Mecatina Trough being identified as important feeding areas for pelagic fish species (e.g., capelin and herring), as well as large cetaceans (Savenkoff et al. 2007).

A dominant feature in the oceanography of the Gulf of St. Lawrence, influencing the Strait, is the freshwater outflow from the St. Lawrence River into the estuary, which continues along the north coast of the Gaspé Peninsula. This 'Gaspé Current' is sustained by subsurface upwelling of ocean water and circulates in a counter clockwise flow with most water exiting the Gulf through the Cabot Strait.

The tidal pulse from the Atlantic Ocean enters the Gulf of St. Lawrence from two directions, through the Cabot Strait and Strait of Belle Isle and tidal energies flow in a counter clockwise fashion increasing in height from a low of 0.6 m (Magdalen Islands) to 5.0 m (Quebec City) (Farquaharson 1970).

The water in the Gulf is highly stratified. In summer there are three layers including: (i) a warm (4-6 ˚C) and salty (33 to 34.6 practical salinity units [psu]) bottom layer (below 125 m); (ii) a cold (-1 to 2 ˚C), slightly fresher (31.5 to 33 psu) at intermediate depths (80 to 100 m), and a warm (up to 20 ˚C), fresher (27 to 32 psu) surface layer (10 to 30 m).

The cold bottom and intermediate layers receive waters from the Labrador Current through the Strait of Belle Isle. This stratification changes in fall and winter, due to air temperature changes and stronger winds and currents, resulting in the cold intermediate layer mixing with the surface water layer, eliminating the surface layer. This results in a two layer system with a surface layer of 1 to 5 ˚C while the bottom layer remains about 2 ˚C.

3.2.2.1 Bathymetry

Detailed bathymetric information for the Strait of Belle Isle was compiled from a number of surveys during the proposed Lower Churchill Development of the late 1970s and early 1980s, and described in Woodworth-Lynas et al. (1992). Five physiographic zones were defined: i) the Labrador Coastal Zone, consisting of the northwestern slope of the ii) Labrador Trough (maximum depths of 115 m and a width of 1 to 2 km) and has generally uniform slopes of 6 to 12 percent; iii) Centre Banks South and North (depths ranging 15 to 85 m) are separated by a narrow depression 85 m deep; iv) the Newfoundland Trough (5 to 12 km wide, 70 to 125 m deep); v) Newfoundland Coastal Zone which is bounded by the coast and a linear escarpment separating it from the Newfoundland Trough.

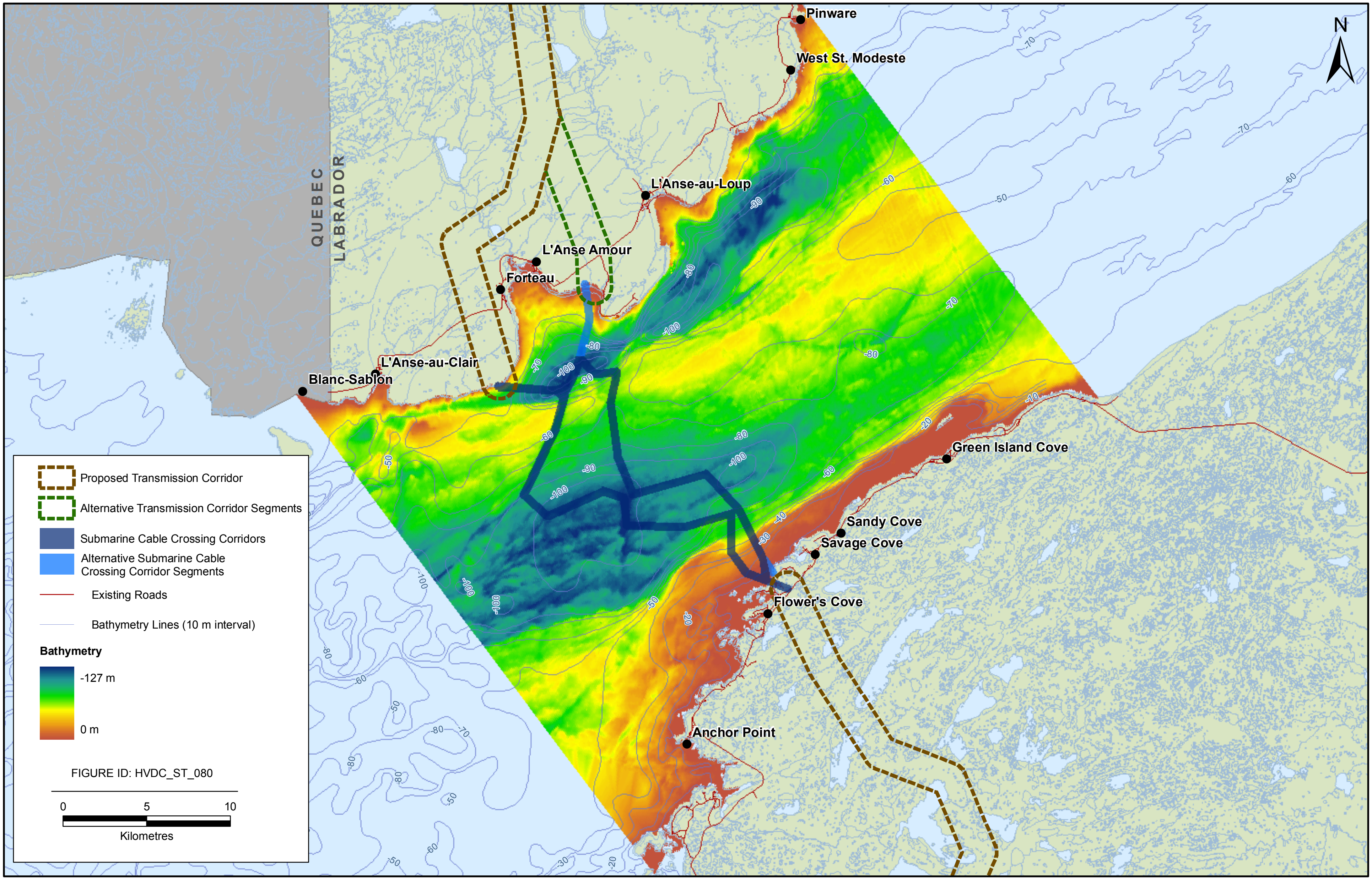
Recent bathymetric data was obtained from a geophysical survey program conducted on behalf of Nalcor Energy by Fugro-Jacques GeoSurveys Inc. in the Strait of Belle Isle from August to October 2007 and supplemented by data obtained from the Canadian Hydrographic Service (CHS). The geophysical survey included a regional study area approximately 40 km by 50 km in size, and extended from approximately L'Anse au Clair to the Pinware River on the Labrador coast, and from St. Barbe Bay (between Anchor Point and Black Duck Cove) to Green Island Brook on the Newfoundland side of the Strait. The regional multibeam survey data were acquired by a Reson SeaBat 8101 system operating at a frequency of 240 kHz. This data was recently integrated with CHS data, and the results are displayed in Figure 3.5.

3.2.2.2 Temperature and Salinity

DFO maintains a hydrographic database that contains seasonal maps of mean sea surface temperature and salinity (DFO 2007b). Available information for the Strait of Belle Isle has been divided into two sections due to jurisdictional issues and data collection activities. The southern part of the Strait of Belle Isle is considered in the Gulf of St. Lawrence database, whereas the northern portion is located in the Labrador Shelf database. Surface salinity levels hover around 30 to 33 psu in the area of the Strait of Belle Isle, with the higher levels found during winter months, at around 33 psu at its peak. Sea surface temperature is also captured from remote operational sensing in the Maritimes region by NOAA, and can be found on DFO's website (DFO 2009f). One time satellite passes for sea surface temperature, or 15 day composite images, are available.

Figure 3.6 has been created from this database, using 2009 mid-season 15-day composite images from the NOAA database to demonstrate the seasonality in sea surface temperature. February 1 to 15 represents winter, May 1 to 15 represents spring, August 1 to 15 represents summer, and fall is represented by November 1 to 15.

DFO undertakes helicopter-based surveys during winter in the Gulf of St. Lawrence, including the Strait of Belle Isle (DFO 2008c). These surveys have been monitoring winter-time conditions since 1996, and look at temperature, cold layer thickness, and the thickness of the Labrador Shelf water intrusion through the Strait of Belle Isle. Labrador shelf waters are considered near freezing waters with high salinities (greater than 32.35 psu). Surveys conducted in 2008 showed the intrusion of Labrador shelf waters occupied a slightly smaller area than in 2007, and mostly was in the area of the Mecatina trough (DFO 2009h).



nalcor energy

FIGURE 3.5

Strait of Belle Isle - Bathymetry (2007 Geophysical Survey and Canadian Hydrographic Service Data)

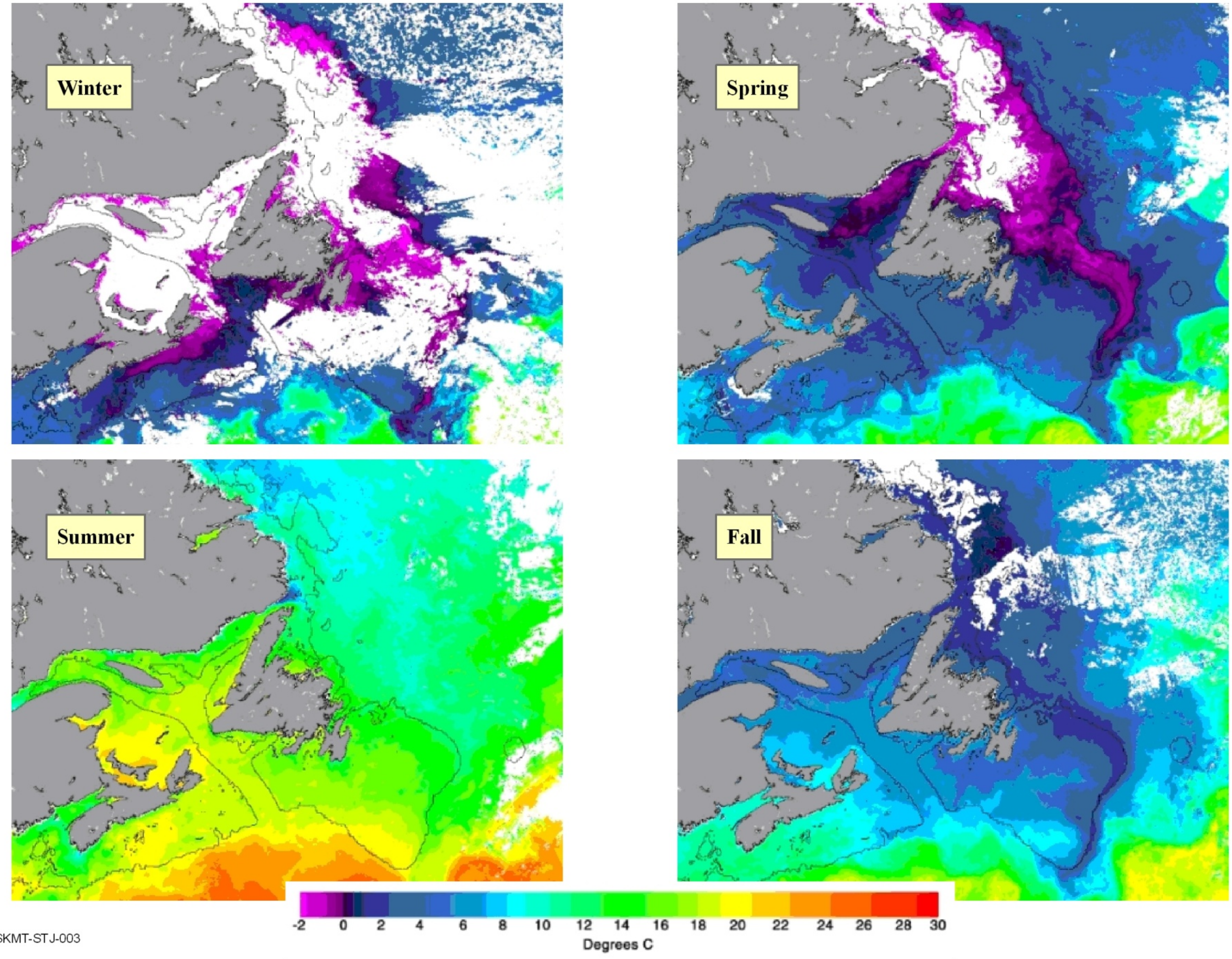


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FIGURE 3.6

NOAA Seasonal Sea Surface Temperature

The DFO Bedford Institute of Oceanography (BIO) runs an online hydrographic database, which holds a collection of temperature and salinity measurements for a large geographic area, at different depths (BIO 2010). Temperature and salinity data were extracted for the Study Area, with the geographical limits defined as 51˚N to 52˚N, and 57.1˚W to 56.2˚W. Measurements available were averaged by depth with bin depth of 10 m. The results are presented in Figures 3.7 and 3.8.

In relation to stratification, the Strait of Belle Isle is a two-layer system in summer and a homogeneous layer in fall and winter. In summer, the surface layer is 50 to 60 m below the surface with average temperatures reaching between 10 and 11˚C, and average salinities between 30.6 and 32 psu. Below 60 m, the bottom layer average temperatures range between -0.4 and 3.5˚C, and salinity averages between 31.5 and 32 psu. Conditions in the fall and winter are colder and saltier, with one homogeneous layer beginning to form in October. Average temperatures range from 2.73˚C in November to -1.8˚C in April and the average salinities range from 31.6 psu in November to 33.1 psu in April after which the stratification begins to occur.

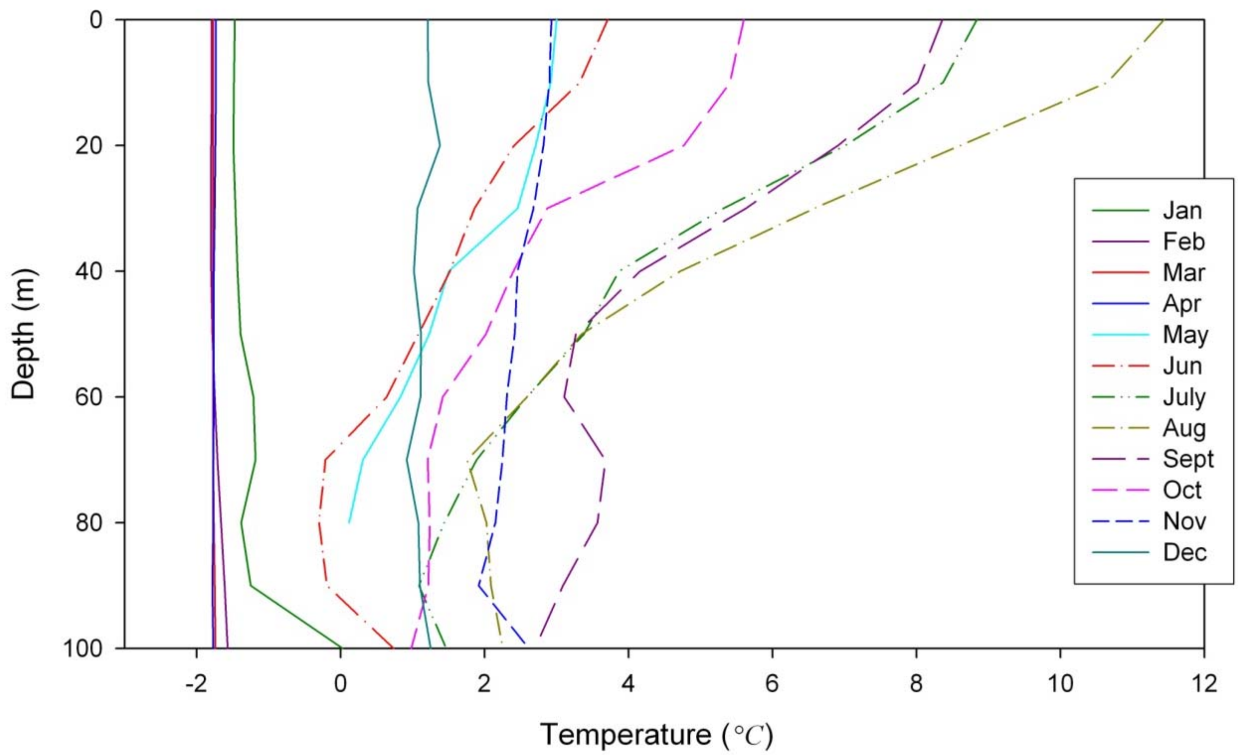

Figure 3.7 Average Monthly Water Temperature by Depth for the Strait of Belle Isle (BIO 2010)

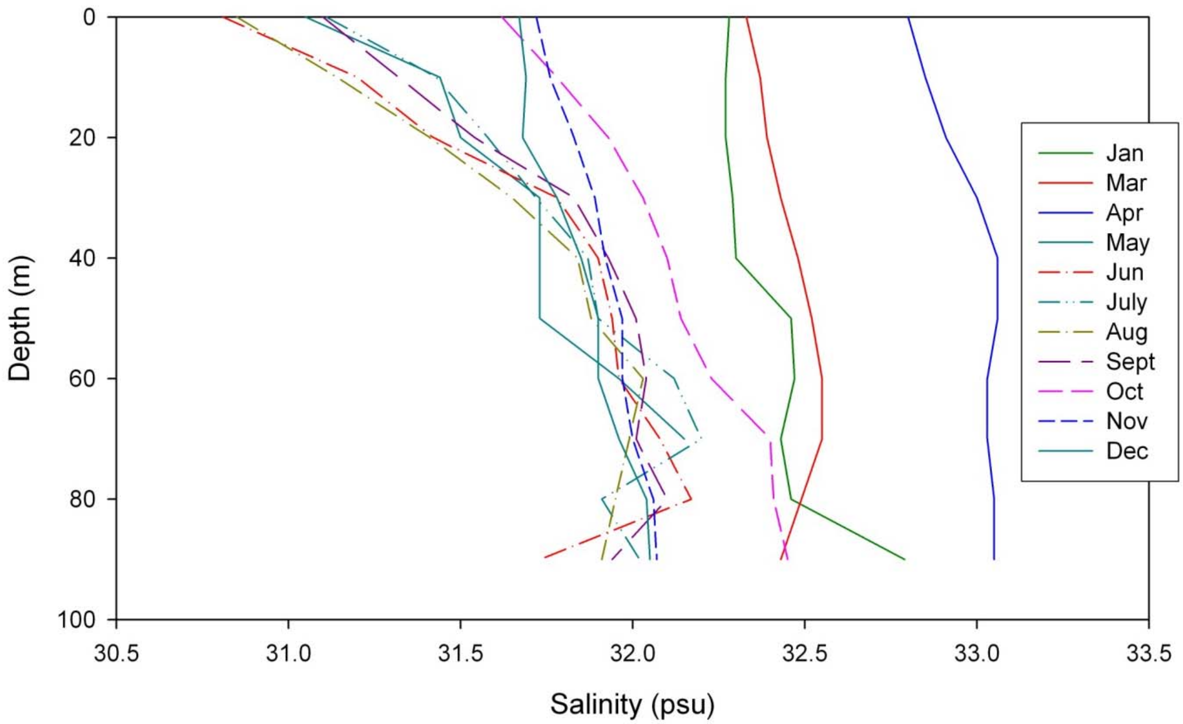

Figure 3.8 Average Monthly Water Salinity by Depth for the Strait of Belle Isle (BIO 2010).

3.2.2.3 Currents

Generally, currents in the Strait of Belle Isle have a strong tidal component, following the general orientation of the Strait. Current velocity is highest at the surface, and decreases with depth. Meteorological conditions can highly influence surface currents. The general current pattern in the Gulf of St. Lawrence is depicted in Figure 3.9

The unique characteristics of the physical oceanographic processes of the Strait of Belle Isle have been extensively studied, beginning as early as the late 1800s with a report on currents in the area by Dawson (1907), as cited by Hatch Mott McDonald (2004) and others. This report documented the flow of water moving in both directions through the Strait of Belle Isle, with cold water flowing in from the Labrador shelf along the Labrador, coast, and southerly out through the Strait along the coast of Newfoundland. Further studies by Huntsman et al. (1954) and later by the Bedford Institute of Oceanography (BIO), as reported by Farquharson and Bailey (1966), gave a general overview of the currents in the Strait of Belle Isle area. BIO deployed current moorings in a straight line from Pointe Amour to Savage Point, and confirmed earlier results from Dawson (1907), with surface flow from the Gulf on the south side of the Strait, and surface flow on the north side of the Strait flowing into the Gulf of St. Lawrence. This report also noted, however, that there was subsurface flow from the Labrador Shelf into the Gulf of St. Lawrence, and was on both sides of the Strait of Belle Isle (Farquharson and Bailey 1966). Garrett and Petrie (1981) re-analyzed the data from the 1963 BIO program, and demonstrated that near-bottom currents were significantly weaker than those near the surface, although less variable. They also demonstrated that currents are generally uniform across the Strait, and there is significant inter-annual variability in terms of inflow into the Gulf of St. Lawrence.

Along with the data collected in the 1960s by BIO, current monitoring studies were conducted in 1978 (NORDCO Ltd. 1978), 1979 (SNC-Lavalin, FENCO Ltd. 1980), and in the early 1980s (SNC-Lavalin 1982; Garrett and Toulany 1981, 1982; Toulany et al. 1987; and Petrie and Toulany 1988). Table 3.2 provides a summary of maximum and mean current speeds measured during the various current monitoring programs (BIO 2010).

Table 3.2 Measured Maximum and Mean Current Speeds for the Four Seasons, at Three Depth Levels (BIO 2010)

	Maximum Current Speed (m/s) Derived from Measurements			
	Winter	**Spring**	**Summer**	**Fall**
Surface	1.8	2.0	2.6	2.5
Mid-Depth	-	-	2.0	1.8
Bottom	-	-	1.6*	2.0**
	Mean Current Speed (m/s) Derived from BIO (2010)			
	Winter	**Spring**	**Summer**	**Fall**
Surface	0.5	0.5	0.6	0.5
Mid-Depth	-	-	0.5	0.4
Bottom	-	-	0.4	0.4

Note: * Highest near-bottom currents in the summer were observed by SNC-Lavalin (1982)
** Highest near-bottom currents in the fall were observed by NORDCO Ltd. (1978).

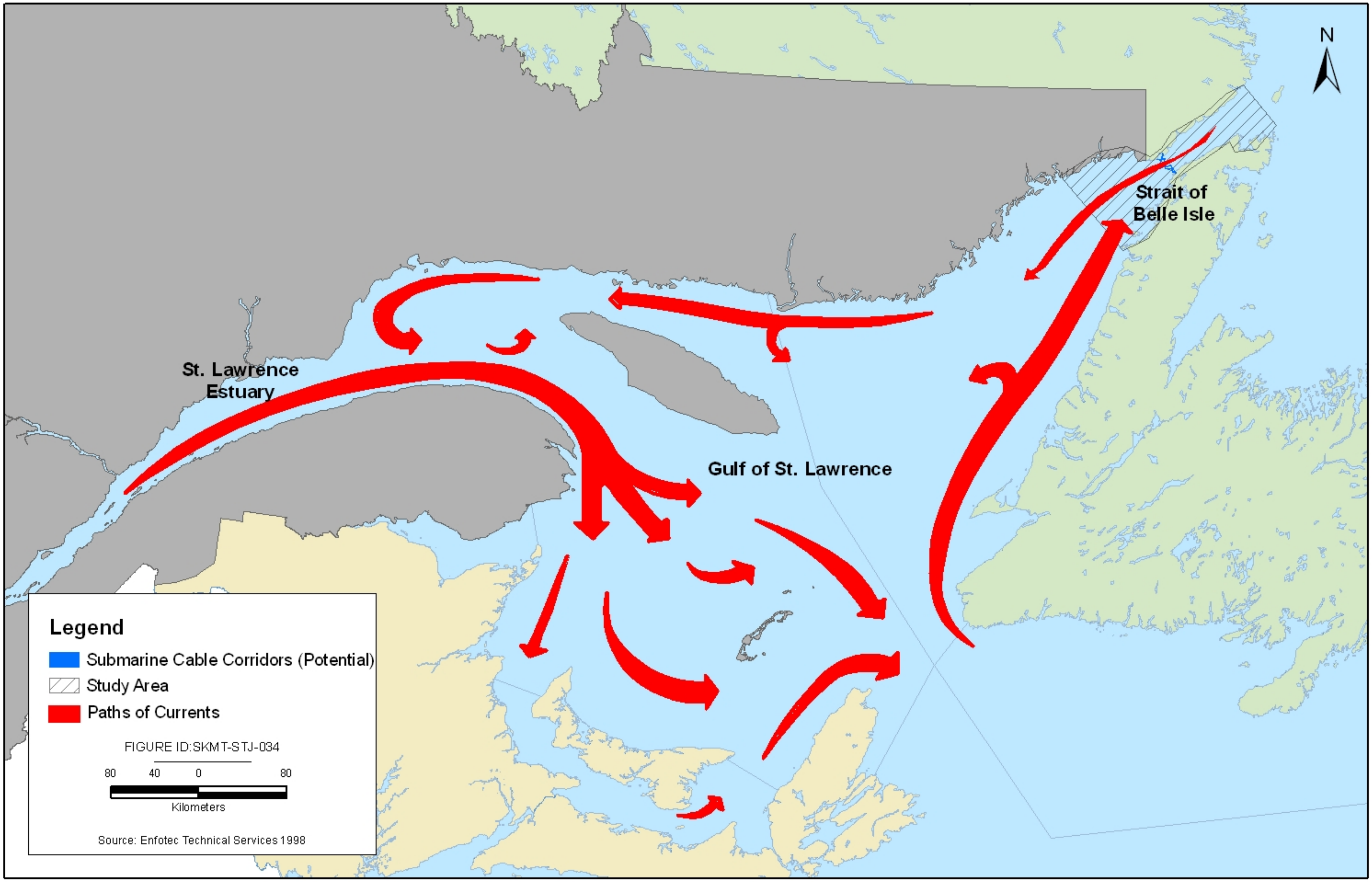

FIGURE 3.9

Current Patterns in the Gulf of St. Lawrence

3.2.2.4 Tides

The CHS tide website (DFO 2010c) reports tidal information for two locations within the Study Area: Blanc Sablon and Baie de Brador, and one location outside the Study Area at Harrington Harbour. The website does not report detailed information for any locations within the Study Area on the Newfoundland side of the Strait of Belle Isle.

The CHS website reports that this area is characterized by variations of water levels in the order of 2.2 m during large tides. The tide is mixed and semi-diurnal having two complete oscillations per day with inequalities in height and time between the two oscillations. A current measurement study undertaken in the proximity of Îles Harrington during the summer season indicates that the predominant tidal stream runs at an angle of 250 degrees 2 miles west of the islands at a maximum rate of 2 knots and an average rate of 1 knot. At Blanc Sablon the flood tidal stream normally runs west at an average rate of 1.5 knots. The ebb stream runs in the opposite direction at approximately the same rate. The tidal streams can attain 2.5 knots when accompanied by dominant winds (DFO 2010c).

Table 3.3 Tidal Parameters at Baie de Brador, Harrington Harbour and Blanc Sablon (DFO 2010c)

Parameter			Site		
			Baie de Brador	**Harrington Harbour**	**Blanc Sablon**
Type of Tide			Mixed semi-diurnal	Mixed semi-diurnal	Mixed semi-diurnal
Range (m)	Mean Tide		1.3 m	1.5 m	1.2 m
	Large Tide		1.9 m	2.2 m	1.8 m
Height (m)	Higher High Water	Mean Tide	1.6 m	1.8 m	1.7 m
		Large Tide	2.0 m	2.2 m	2.0 m
	Lower Low Tide	Mean Tide	0.4 m	0.4 m	0.5 m
		Large Tide	0.1 m	-0.1 m	0.2 m
Extremes Recorded (m)	Extreme High Water		-	3.1 m	-
	Extreme Low Water		-	-0.5 m	-
Mean Water Levels (m)			1.0 m	1.1 m	1.1 m
Maximum Speed of the Currents	Flood		-	2.0 knots	1.5 knots
	Ebb		-	2.0 knots	2.5 knots

As part of its marine environmental study program, Nalcor Energy deployed four tide measuring instruments in the Strait of Belle Isle from 22 August to 21 October 2009, in order to collect further information on tidal activity in the area. Gauges were installed at the public wharves at two locations on each side of the Strait – St. Barbe and Eddies Cove, and at Pinware and Blanc Sablon – resulting in the collection of 60 days of synchronized data during this period. The resulting data will be presented in detail and used, along with other available oceanographic information, in the marine zone of influence/sedimentation modeling study being undertaken for the Project's environmental assessment (AMEC Earth and Environmental, forthcoming).

3.2.2.5 Waves

Wave characteristics have been calculated from data obtained from MSC50, a hindcast of hourly data as provided by the Meteorological Services Canada (Swail et al. 2006). The temporal coverage of the data was from 1954 to 2009 including considerations of ice-covered periods. Modeling was completed for MSC50 node #18071 (51.4˚ N, 56.8˚ W). This node was chosen for modeling since it is offshore and is representative of the proposed submarine cable crossing location. Wave roses were developed for the entire dataset seasonally, and includes fall (October through December), winter (January through March), spring (April through June) and summer (July through August). Wave roses are displayed in Figure 3.10.

Significant wave height (Hsig in m) was less than or equal to 1 m in the fall 60 percent of the time. In the spring and summer, the significant wave height was predominantly less than or equal to 1 meter, 84 percent and 77 percent of the time, respectively. Waves can reach up to 7.0 m but occur infrequently, and mostly occur in winter. Winter wave heights were slightly higher than in other months. In winter, waves of 1 to 2 m occur about 45 percent of the time. At this node, waves generally were largely from the southwest in the spring and summer, (47 and 62 percent of the time, respectively). Wave direction during the winter was predominantly from the west (22.49 percent) and again from the southwest in the fall, but less frequently (19.8 percent of the time).

SNC-Lavalin (1982) determined that wave heights were lowest in August and greatest in November. The maximum wave height in that study was 7.7 m, with the maximum significant wave height of 4.4 m, mean significant wave height of 1.03 m, a significant wave height of 2.0 m was exceeded 8 percent of the time.

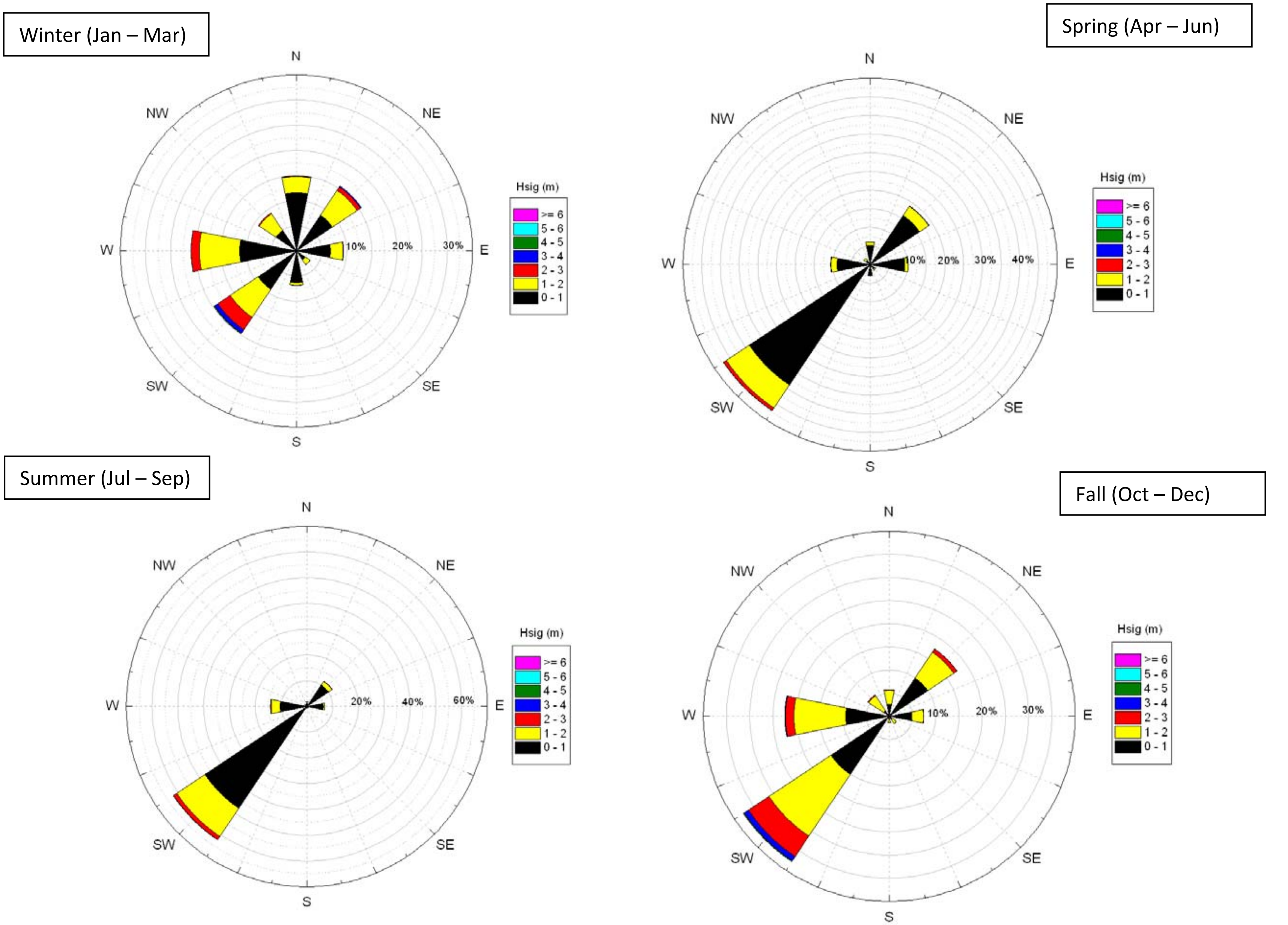

Figure 3.10 Seasonal Wave Roses for the Strait of Belle Isle Area (MSC50 Node 18071)

3.2.2.6 Sea Ice

Sea ice located in the Strait of Belle Isle is usually from one of two sources: locally formed sea ice, and pack ice which has drifted from the Labrador Sea or Arctic region. Ice that is formed solely from thermal effects is usually less than 1 meter thick, however sea ice in this region is often formed from collisions of individual floes, creating sea ice several meters thick (Hatch Mott McDonald 2004). Generally, local ice first begins to form in mid to late December, and coverage can last up to 7 to 9 months. Labrador pack ice drifts into the area by late January, and most of the area is generally covered. Ice moves with the wind and currents, and only small portions of it move into the Gulf of St. Lawrence (Hatch Mott McDonald 2004).

The Canadian Ice Service (Environment Canada) has a database of historical ice coverage for all of Canada (Environment Canada 2010b). This also includes 30 year climatic ice atlases, which provides historical 30 year averages for specific dates on frequency of ice coverage (Figure 3.11), and predominant ice type (Figure 3.12). These two figures demonstrate 30 year averages (1971 to 2000) for representative mid-season dates, where data is available, to give a seasonal perspective. For this analysis February 12 was chosen to be representative of winter, May 14 of spring, July 16 for summer, and November 26 for fall. Ice cover during winter months is near 100 percent for practically 100 percent of the time, and is still covering large portions of the Strait of Belle Isle during spring over 50 percent of the time in some areas. The majority of ice found in the area is newly formed ice.

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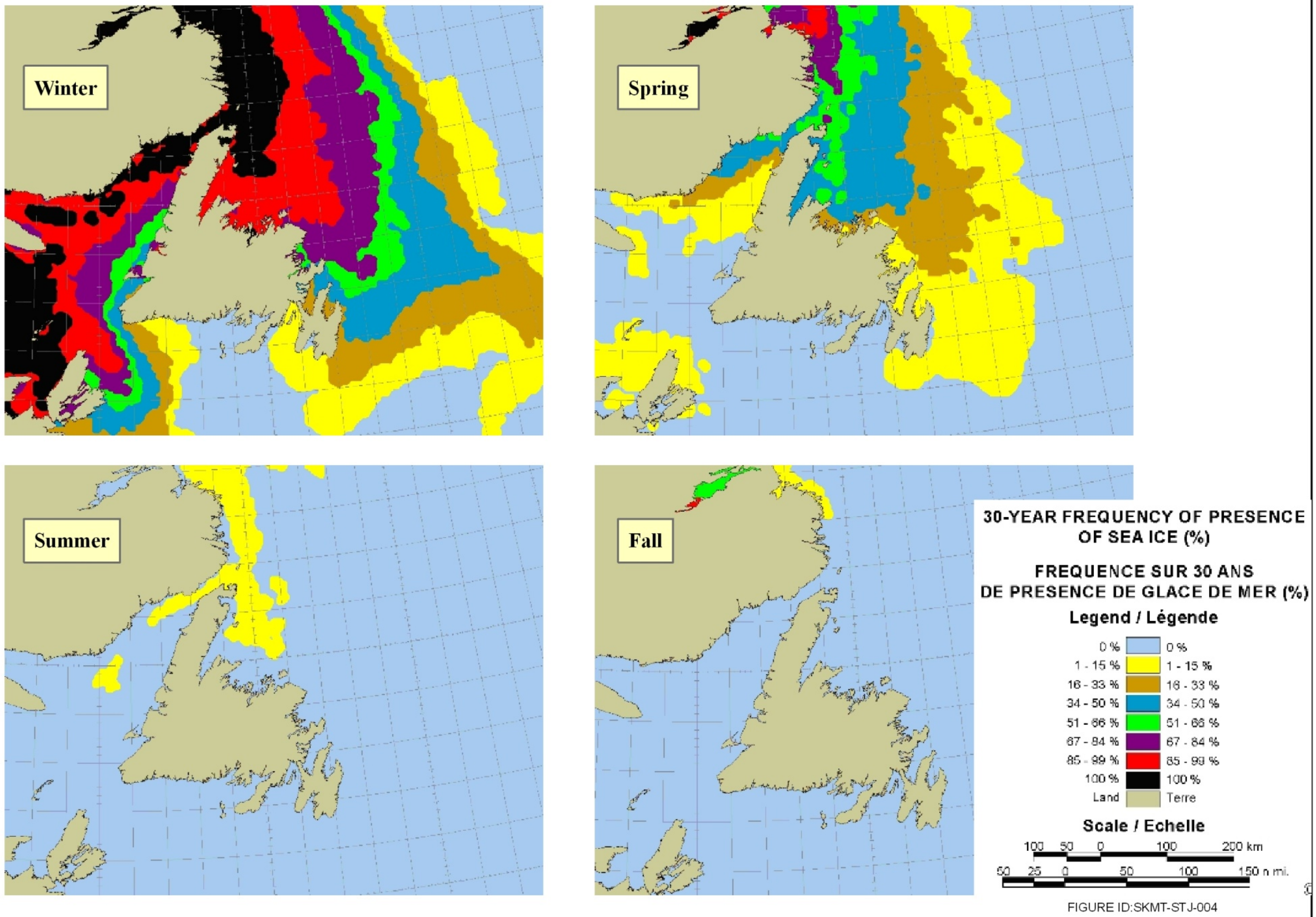

FIGURE 3.11

Seasonal Frequency of Ice Cover (30 Year Average)

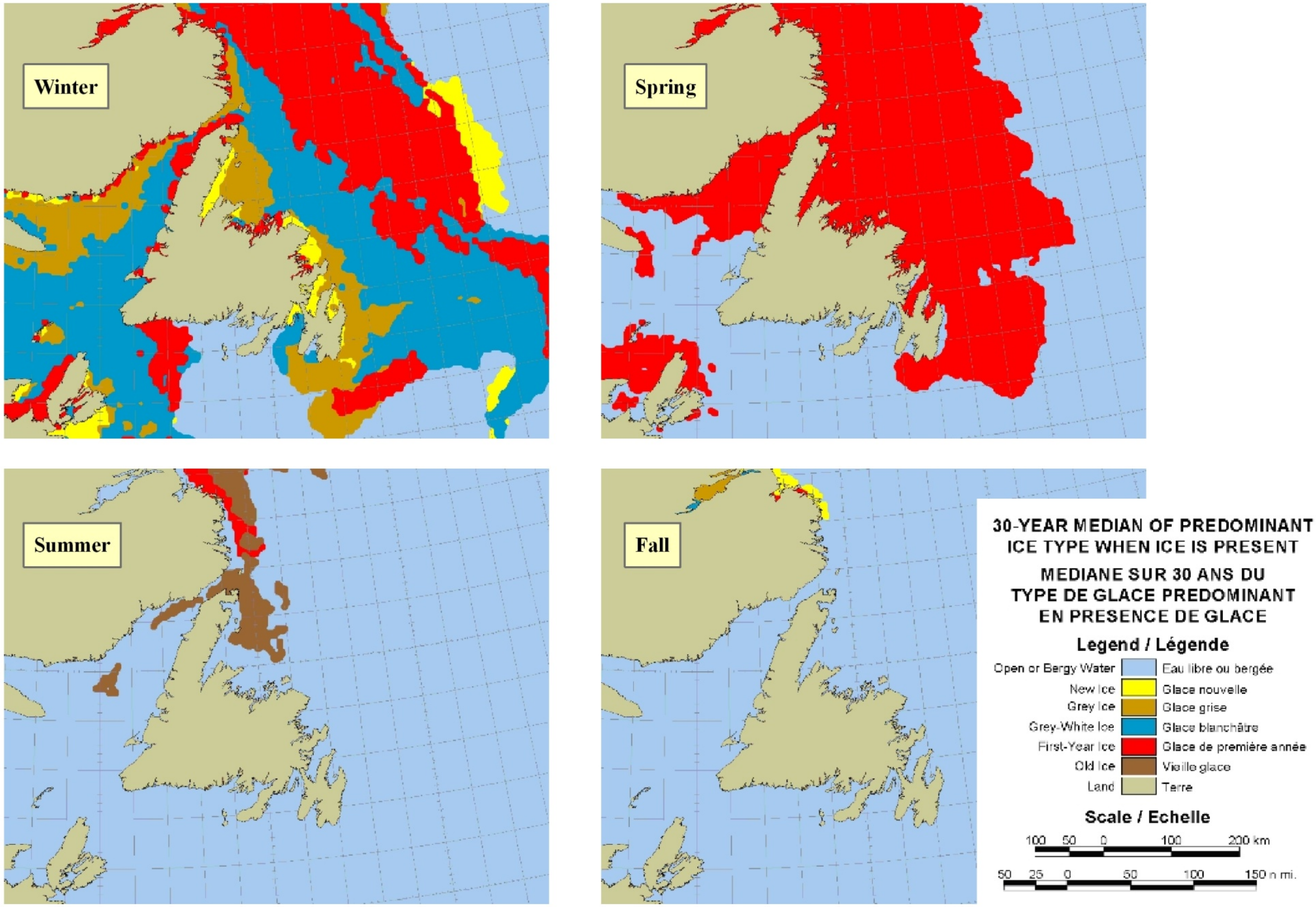

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FIGURE 3.12

Seasonal Median of Predominant Ice Type (30 Year Average)

3.2.2.7 Icebergs

It is estimated that approximately 60 to 90 icebergs drift into the Strait of Belle Isle each year (Hatch Mott McDonald 2004). This constitutes approximately 10 to 15 percent of the icebergs that pass the latitude of the Strait of Belle Isle drifting from the Labrador Shelf and Arctic area (C-CORE 2004).

The largest numbers of icebergs occur in May and June, and most of these icebergs enter on the Labrador side, moving with the currents until the exit on the Island side. Some icebergs move further into the Gulf, and ground along the Quebec Shore (few around Anticosti Island or the Bay of Islands), although infrequently (Hatch Mott McDonald 2004).

Iceberg surveys in the area have commonly focused around risk of scour on the seafloor. According to an iceberg scour risk report (C-CORE 2004), a shoal to the north end of the Strait of Belle Isle may prevent larger, deeper icebergs from passing through. However, evidence of scouring in the area suggests that some do pass through the Strait of Belle Isle, scouring the seabed. Grounding rates of icebergs were also calculated, and mapped (see Figure 3.13) in the Strait of Belle Isle during this risk report.

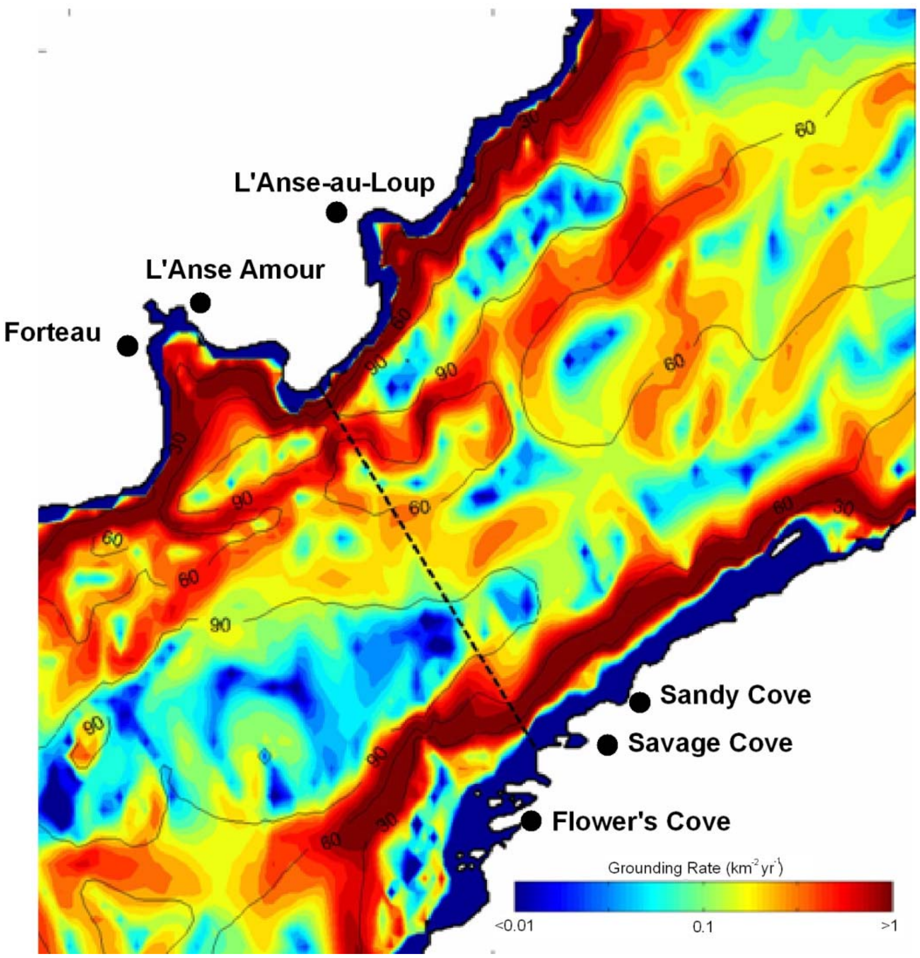


Figure 3.13 Modelled Grounding Rates for Icebergs in the Strait of Belle Isle (Source: C-CORE 2004)

3.2.2.8 Surficial Geology and Substrates

There has been considerable investigation of the geologic environment underlying the Strait of Belle Isle over the last 35 years, with much of the work focused on the potential locations of a fixed link crossing between Labrador and Newfoundland (e.g., Hatch Mott McDonald 2004) and the sites for a possible crossing of a HVdc transmission cable (e.g., SNC-Lavalin 1980). Information on the geological characteristics of underlying bedrock in the Strait has not been reviewed in this document as it is not relevant to characterizing marine fish habitat features in the Strait. Information on the surficial geology, substrates, and sediments as it pertains to such habitat is summarized below.

An extensive grab and dredge sampling program in 1979 determined that the soil overburden underlying the Strait averaged 0.5 to 1.0 m thick and was composed of a layer of shells/shell fragments overlying sand, gravel, cobbles, and boulders (SNC-Lavalin 1980). Rock fragments averaged 10 to 12 cm diameter with occasional larger fragments up to 30 cm. The soil material was 75 percent fine to coarse gravel which was frequently overlain by layer of cobble. Work by the Nova Scotia Research Foundation (1974) identified sand and gravel waves in the substratum which suggested that the bottom material may be fairly mobile, likely indicative of strong bottom currents.

DFO has collected data on substrate type in the Strait of Belle Isle using the RoxAnn system for seabed classification using data collected from single beam echo sounding along transects. The system discerned various bottom types based on hardness and texture. DFO initially classified the RoxAnn data into three classifications based on potential as scallop habitat specifically ‘Scallop Ground’, ‘Not Scallop Ground’, and ‘Possible Scallop Ground’ (Naidu et al. 1996). Jacques Whitford Environment Limited (2000) re-analyzed the RoxAnn data to identify specific habitat types based on substrate size. The seabed substrate classification was completed for the entire Strait of Belle Isle and for the potential submarine cable corridors with a 2 km buffer (Table 3.4).

Table 3.4 Seabed Substrate Classification, Based on RoxAnn Data collected by Echo Sounder, for the Strait of Belle Isle and the Submarine Cable Crossing Corridor (after JWEL 2000)

Substrate Classification	Strait of Belle Isle (%)	Submarine Cable Crossing Corridor (%)
Unclassified	2.7	2.5
Fine sand	1.0	0.8
Shells, coarse sand, pebbles	8.3	14.8
Pebbles and rock (2.5 – 12.7 cm)	7.0	12.2
Rock (7.6 – 25.4 cm)	36.4	40.2
Rock (25..4 – 61.0 cm)	30.1	20.1
Rock (61.0 – 121.9 cm)	1.3	0.4
Rock (> 121.9 cm)	13.3	9.1

The RoxAnn data analyses determined that approximately 90 percent of the seabed was comprised of pebbles, cobbles, and boulders ranging from 2.5 cm to more than 1 m diameter, with 65 percent of the seabed comprised of boulders cobbles in a narrower size range, 2.5 to 75 cm. The remaining 10 percent consisted of coarse grained sand, shells with pebbles, and fine sand (1 percent).

Further and more detailed information on the surficial geology in the Study Area – and particularly within the Project's proposed submarine cable crossing corridors themselves – have been obtained through recent marine survey work completed by Nalcor Energy, and reported in AMEC Earth and Environmental (2010) and Fugro-Jacques Geosurveys Inc. (2010). These reports have been submitted separately as part of the Project's EA process.

3.2.2.9 Coastal Environment

Available coastal, marine, estuarine, and deep water habitat information has been assessed and compiled to be consistent with the current DFO approach to characterizing and quantifying coastal marine habitat (Kelly et al. 2009). This hierarchical system consists of four levels of description, each providing progressively more detail on habitat attributes. The level of assessment moves from cursory, to general (Ecosystem, Ecoregion) and then to more detailed requiring more site specific fish and fish habitat information. The most detailed level of habitat classification is at the 'Shore Zone and Shore Unit' which are delineated into 4 zones as follows:

- *Backshore*: From above the mean high tide to the vegetation beyond the shoreline in an area affected by large waves during a high tide;
- *Intertidal Zone*: From mean low tide to mean high tide. The Intertidal Zone will demarcate the range of expected mean tide;
- *Shallow Subtidal Zone*: Mean low tide to a depth of 30 m. The shallow sub-tidal zone is routinely influenced by wave action;
- *Deep Subtidal Zone*: >30 m depth which is the zone below normal wave base but which may be disturbed.

A very brief summary of the AMEC Earth and Environmental (2010) information is provided here, with greater detail available in that document. The substrate distributions were surveyed in each of five shoreline to offshore zones as follows: Shallow Subtidal (0-30 m depth); Deep Subtidal 1 (30-60 m depth); Deep Subtidal 2 (60-90 m depth); Deep Subtidal 3 (90-120 m depth); and Deep Subtidal 4 (120-150 m depth) (Table 3.5).

Table 3.5 Substrate Distributions (Percentage) on Subtidal Zones

Substrate Class	Shallow Subtidal	Deep Subtidal 1	Deep Subtidal 2	Deep Subtidal 3	Deep Subtidal 4
Bedrock	21.7	11.4	8.7	2.4	0
Coarse-Large	0	0	7.1	21.4	4.1
Coarse-Small	62.8	65.8	71.3	66.1	95.9
Coarse-Small/Shells	0	16.1	8.0	6.6	0
Shells	0	0.1	4.8	3.6	0
Fine	15.5	6.7	0	0	0

The shoreline of the Strait 'sub-zone' was mapped during the CCRI for the Nordic Economic Development Corporation from videotape collected during aerial reconnaissance. Classification of the coastal environment for the Northern Peninsula (west) is presented in Figure 3.14.

No coastal or shoreline information exists for the Labrador side of the Strait, whereas the Northern Peninsula (west) coastal geomorphology has been classified. Data which is used in the CCRI database for the Northern Peninsula (East) comes from the data which was collected by Environment Canada and described below. In the CCRI report (Nordic Economic Development Corporation 2000) there are a number of constraints identified with respect to the data collection and analyses which suggests caution on the usefulness of this information.

Six shoreline classes were identified for the Study Area including:

Bedrock Cliff: Shoreline with a bedrock substrate, appreciable increase in slope magnitude at the high water mark, little or no backshore, waves break against cliff. Within the Study Area cliffs ranged from 2 to greater than 300 m.

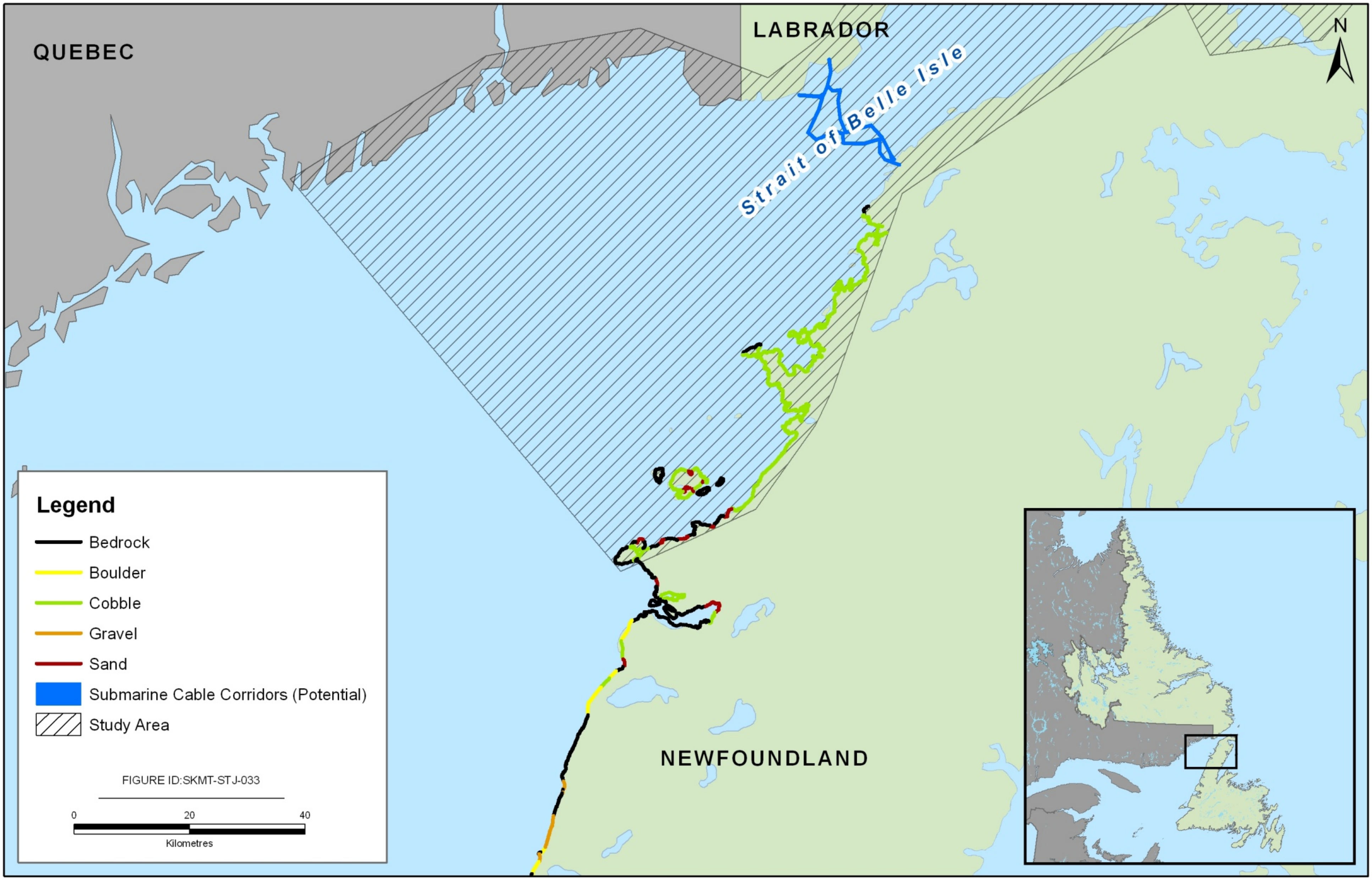
Bedrock Tidal Flats: Low relief shoreline, bedrock substrate, no change in slope at high water mark. Back slope can consist of cliffs, beach deposits, vegetated soils, or human infrastructure.

Boulder Tidal Flats: Shoreline protected from tidal energy by presence of boulders in nearshore environment (within 20 m of shoreline), shoreline and back shore consist of sandy and/or gravelly sediments, or vegetated soils.

Gravel Beaches: Beaches dominated by substrates larger than sand, back shore can be cliff, raised beach, vegetated soils, or human infrastructure (in the CCRI, the videotape resolution did not permit differentiation of different beach categories).

Sandy Beaches: Beaches dominated by sandy substrates, back shore can be cliff, raised beach, vegetated soils, or human infrastructure.

Tidal Mud Flats: Shoreline that is sheltered from effects of wave energy, sediment (mud to fine gravels) accumulation in the nearshore zone, shorelines can consist of salt marshes to sandy and gravelly beaches, back shore can be cliff, raised beach, vegetated soils, or human infrastructure.



nalcor energy

FIGURE 3.14

Substrate Classification Obtained from CCRI

The CCRI shoreline classification determined that the intertidal zone in the Study Area was quite narrow, with the width of beaches generally 5 m or less, likely as a result of the low tidal range in the area and low sediment inputs. The Study Area is also undergoing a decline in relative sea level (RSL), which is considered to have resulted in relict features such as raised beaches, and has resulted in the shorelines being considered a sediment 'sink', that is, sediments become trapped above the high water mark (Catto et al. 2000).

In an effort to protect the environment from events such as oil spills, Environment Canada has undertaken an Atlantic Sensitivity Mapping Program (ASMP) to provide support to environmental responders. As part of the ASMP, classification of the coastal zone for most of Atlantic Canada was completed, via aerial reconnaissance, and the classification scheme is consistent with that of the DFO methodology (Kelly et al. 2009). Within the Study Area, information exists for the Newfoundland side only. This dataset includes classification of the coastal zone, which is divided into the following components: shoreline, lower intertidal zone (material and form), and backshore (material and form). The percent frequency of the various classes for the lower intertidal zone material (substrate) and form class and are presented in Tables 3.6 and 3.7, respectively. Shoreline classification type is presented in Table 3.8, while the backshore material and form are presented in Tables 3.9 and 3.10, respectively. The ASMP contains details for a number of different anthropogenic structures (including wharves, sea walls, breakwaters, bridges, causeways and rip-rap), however, for the purposes of the review of available fish and fish habitat information, all anthropogenic structures were grouped into one category. The above five coastal shoreline attributes within the Study Area have been mapped and these are provided in Appendix C. Owing to the level of detail in the dataset, 4 sub-maps have been generated for each of the five attributes in the Study Area.

The Lower Intertidal Zone within the Newfoundland side of the Study Area consists primarily of bedrock (78.39 percent), with a proportion of mixed coarse material with no sand (16.81 percent), while other materials represent a small proportion of the distribution (less than 2 percent each). The form class of the Lower Intertidal Zone consists largely of platforms (77.98 percent) and some beach (15.79 percent). The Shoreline Type in the Study Area consists primarily of beaches (boulders, mixed sand-gravel, pebble-cobble, sand), with pebble-cobble beaches (45.63 percent) being the dominant shoreline type, followed by boulder-beach (24.63 percent). The backshore forms in the Study Area are dominated by beaches (56.92 percent) and cliff (33.78 percent), with other forms representing a small proportion of the distribution (less than 2 percent each). The dominant material in the backshore is mainly mixed coarse material – no sand (60.96 percent) with resistant bedrock (31.45 percent) also being common. Anthropogenic structures represent 1.9 percent and 5.59 percent of the Lower Intertidal and Backshore zones, respectively.

Table 3.6 Substrate Distribution for the Lower Intertidal Zone in the Study Area (Newfoundland side only)

Material	**Length (m)**	**Percent**
Anthropogenic Structure	13831.23	1.91
Bedrock	568294.10	78.39
Mixed Coarse with Sand	2749.72	0.38
Mixed Coarse with no sand	121881.10	16.81
Mud	8377.00	1.16
Sand	9812.47	1.35
Total	**724945.6**	**100.00**

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

Table 3.7 Form Class Distribution for the Lower Intertidal Zone in the Study Area (Newfoundland side only)

Form	**Length (m)**	**Percent**
Anthropogenic Structure	13831.23	1.91
Beach	114482.65	15.79
Cliff	2995.78	0.41
Platform	565298.29	77.98
Tidal Flat	28337.60	3.91
Total	**724945.55**	**100.00**

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

Table 3.8 Shoreline Type Distribution in the Study Area (Newfoundland side only)

Type	**Length (m)**	**Percent**
Anthropogenic Structure	13831.23	1.91
Bedrock	169196.41	23.34
Boulder Beach	178560.19	24.63
Mixed Sand-Gravel Beach	20172.22	2.78
Pebble-Cobble Beach	330779.46	45.63
Salt Marsh	11136.85	1.54
Sand Beach	1269.19	0.18
Total	**724945.55**	**100.00**

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

Table 3.9 Substrate Distribution for the Backshore in the Study Area (Newfoundland side only)

Material	Length (m)	Percent
Anthropogenic Structure	40511.36	5.59
Bedrock Resistant	227973.76	31.45
Marsh Grass	13652.24	1.88
Mixed Coarse - No Sand	441953.15	60.96
Sand	855.03	0.12
Total	**724945.54**	**100.00**

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

Table 3.10 Form Class Distribution for the Backshore in the Study Area (Newfoundland side only)

Form	Length (m)	Percent
Anthropogenic Structure	40511.36	5.59
Beach	412663.15	56.92
Cliff	244920.26	33.78
Dune	855.03	0.12
Platform	11247.55	1.55
Salt Marsh	13652.24	1.88
Spit	1095.95	0.15
Total	**724945.54**	**100.00**

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

The shorelines of potential landing sites (Forteau Point, L'Anse Amour, Mistaken Cove, and Yankee Point) of the proposed submarine cable crossings were surveyed and mapped by AMEC Earth and Environmental (2010). Substrate characteristics, flora and fauna present, and habitat filed descriptions were collected and used in combination with photos (aerial and land based) and marine charts to characterize the coastal zone features.

At the Forteau Point site, substrate in the intertidal zone consisted of bedrock, bedrock with sand deposits, and boulder field. Bedrock ranged from 5 to 40 m width and -1˚ to 30˚ slope. The bedrock with sand layer was directly behind the bedrock layer and ranged from 15-34 m width and 6˚ to 15˚ slope. The boulder field layer was 10 m in width and ranged from 10˚ to 40˚ slope. The backshore was 10 to 55 m width, -7˚ to 40˚ slope, with vegetation consisting of grasses, lichens, mosses, shrubs and trees, with the backshore terminating at the base of cliffs.

At the L'Anse Amour site, substrate in the intertidal zone was a beach that changed from mostly sand to mostly gravel/cobble. The width of the beach ranged from 4 to 14 m with a slope of 5˚ to 18˚. Sand dunes were present that had become covered in moss and grass in the backshore. Brown algae were observed washed up on the beach. The backshore was 5 to 22 m width, 0˚ to 200˚ slope, with 3 distinct areas: (i) grasses; (ii) grasses with shrubs, and (iii) grasses, shrubs and trees. The backshore terminated at the base of a cliff.

The intertidal zone at the Mistaken Cove site consisted of largely exposed bedrock and sand/gravel beaches. The exposed bedrock areas ranged from 3.6 to 16.1 m width with a slope of 0˚. Sand/gravel beaches ranged from 4 m to greater than 50 m in width, with a slope range of 0˚ to 25˚. The backshore consisted of two distinct vegetation types: (i) grasses and (ii) trees and tuckamore. The backshore width was 2 to 10.7 m width, and 0˚ to 18˚ slope.

The Yankee Point intertidal zone was divided into two distinct areas, having (i) bedrock with gravel/pebbles, a width of 2.5 m to 35 m, and a slope of 0˚ to 15˚; or (ii) gravel with a width range of 6.2 m to 31 m, and slope of 10˚ to 30˚. The backshore ranged from 28.9 m to 174 m width, and had a slope of 2˚ to 15˚. The backshore consisted of areas with grass and patches of tuckamore located immediately behind the survey area.

3.2.3 Biological Environment

Information on the biological environment provided below includes a summary of the plankton (phytoplankton and zooplankton) and primary production, benthic invertebrates, as well as information available on the marine algae located within the Study Area.

3.2.3.1 Plankton

Plankton refers to free-floating organisms that drift in the water column. This may include bacteria, fungi, phytoplankton (e.g., marine algae), zooplankton (marine invertebrates), eggs and larvae of macro invertebrates, and ichthyoplankton (eggs and larvae of fish).

Plankton production is important because areas of enhanced production and/or biomass tend to be congregation areas for fish, seabirds, marine mammals, and possibly sea turtles. Production is enhanced in areas of bottom upwelling where nutrient-rich bottom water is brought to the surface by a combination of bottom topography, wind and currents. It is for this reason, during the determination of EBSAs, the Strait of Belle Isle region was considered an important area in terms of primary production. Labrador shelf waters entering the Gulf of the St. Lawrence through the Strait of Belle Isle, tidal mixing, and upwelling processes have lead to highly productive areas within the Study Area (Savenkoff et al. 2007).

Phytoplankton

Phytoplankton in high-latitude ecosystems is a complex system limited by light regimes and presence of sea ice (Harrison and Li 2008). The area of the Strait of Belle Isle is subject to high meteorological forcings, including tidal mixing and upwelling, which supplies nutrients to the upper water column, but also limits the amount of light available for phytoplankton growth.

The northeastern Gulf of St. Lawrence has a very low phytoplankton biomass between April and October compared to the other parts of the Gulf (de Lafontaine et al. 1991). A decreasing production rate between April and May has led the authors to surmise that the phytoplankton bloom in this area might typically occur in late March/early April, immediately following ice melt.

Chlorophyll '*a*' concentrations (a measure of primary production) are derived from ocean colour. By detecting the presence of pigments in particular parts of the visible light spectrum using optical instruments on satellites, the amount and distribution of phytoplankton in the ocean can be detected. This is then calibrated in terms of chlorophyll concentration, usually given in units of milligrams per cubic meter of water. DFO maintains a remote operational sensing database (DFO 2009f). On this website, one time satellite passes for chlorophyll 'a' or 15 day composite images, are available. Figure 3.15 has been created from this database, using 2009 mid-season 15-day composite images from the NOAA database to demonstrate the seasonality in chlorophyll '*a*' concentrations. February 1 to 15 represents winter, May 1 to 15 represents spring, August 1 to 15 represents summer, and fall is represented by November 1 to 15.

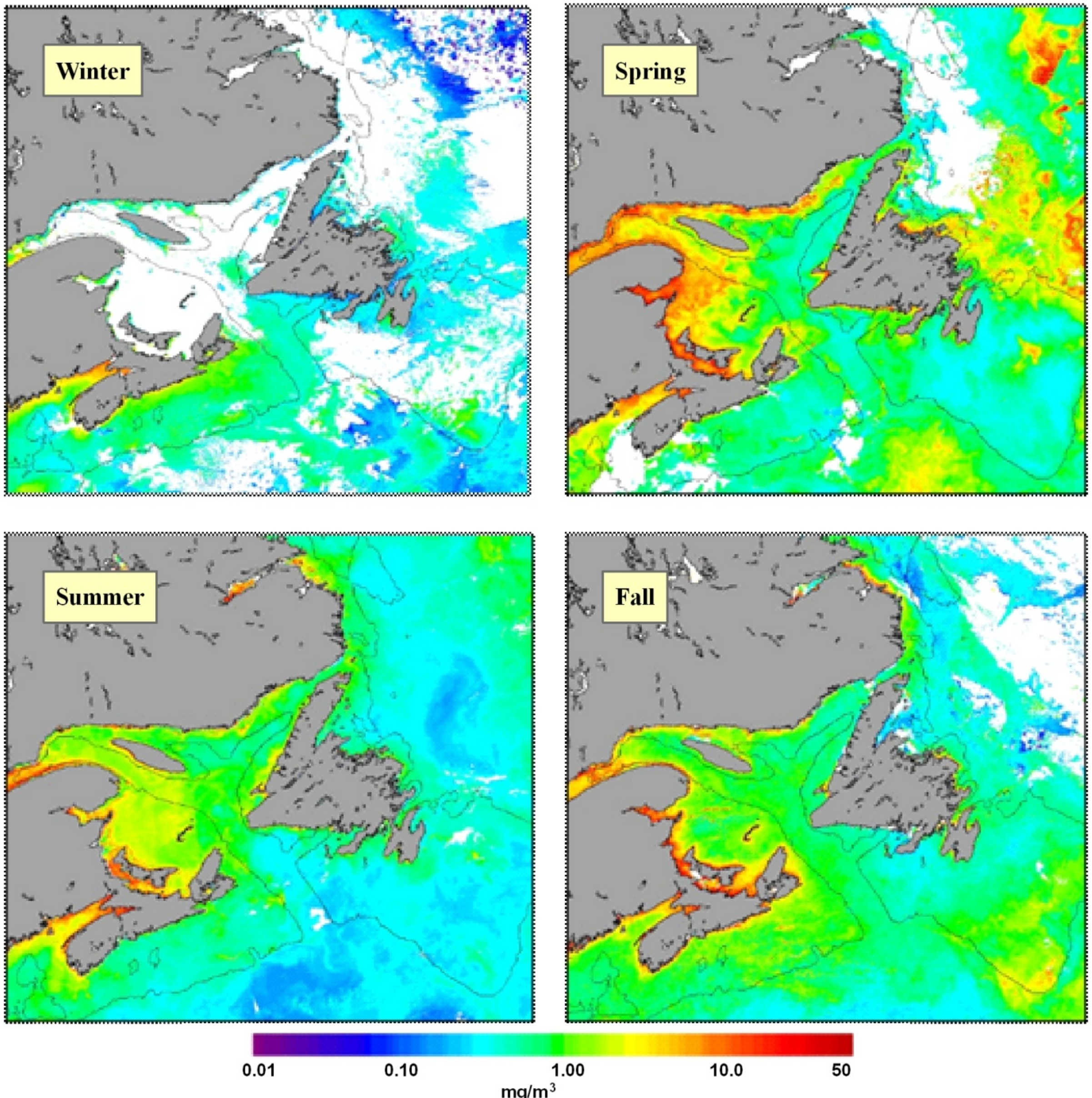


FIGURE ID:SKMT-STJ-006

FIGURE 3.15

Seasonal Chlorophyll "a"

Zooplankton

Zooplankton is the link between primary production and higher-level organisms in the marine ecosystem, transferring organic carbon from phytoplankton to fish and animals higher in the food chain.

There is evidence that the waters from the Labrador Shelf, and the circulation into the Gulf of St. Lawrence provides the Gulf region with a larval plankton transport mechanism (Mullins, 2010, pers. comm.). Snow crab larvae from the Labrador Shelf are thought to be transported to the northern Gulf of St. Lawrence by the currents in the Strait of Belle Isle (Lambert, 2010, pers. comm.). Krill is one of the key species of the food web in the Gulf of St. Lawrence. One of the primary retention areas of krill occurs in the Northeastern Gulf within the Study Area (Sourisseau et al. 2004).

3.2.3.2 Benthic Invertebrates

Benthic invertebrates are bottom dwelling organisms. Benthic invertebrates can be divided into infaunal (in the seafloor) and epifaunal (on the seafloor or attached to it and objects). Benthic community assemblages depend on environmental conditions such as depth, temperature, salinity and bottom type. Currents and other oceanographic processes can also influence benthic communities by facilitating the supply of nutrients. The Strait of Belle Isle Study Area was determined to be an Important Area (IA) in terms of benthic invertebrates during the identification of EBSAs in the Gulf of St. Lawrence (DFO 2007a). This was mostly due to large aggregations of shrimp species (See Section 3.3.3.4). Benthic invertebrates can also include shellfish, which are commercial or potentially important species (Section 3.3.3).

Savenkoff et al. (2005) identified a lack of data on benthic invertebrates for the northern Gulf of St. Lawrence. Several literature reviews of coastal benthic resources of Newfoundland and Labrador are available (MacLaren 1977; South et al. 1979; Barrie and Browne 1980; Thompson and Aggett 1981; LeDrew 1984; Hardy 1985; Gilkinson 1986). Most of these studies are focused outside of the Study Area. In order to delineate sensitive areas as part of the GOSLIM planning process, Chabot et al. (2007) compiled data from various sources for 44 invertebrate taxa in the Gulf of St. Lawrence. Results for the Strait of Belle Isle came mainly from DFO Scientific Multispecies surveys conducted by DFO research vessels: the CCGS Alfred Needler in 2000 to 2004; and the CCGS Teleost in 2004 to 2006 (Chabot, 2010, pers. comm.). During the analysis of this information, rare species and species with limited distributions were treated differently (Chabot, 2010, pers. comm.). Invertebrates captured within the Strait of Belle Isle Study Area include 20 species of shrimp, species from the soft coral family Alcyoniidae, anemones (Anthozoa), sponges (Porifera), tunicates (Ascidiacea), sea stars (Asteroidea), Gorgonocephalidae, Ophiuridae, sea urchins, as well as various bivalve and crab species (Chabot et al. 2007).

Ardisson and Bourgel (1992) presented a study on benthic littoral fauna over a 12 year period (1974 to 1985) in the Gulf of St. Lawrence. This study looked at those species of invertebrates present at moored navigational buoys throughout the Gulf of St. Lawrence. This study determined that specific species of sessile organisms regularly occurred together, including bivalve molluscs *Mytilus edulis, Hiatella arctica*, Hydrozoa species *Obelia longissima, O. geniculata, Tubularia larynx* and crustacean species *Balanus crenatus, Semibalanus balanoides*. These species were also present on moored buoys within the Study Area, located on the coast of the Quebec Lower North Shore.

AMEC Earth and Environmental (2010) conducted macrofaunal surveys along the corridors of the proposed submarine cable crossings in 2008 and 2009 and found 35 and 20 taxa, respectively. In 2008, these surveys were conducted using a drop video camera deployed form the stern of a boat. In 2009, shallower waters were surveyed (less than 30 m) from a smaller vessel and also with the use of team of divers with a mobile vide system. The video was subsequently analyzed and macrofaunal identifications were made lowest possible taxonomic level. Data were analyzed to determine percent occurrence and relative abundance (abundant, common, occasional, uncommon). A species list from the 2008 and 2009 surveys is compiled and presented in Table 3.11. For the 2008 marine survey, starfish (*Asterias sp.*), pale urchin (*Strongylocentrotus pallidus*) and hydroids (numerous species) are the most widely distributed, while in the 2009 surveys perwinkle (*Littorina sp.*) are the most widely distributed.

Table 3.11 Macrofaunal Taxa as Found in the 2008 and 2009 Marine Surveys of the Proposed Cable Crossing Corridors (AMEC Earth and Environmental 2010)

Common Name	Taxon	Category
Periwinkle	*Littorina sp.*	Mollusc
Starfish	*Asterias sp.*	Echinoderm
Starfish	*Crossaster sp.*	Echinoderm
Basket star	*Gorgonocephalus sp.*	Echinoderm
Blue mussel	*Mytilus edulis*	Mollusc
Pale urchin	*Strongylocentrotus pallidus*	Echinoderm
Toad crab	*Hyas sp.*	Crustacean
Green urchin	*Strongylocentrotus droebachiensis*	Echinoderm
Rock crab	*Cancer sp.*	Crustacean
Snow crab	*Chionoecetes opilio*	Crustacean
Hermit crab	*Parugus sp.*	Crustacean
Whelk	Buccinum sp.	Mollusc
Barnacle	*Balanus sp.*	Crustacean
Limpet	Patellogastropoda	Mollusc
Sponge	Porifera	Porifera
Sea cucumber	*Cucumaria frondosa*	Echinoderm
Isopod	Isopoda	Crustacean
Grass shrimp	*Palaemonetes sp.*	Crustacean
Brittle star	Ophiuroidea	Echinoderm
Ribbon whelk	Gastropoda	Mollusc
Sea anemone	*Metridium sp.*	Cnidarian
Stalked sea squirt	*Boltenia sp.*	Tunicate

Table 3.11 (Cont'd) Macrofaunal Taxa as Found in the 2008 and 2009 Marine Surveys of the Proposed Cable Crossing Corridors (AMEC Earth and Environmental 2010)

Common Name	Taxon	Category
Bryozoans		Colonial
Deep sea scallop	*Placopecten magellanicus*	Bivalve
Soft coral	*Gersemia sp.*	Colonial
Icelandic scallop	*Chlamys islandica*	Shellfish
Sand dollar	*Echinarachnias parma*	Echinoderm
Fan worm	Polychaeta	Other
Stalked jellyfish	Stauromedusae	Cnidarian
Pycnogonid	Pycnogonida	Other

The AMEC Earth and Environmental (2010) survey also associated occurrence of benthic taxa with substrate (grain size), providing a good indication of habitat utilization and/or habitat preference.

3.2.3.3 Algae

AMEC Earth and Environmental (2010) conducted macrofloral surveys along the corridors of the proposed submarine cable crossings in 2008 and 2009 (nearshore only) and found 9 and 17 taxa, respectively. In the 2008 surveys, coralline algae (various species) was determined to occur the majority of the time within the survey area, while in 2009 crustose algae (*Lithothamnium sp*.) occurred over the majority of the area. Table 3.12 provides an overview of the algal species present in the 2008 and 2009 surveys.

Table 3.12 Macrofloral Taxa as Found in the 2008 and 2009 Marine Surveys of the Proposed Cable Crossing Corridors

Common Name	Taxon	Macrofloral Type
Coralline algae	Various species; *Corillina officinalis*	Red algae
Crustose algae	*Lithothamnium sp.*	Red algae
Sea colander	*Agurum cribosum*	Brown algae
Red fern	*Ptilota sp.*	Red algae
Sour weed	*Desmarestia sp.*	Brown algae
Kelp	*Laminaria sp.*	Brown algae
Knotted wrack	*Ascophyllum nodosum*	Brown algae
Edible kelp	*Alaria sp.*	Brown algae
Rockweed	*Fucus sp.*	Brown algae

Table 3.12 (Cont'd) Macrofloral Taxa as Found in the 2008 and 2009 Marine Surveys of the Proposed Cable Crossing Corridors (AMEC Earth and Environmental 2010)

Common Name	Taxon	Macrofloral Type
Brown filamentous algae	Phaeophyceae	Brown algae
Green filamentous algae	Arachaeplastida	Green algae
Dulse	*Palmaria palmata*	Red algae
Unidentified brown algae		Brown algae
Sea lettuce	*Ulva sp.*	Green algae
Cord weed	*Chorda sp.*	Green algae

The CCRI database was examined for relevant information on marine fish and fish habitat in the Strait of Belle Isle. Notable areas for the presence of aquatic plants were identified during the collection of CCRI data, including kelp, Irish moss, eel grass and rockweed. This information is only available for the Newfoundland side of the Strait, and is presented in Figure 3.16. Note that the lack of data for this area does not indicate the absence of particular species of aquatic plants.

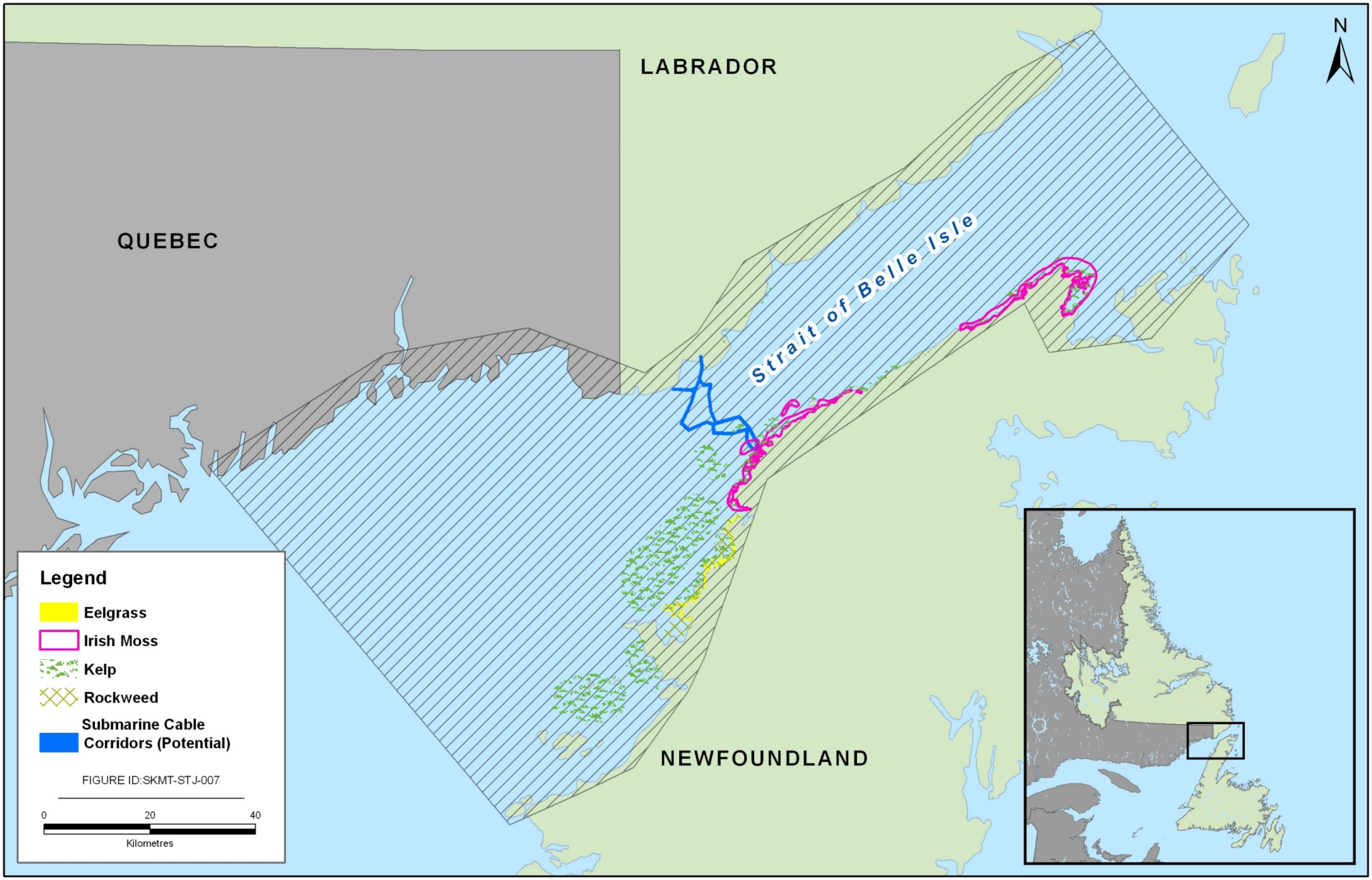


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FIGURE 3.16

Aquatic Plant Locations Obtained from the CCRI

3.3 Marine Fish Species

Marine finfish species in the Strait of Belle Isle fall into two broad categories, based on their location in the water column. Groundfish, as the name suggests, tend to live closer to the bottom and include commercial species such as Atlantic cod, American plaice (*Hippoglossoides platessoides)*, Greenland halibut (*Reinhardtius hippoglossoides)*, lumpfish (*Cyclopterus lumpus*) and witch flounder (*Glyptocephalus cynoglossus*). Geographic distribution is not uniform and is influenced by temperature, depth and physical and biological aspects of the habitat. Pelagic fish live and feed higher in the water column, closer to the water surface. Examples include Atlantic salmon (*Salmo salar*), Atlantic herring, Atlantic mackerel (*Scomber scombrus*), capelin (*Mallotus villosus*), and sharks (DFO 2005a). Shellfish are discussed and include invertebrates of commercial value or interest, including Iceland scallop (*Chlamys islandica),* shrimp, lobster, crab and sea cucumber. Information on species listed under the *Species at Risk Act (SARA*) or those that have been assessed by the COSEWIC are discussed separately.

The Northwest Atlantic Fisheries Organization (NAFO) is an inter-governmental fisheries science and management body that was established in 1979 for the management and conservation of the various commercial fish stocks within its jurisdiction, which includes all of the northwest Atlantic Ocean outside of the exclusive economic zones (EEZs) of member countries. The area of NAFO responsibility has been sub-divided into Divisions and Statistical Areas (Figure 3.17) to support management purposes. The following discussion of species distributions and fish stocks often makes reference to these NAFO Areas.

In the ensuing sections selected species are discussed in detail. Species selection was based on several factors:

- overall distribution within the Study Area;
- role in the ecosystem;
- recreational, commercial or economic importance;
- species for which a future fishery may be considered; and
- species of special conservation concern.

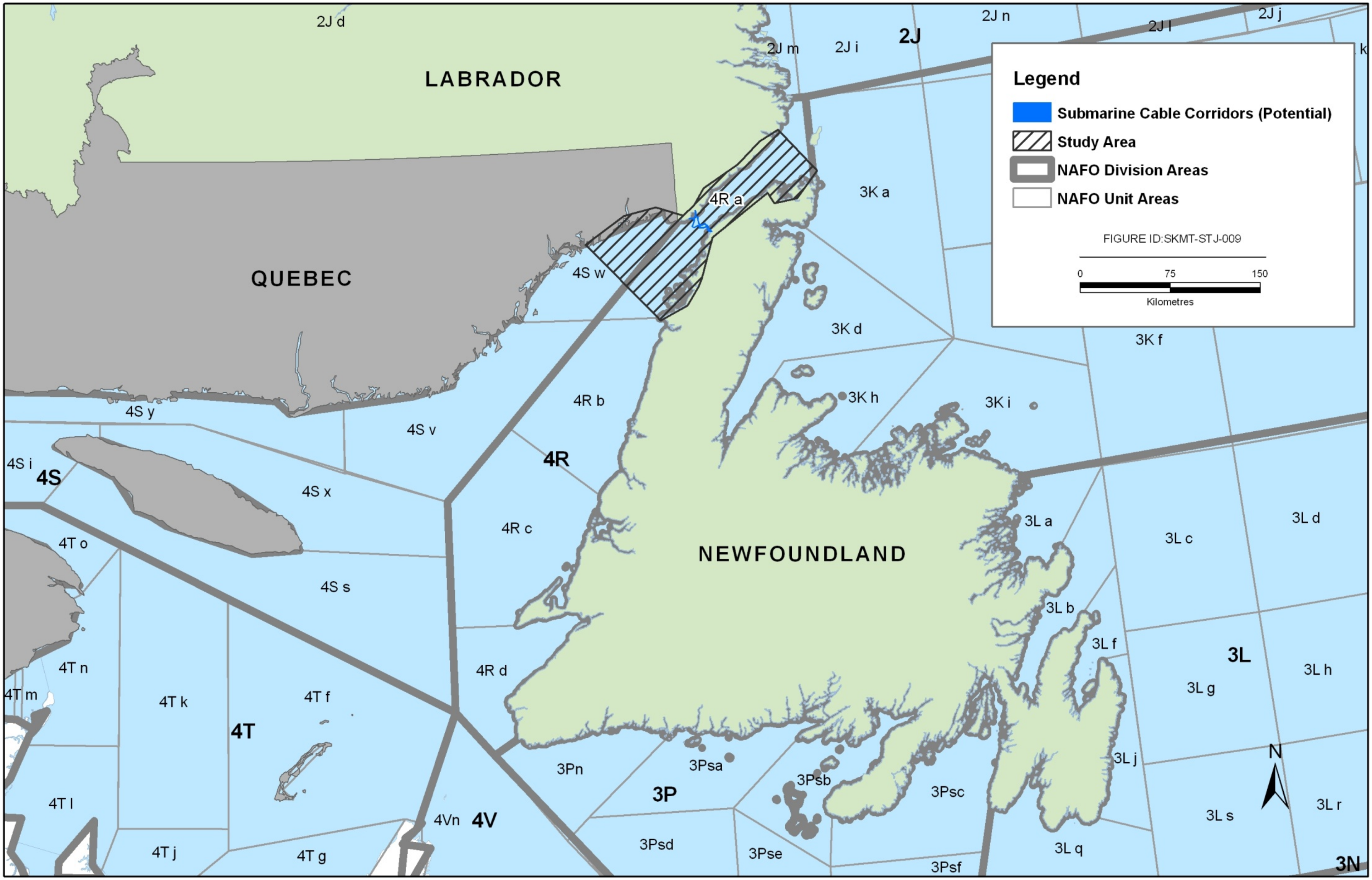

FIGURE 3.17

NAFO Division and Unit Areas

3.3.1 Demersal Fish (Groundfish)

Groundfish species captured in the Strait of Belle Isle Study Area between 1999 and 2009 by DFO scientific surveys and sentinel fisheries are provided in Table 3.13.

Table 3.13 Groundfish Captured in the Strait of Belle Isle Study Area by DFO Scientific Surveys and Sentinel Fisheries (1999 to 2009)

Group (Family)	Common Name	Scientific Name
Cod (Family Gadidae)	Atlantic cod	*Gadus morhua*
	Greenland cod	*Gadus ogac*
	Arctic cod	*Boreogadus saida*
	Atlantic tomcod	*Microgadus tomcod*
Skate (Family Rajidae)	Thorny skate	*Amblyraja radiate*
	Smooth skate	*Malacoraja senta*
Sculpin (Family Cottidae)	Atlantic hookear sculpin	*Artediellus atlanticus*
	Arctic hookear sculpin	*Artediellus uncinatus*
	Arctic staghorn sculpin	*Gymnocanthus tricuspis*
	Sea raven	*Hemitripterus americanus*
	Twohorn sculpin	*Icelus bicornis*
	Spatulate sculpin	*Icelus spatula*
	Longhorn sculpin	*Myoxycephalus*
	Fourhorn sculpin	*Myoxocephalus quadricornis*
	Shorthorn sculpin	*Myoxycephalus scorpius*
	Moustache sculpin	*Triglops murrayi*
Poacher fish (Family Agonidae)	Alligator fish	*Aspidophoroides monopterygius*
	Arctic alligator fish	*Ulcina olrikii*
	Atlantic poacher	*Leptagonus decagonus*
Lumpfish and Snailfish (Family Cyclopteridae)	Lumpfish	*Cyclopterus lumpus*
	Leatherfin lumpsucker	*Eumicrotremus derjugini*
	Atlantic spiny lumpsucker	*Eumicrotremus spinosus*
	Striped seasnail	*Liparis liparis*

Table 3.13 (Cont'd) Groundfish Captured in the Strait of Belle Isle Study Area by DFO Scientific Surveys and Sentinel Fisheries (1999-2009)

Family	Common Name	Scientific Name
	Variegated snailfish	*Liparis gibbus*
	Sea tadpole	*Careproctus reinhardti*
	Scotian snailfish	*Careproctus ranula*
Eelpouts (Family Zoarcidae)	Fish doctor	*Gymnelus viridis*
	Esmarks eelpout	*Lycodes esmarkii*
	Newfoundland eelpout	*Lycodes lavalaei*
	Pale eelpout	*Lycodes pallidus*
	Arctic eelpout	*Lycodes reticulates*
	Ocean pout	*Zoarces americanus*
	Atlantic soft pout	*Melanostigma atlanticum*
Shannys (Family Stichaeidae)	Fourline snake blenny	*Eumesogrammus praecisus*
	Arctic shanny	*Stichaeus punctatus*
	Radiated shanny	*Ulvaria subbifurcata*
	Snake blenny	*Lumpenus lampretaeformis*
	Daubed shanny	*Leptoclinus maculatus*
Righteye Flounder (Family Pleuronectidae)	Witch flounder	*Glyptocephalus cynoglossus*
	American plaice	*Hippoglossoides platessoides*
	Atlantic halibut	*Hippoglossus hippoglossus*
	Winter flounder	*Pseudopleuronectes americanus*
	Yellowtail flounder	*Limanda ferruginea*
	Greenland halibut	*Reinhardtius hippoglossoides*
	Sole	*Paralichthys sp.*
Wolffish (Family Anarhichadidae)	Atlantic wolffish	*Anarhichas lupus*
	Northern wolffish	*Anarhichas denticulatus*
	Spotted wolffish	*Anarhichas minor*

Small captures of redfish (*Sebastes sp*.), white hake (*Urophycis tenuis*) and Fourbeard rockling (*Enchelyopus cimbrius*) were also found during the scientific surveys and sentinel fisheries.

Due to their commercial importance, selected species including lumpfish, Greenland halibut, and witch flounder are discussed in more detail in the following section. Atlantic cod, Atlantic wolffish, Northern wolffish, spotted wolffish, and American plaice, are discussed under the later section on Species of Special Conservation Concern.

The CCRI database was also examined for relevant information on marine fish and fish habitat in the Strait of Belle Isle. People who participated in the CCRI data collection process provided commercial fishery and observational data for the following groundfish: halibut, cod, winter flounder, flounder, lumpfish and sandlance. All of these species are commercial species, with the exception of sandlance. Spawning areas were noted for cod, lumpfish, flounder, winter flounder, and sandlance, and this information is presented in Figure 3.18.

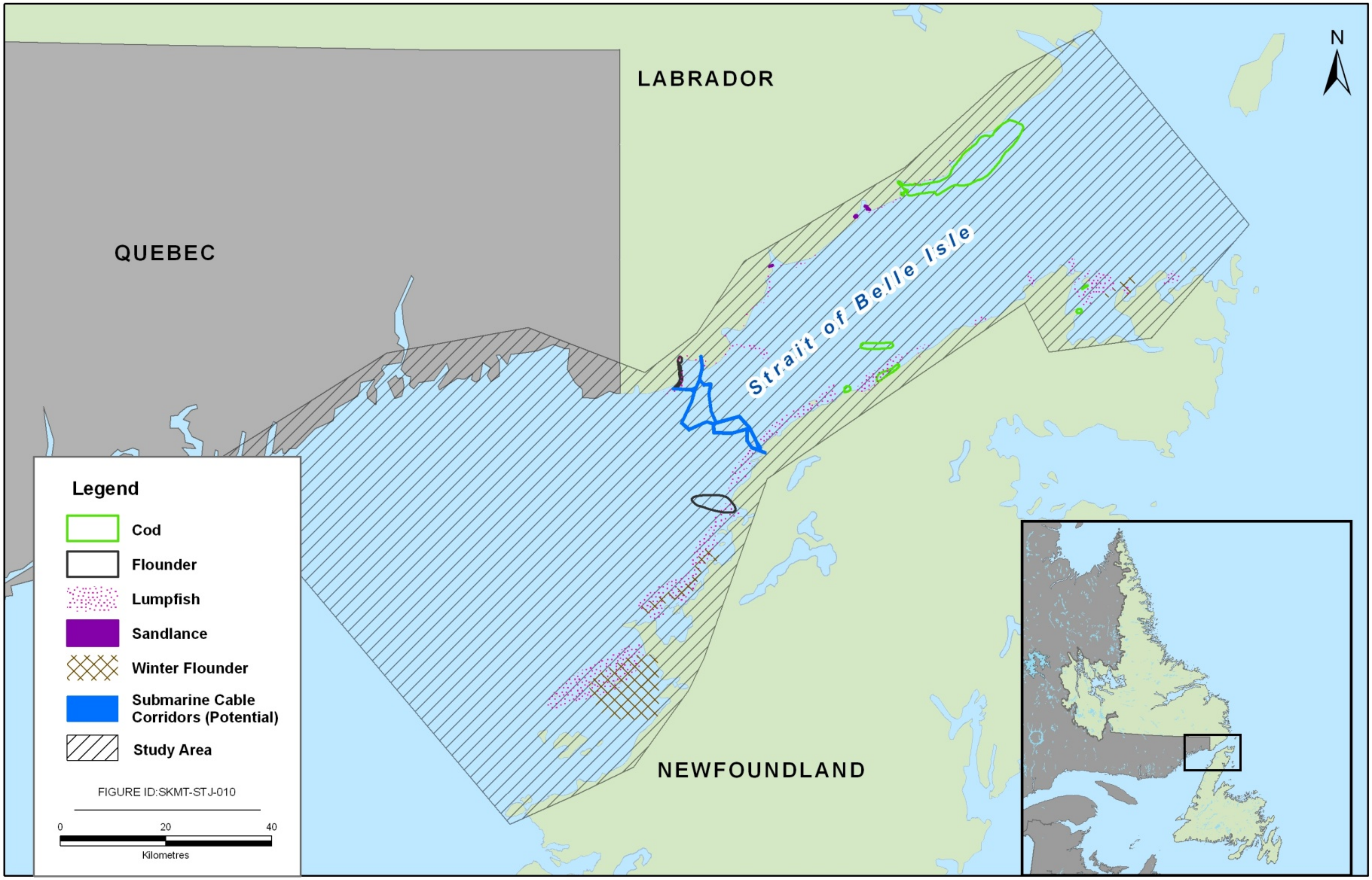

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FIGURE 3.18

Groundfish Spawning Locations Obtained from the CCRI

3.3.1.1 Lumpfish

Lumpfish are the focus of a targeted growing and important commercial fisheries within the Study Area. Lumpfish primarily inhabit rocky or stony bottoms and are considered groundfish. However several studies indicate that lumpfish remain in the offshore pelagic area most of their mature lives (DFO 2006a).

Found on both sides of the Atlantic and in the northwest Atlantic, lumpfish range from Greenland to Chesapeake Bay (DFO 2006a.) According to the DFO (2006a) little scientific information exists on the lumpfish in the Gulf of St. Lawrence. However, tagging studies were conducted in 2004 and 2005 in the northern Gulf of St. Lawrence (Fréchet et al. 2006) to determine migration patterns. Results from this study suggested that lumpfish migration is limited, with most individuals moving within an area of less than 40 km. It was noted, however, that there are still uncertainties about migration of lumpfish since the targeted fishery is seasonal and very short lived (Fréchet et al. 2006).

Mature lumpfish migrate from offshore to coastal areas prior to spawning, which occur in May and June each year. Males typically arrive earlier than females in an attempt to mark their territory. Spawning is assumed to be temperature dependent, beginning at approximately 4˚C. Females lay 2 to 3 egg masses at 8 to 14 day intervals and return offshore, leaving males to guard their egg masses (DFO 2006a). During early life stages, lumpfish are found attached to floating algae and rocks, lobster traps and other solid objects (DFO 2006a). The diet of lumpfish includes many invertebrates including euphausiid shrimps, pelagic amphipods, copepods, as well as other shellfish, jellyfish and anemones. Predators of lumpfish in the northern Gulf of St. Lawrence include grey seals and Greenland sharks (DFO 2006a).

There is a directed fishery for lumpfish in the northern Gulf of St. Lawrence, including the Strait of Belle Isle. This fishery targets females for their gonads (roe) during the spring (Fréchet et al. 2006). Capture locations of lumpfish in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.19. Lumpfish spawning locations have also been identified in the CCRI database (Figure 3.18), and were mostly identified as being on the Newfoundland side of the Strait, although some small spawning grounds were located on the Labrador side.

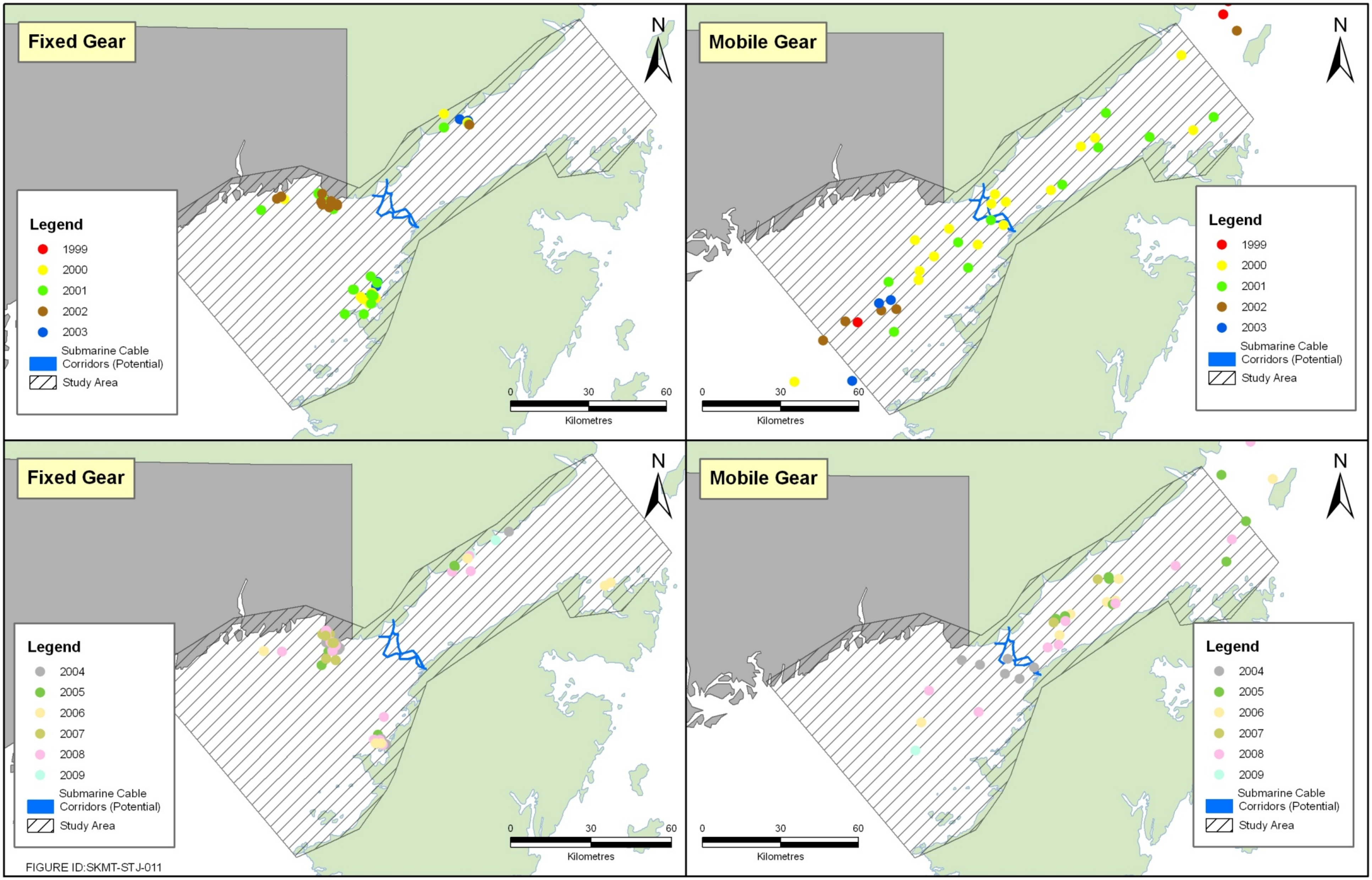

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FIGURE 3.19

Sentinel Fisheries Data and DFO Scientific Surveys - Lumpfish (1999 to 2009)

3.3.1.2 Greenland Halibut

Greenland halibut, a deep water flatfish also known as turbot, ranges from Greenland to the Scotian Shelf and have a preferred temperatures range from 0˚C to 4.5˚C (Sikumiut 2008). In the Gulf of St. Lawrence, Greenland halibut are commonly found in channels ranging 130 to 500 m in depth (DFO 2009d). Depth range for this species is 90 to 1,600 m, with larger fish commonly captured in deeper waters (Scott and Scott 1988). Greenland halibut are a selected species for detailed discussion due to a targeted important commercial fishery within the Study Area.

Males reach sexual maturity prior to females, and growth slows after this stage is reached resulting in smaller size at age than females. This accounts for the predominance of larger females in catches of the commercial fisheries (DFO 2009d). In the Gulf of St. Lawrence, spawning occurs primarily in winter, ranging from January to March. Hatching and incubation time depends on environmental conditions such as temperature. After the clear, fertilized eggs hatch, the juveniles rise in the water column to about 30 m below the surface until they are about 70 mm in length (Scott and Scott 1988). The young eventually descend to greater depths. However, unlike most flatfish, Greenland halibut often behave as pelagic fish, spending much of their time off the bottom (Scott and Scott 1988).

Greenland halibut have been fished since the mid-1970s in the Gulf of St. Lawrence (DFO 2009d). However, Greenland halibut have not been captured in the Strait of Belle Isle in the sentinel fisheries or DFO scientific surveys, with the exception of one capture in 1999 (Figure 3.20). Fixed gear sentinel fisheries have captured this species directly outside of the Strait of Belle Isle, on the Quebec lower north shore coast, and in St. John Bay. Capture locations of Greenland halibut in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.20.

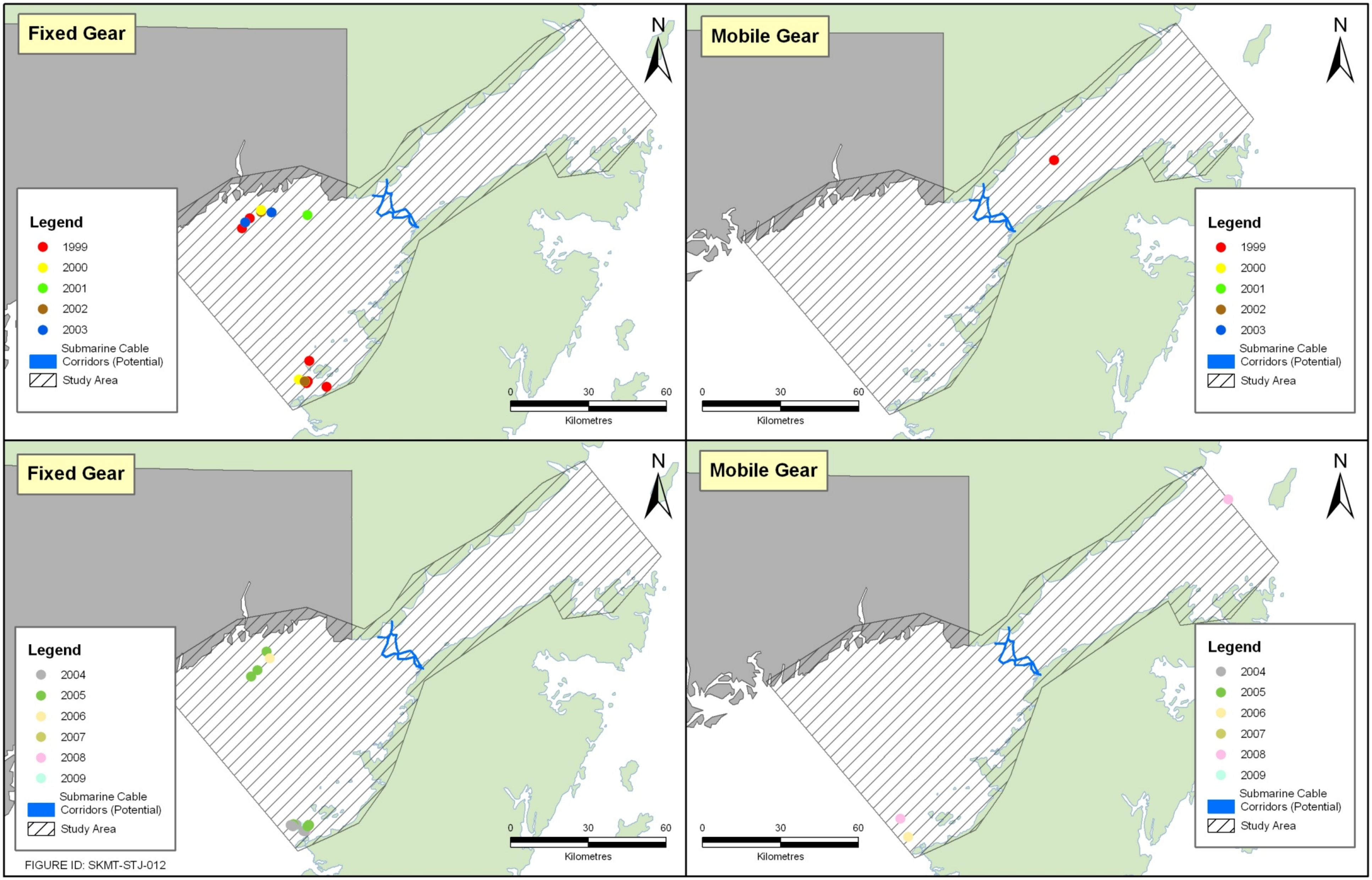

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FIGURE 3.20

Sentinel Fisheries Data and DFO Scientific Surveys - Greenland Halibut (1999 to 2009)

3.3.1.3 Witch Flounder

Witch flounder, also known as grey sole, are found mostly in deep waters of the North Atlantic, ranging from the lower Labrador coast to Cape Hatteras, North Carolina (DFO 2005c). Like other flatfish, they have flattened bodies and lay on their left side, with their stomach and other visceral contents on the right. Witch flounder are relatively slow growing and long lived in comparison to other flatfish and prefer gullies with clay, muddy sand or pure mud bottoms rather than the coarser substrate of the banks and inshore areas (DFO 2009g). They have been captured in bottom temperatures ranging from -1˚C to 11˚C, but are most abundant in bottom temperatures ranging from 2˚ to 6˚C. A small mouth restricts prey to small organisms such as marine worms, small crustaceans, shellfish and other shrimp-like creatures (DFO 2009g).

Spawning of witch flounder occurs from spring to late summer with exact timing depending on geographical area. Spawning in the Gulf of St. Lawrence occurs in deeper water in late spring/early summer (DFO 2005c). In January and February, spawners aggregate in the deeper channels within the Gulf of St. Lawrence. The females of this species are highly fertile, releasing approximately 500,000 eggs. Once fertilized, the eggs float and hatch several days later. The larvae have a long pelagic stage, lasting about one year before juveniles settle to the bottom in deep waters. In the northern parts of their distribution, including in the Gulf of St. Lawrence, witch flounder move to deeper waters during the winter and cease feeding.

There has been a commercial fishery in the northern Gulf of St. Lawrence (4RST), with an average catch of 3,500 t since 1975 (DFO 2009g). Capture locations of witch flounder in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.21.

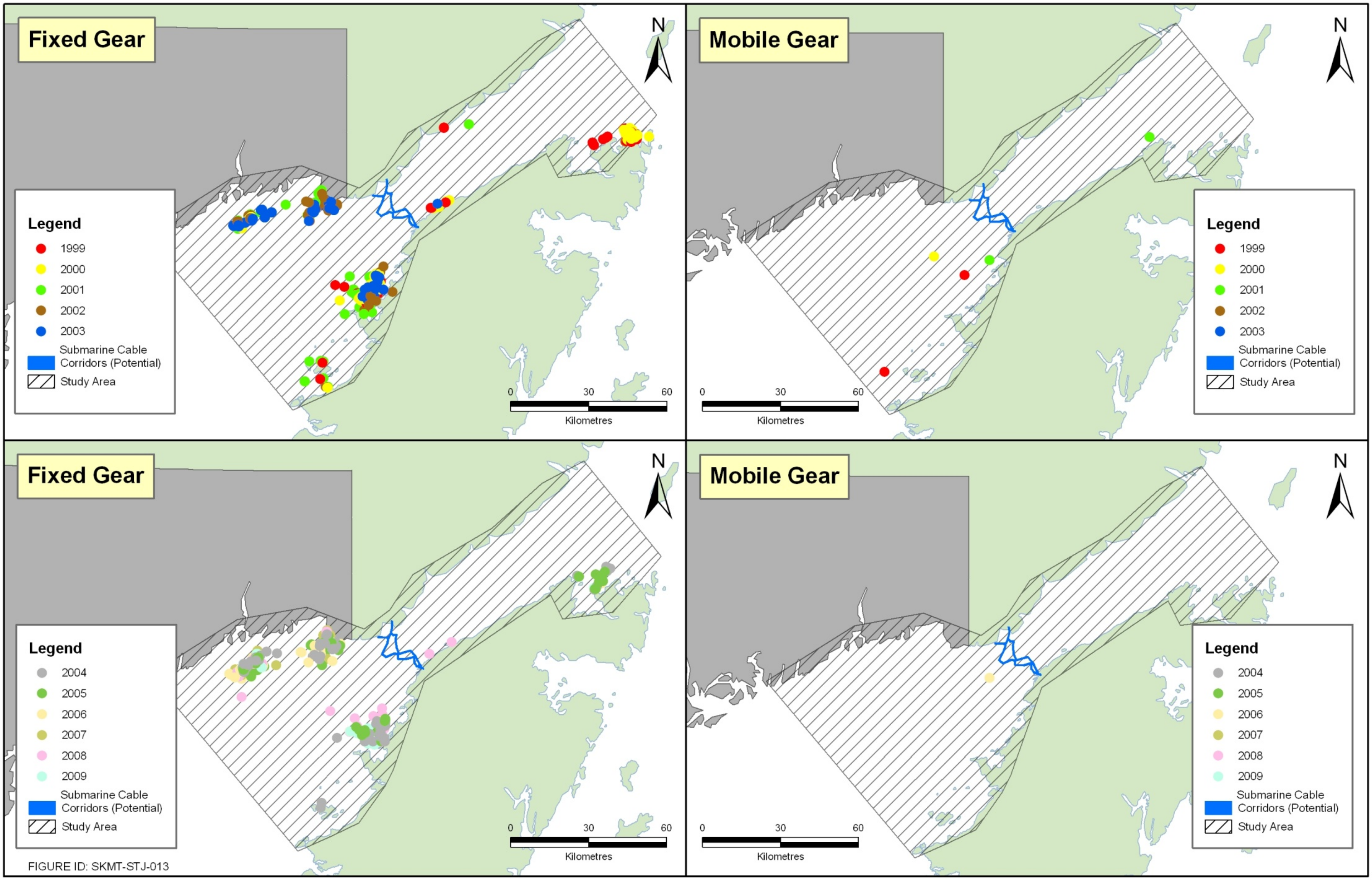

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FIGURE 3.21

Sentinel Fisheries Data and DFO Scientific Surveys - Witch Flounder (1999 to 2009)

3.3.2 Pelagic Fish

Pelagic fish captured in the Strait of Belle Isle Study Area between 1999 and 2009 by DFO scientific surveys and sentinel fisheries are outlined in Table 3.14.

Table 3.14 Pelagic Fish Captured in the Strait of Belle Isle Study Area by DFO Scientific Surveys and Sentinel Fisheries (1999 to 2009)

Group (Family)	Common Name	Scientific Name
Herring (Family Clupeidae)	Atlantic herring	*Clupea harengus*
Smelts (Family Osmiridae)	Capelin	*Mallotus villosus*
Mackerels (Family Scombridae)	Atlantic mackerel	*Scomber scombrus*
Sturgeons (Family Acipenseridae)	Atlantic Sturgeon	*Acipenser oxyrhinchus*
Sharks (Order Squaliformes)	Sharks	
Dogfish Sharks (Family Squalidae)	Spiny dogfish	*Squalus acanthias*
	Black dogfish	*Centroscyllium fabricii*

During the identification and characterization of EBSAs in the Gulf of St. Lawrence under the GOSLIM project, the Strait of Belle Isle was determined to be an IA for pelagic fish species due to high feeding concentrations of spiny dogfish, herring, capelin and sandlance. It was also determined to be an important spawning area for herring (Savenkoff et al. 2007).

Commercially important species (Atlantic herring, capelin, and Atlantic mackerel) are discussed in more detail in the next section. Salmonid fishes including Atlantic salmon, Arctic char (*Salvelinus alpinus*), and brook trout (*Salvelinus fontinalis*) are also discussed as these species are important migrants through the Study Area and also as residents within the estuaries of rivers in the Study Area.

Spiny dogfish, basking shark (*Cetorhinus maximus*), and American eel (*Anguilla rostrata*) are discussed under the section on Species of Special Conservation Concern.

The CCRI database was also examined for relevant information on marine fish and fish habitat in the Strait of Belle Isle. Many pelagic fish species were caught recreationally (brook trout, Atlantic salmon, capelin, Atlantic herring, Atlantic mackerel), commercially (Atlantic salmon, capelin, Atlantic herring, Atlantic mackerel, American eel, shark) or observed (Atlantic salmon, capelin, Atlantic herring, Atlantic mackerel, American eel, shark, Arctic char, stickleback, sunfish, swordfish and tuna) in the Study Area. Of those species, spawning areas were noted for capelin, Atlantic herring, Atlantic mackerel and Atlantic salmon along the coastal zone and this information is presented in Figure 3.22.

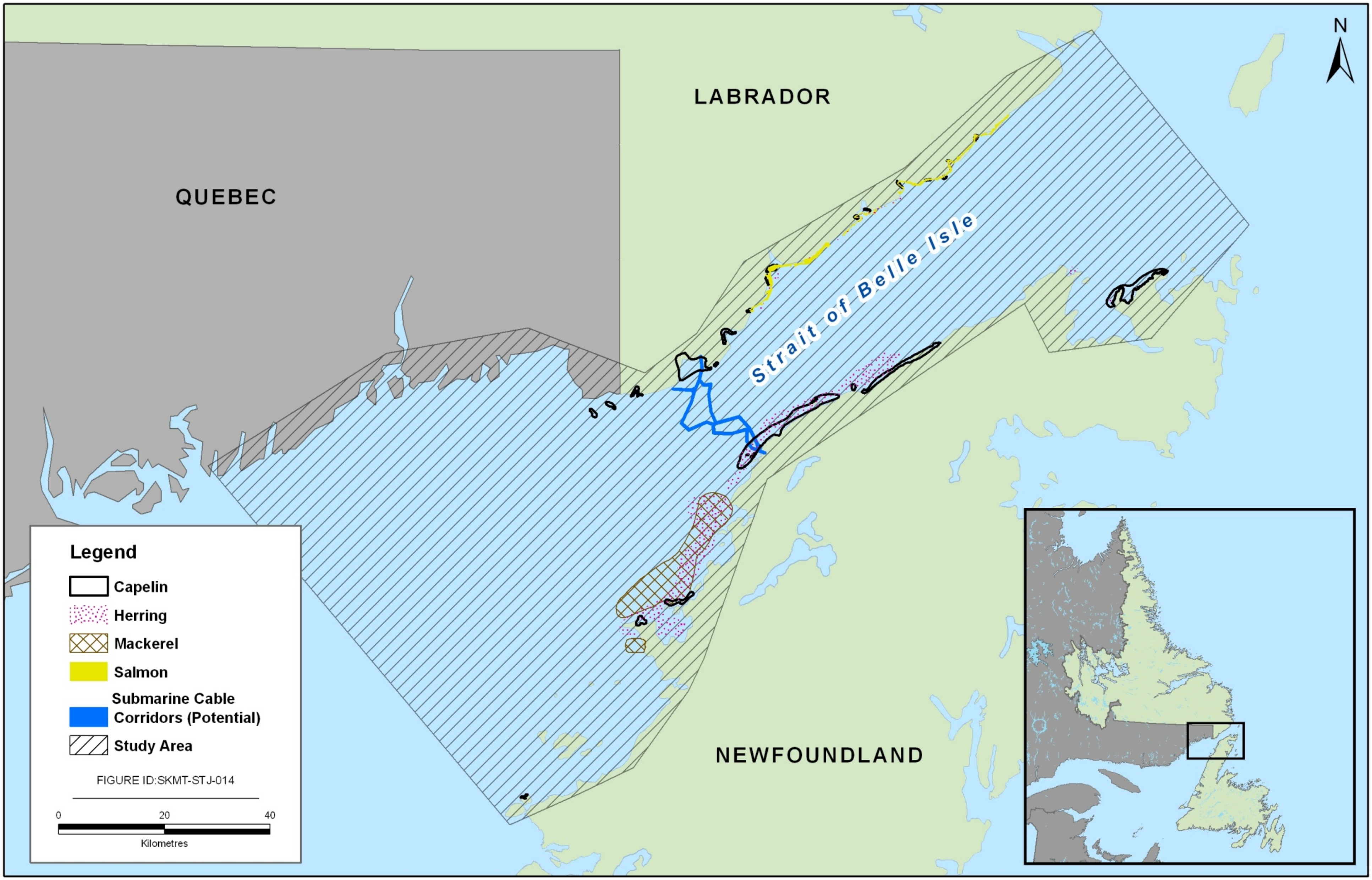

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FIGURE 3.22

Pelagics Spawning Locations Obtained from the CCRI

3.3.2.1 Capelin

Capelin are a small pelagic fish species found in the northwest Atlantic including off the coast of Newfoundland and Labrador, Grand Banks, Gulf of St. Lawrence within the Scotian Shelf and the Bay of Fundy (DFO 2008b). This species has been selected for detailed discussion here due to its importance within the food chain and its commercial value.

Most spawning occurs in coastal areas, although a small component of the population remains in offshore areas and spawns in areas such as the Southeast Shoal. Coastal spawning occurs in both inter-tidal waters and on beaches of sand or fine gravel substrate. This occurs in water temperatures between 6˚C and 10˚C, predominantly at night (DFO 2008b). Eggs attach to the substrate, and incubation timing varies by temperature, and can last approximately 15 days at 10˚C (DFO 2008b). Upon hatching, larvae are near the surface, and remain planktonic feeders until winter. The majority of growth occurs during the first year, and the first spawn can occur by age two. Nearly all males die after reproduction (DFO 2008b).

Capelin are a significant link in food chains as they provide the transfer of energy between primary and secondary producers to higher trophic levels (DFO 2008b). Within the northern Gulf of St. Lawrence, including the Strait of Belle Isle, capelin are a main forage species prey (DFO 2007a, DFO 2008b). It has been demonstrated that the main cause of mortality for capelin in this area has been predation by various species. Savenkoff (pers. comm. as cited in DFO 2008b) indicated that during the mid-1980s, capelin were preyed on by Atlantic cod and redfish. After the decline of these groundfish in the early 1990s, capelin were important prey items for cetaceans, harp seals, and Greenland halibut in the mid-1990s and early 2000s. By the mid-2000s, capelin were also the main prey items for redfish and other capelin. In DFO (2007a) it was suggested that aggregations of capelin in the Strait of Belle Isle may contribute to abundance of marine mammals in the area, further underlining the importance of capelin in the Study Area.

There has been an upward trend for landings of capelin in the Gulf of St. Lawrence (DFO 2008b). Concentrated catches in the Strait of Belle Isle have been reported by the research vessel CCGS Teleost in 2005, 2006 and 2007, and by the CCGS Alfred Needler (Gregoire et al. 2008). There is a commercial purse seine fishery in NAFO division 4R and 4S in June and July, and in recent years the most significant landings of capelin have been within 4Ra (Strait of Belle Isle) (Gregoire et al. 2008). Capture locations of capelin in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.23. Spawning locations for capelin were identified in the CCRI database and are presented in Figure 3.22. These are likely locations where capelin have been observed “rolling” on the beaches in the area.

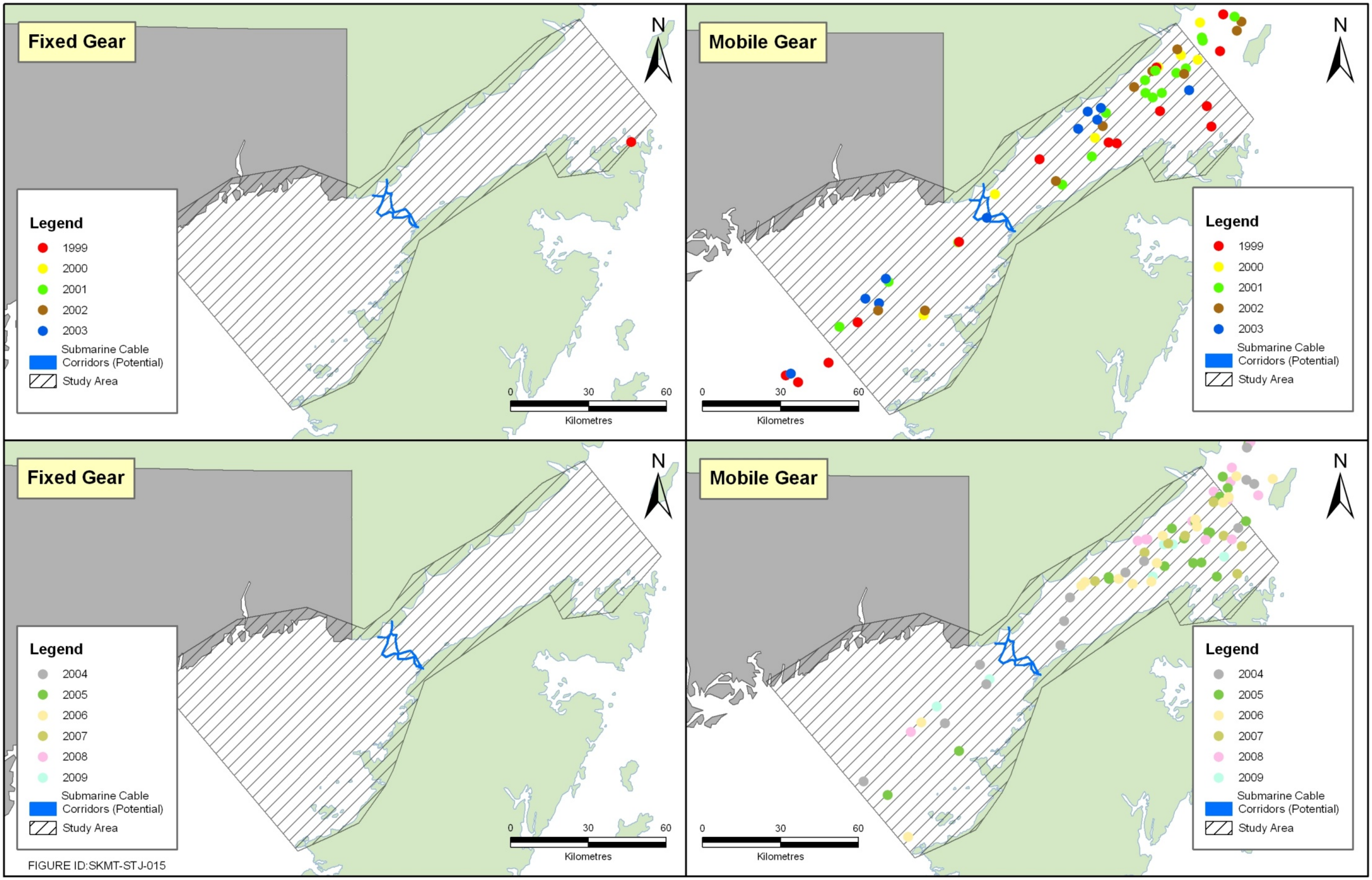

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FIGURE 3.23

Sentinel Fisheries Data and DFO Scientific Surveys - Capelin (1999 to 2009)

3.3.2.2 Atlantic Herring

Atlantic herring are schooling pelagic fish found in the northwest Atlantic from Labrador to Cape Hatteras (McQuinn et al. 1999). In the northwest Atlantic, herring form schools for feeding purposes, spawn near the coast, and overwinter in deeper waters. Herring return to the same feeding and spawning areas every year (DFO 2006b). After spawning, eggs attach to the substrate, and form a thick carpet of eggs a few centimeters thick on the sea floor (DFO 2006b). Like capelin, Atlantic herring are an important food chain link, providing food for various trophic levels.

On the west coast of Newfoundland (NAFO Division 4R), there are two spawning stocks present: one which spawns in the spring, and one that spawns in the fall (Savenkoff et al. 2006). The spring spawning stock spawns near the west coast of Newfoundland, and in and around St. Georges Bay (McQuinn et al. 1999) during the months of April and May (Savenkoff et al. 2006). The fall spawning stock spawns north of Point Riche from mid-July to mid-September (McQuinn et al. 1999). The Strait of Belle Isle has been identified as the main area for spawning of the fall herring component of the northern Gulf (DFO 2009e). Outside of the spawning season, the two stocks can be found to coincide with one another in St. Georges Bay (spring), Strait of Belle Isle (summer) and in Bonne Bay during the fall (McQuinn et al. 1999).

Like capelin, the major source of mortality for the northern Gulf of St. Lawrence herring is predation. Redfish (*Sebastes spp*.) and large cod were the main predators in the mid-1980s. Cetaceans and harp seals replaced these species as the main predators in the mid-1990s and 2000s, and harp seals in 2000s (DFO 2006b). Prey items included zooplankton (less than 5 mm) in the mid-1980s, consisting mostly of copepods, and in the 1990s and 2000s small and large zooplankton (euphausids and amphipods) were the two main prey items in the northern Gulf of St. Lawrence (DFO 2006b).

Capture locations of Atlantic herring in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.24. Spawning locations for Atlantic herring were identified within the CCRI database, and are presented in Figure 3.22. Spawning locations were identified primarily on the Newfoundland side of the Strait.

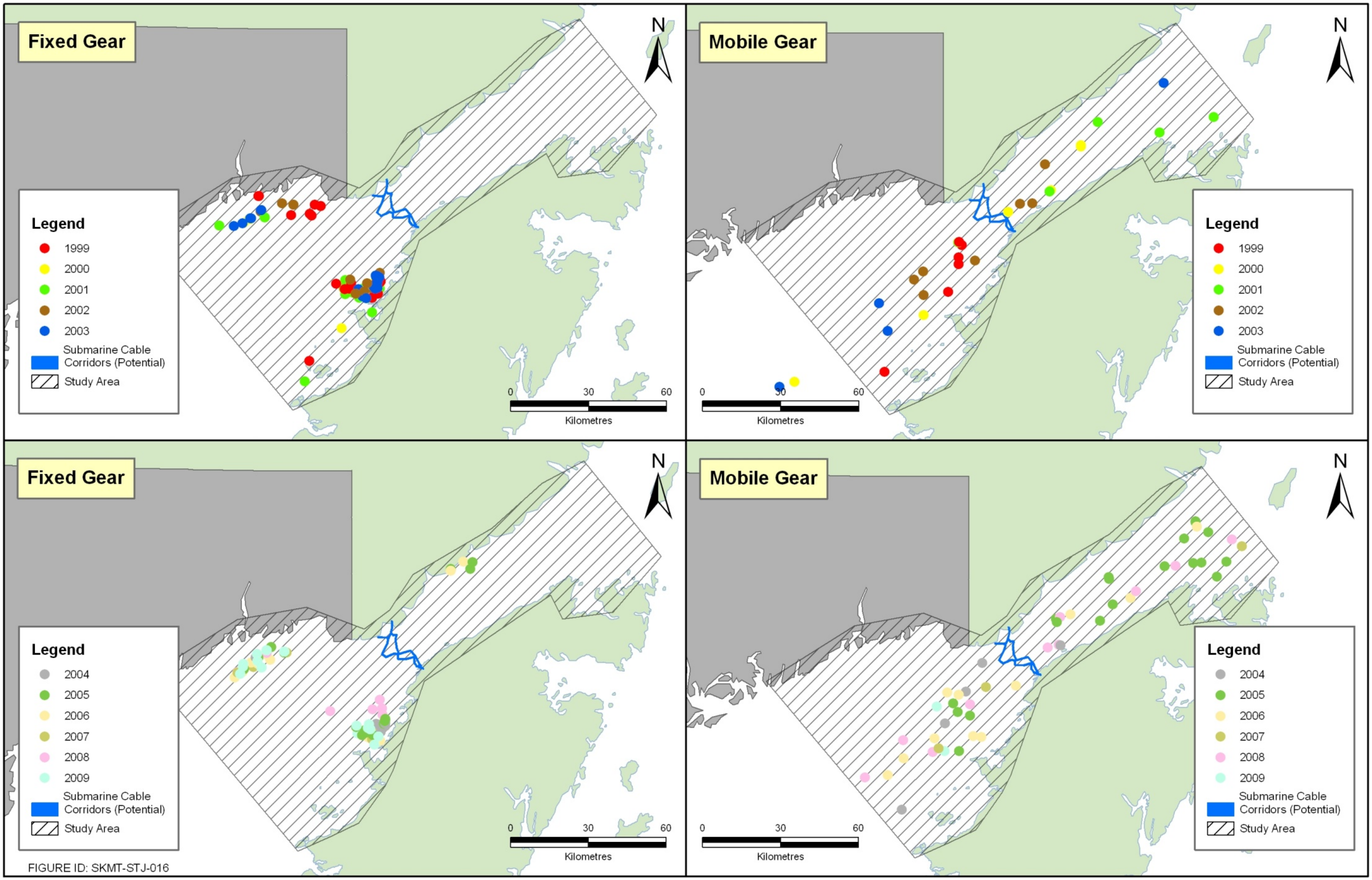

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FIGURE 3.24

Sentinel Fisheries Data and DFO Scientific Surveys - Atlantic Herring (1999 to 2009)

3.3.2.3 Atlantic Mackerel

Like capelin and Atlantic herring, Atlantic mackerel are an important food chain link, providing food for various trophic levels, as well as being the target of a commercial fishery.

Atlantic mackerel are a pelagic fish species that occurs on both sides of the North Atlantic and in the northwest Atlantic is distributed from North Carolina to Newfoundland (DFO 2008a). Mackerel are often found inshore in spring and summer, but occur in deeper waters at the edge of the continental shelf in late fall and winter.

In the Gulf of St. Lawrence, spawning occurs in the southern region. Data collected during the mid-1980s, 1990s and early 2000s examined ecosystem function of the Gulf of St. Lawrence with a mackerel perspective (Gregoire et al. 2006). Gregoire et al. (2006) demonstrated that small (less than 5 mm) and large (larger than 5 mm) zooplankton were the major prey item of mackerel in the mid-1980s. Data collected in the mid-1990s and early 2000s showed that while zooplankton were still the main dietary component of mackerel in the northern Gulf of St. Lawrence, shrimp (*Pandalus borealis*) and capelin made up larger components of the diet. During the mid-1980s, mackerel were preyed upon by cetaceans and large demersal fish (primarily cod), but by the mid 1990s and early 2000s, the main predators of mackerel were predominantly cetaceans (Gregoire et al. 2006).

There is a directed fishery for mackerel in both Newfoundland and Quebec regions of the Gulf of St. Lawrence. Capture locations of Atlantic mackerel in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.25. Spawning locations for Atlantic mackerel were identified within the CCRI database, and presented in Figure 3.22. Spawning locations were identified primarily on the southwest side of the Strait (Newfoundland coast).

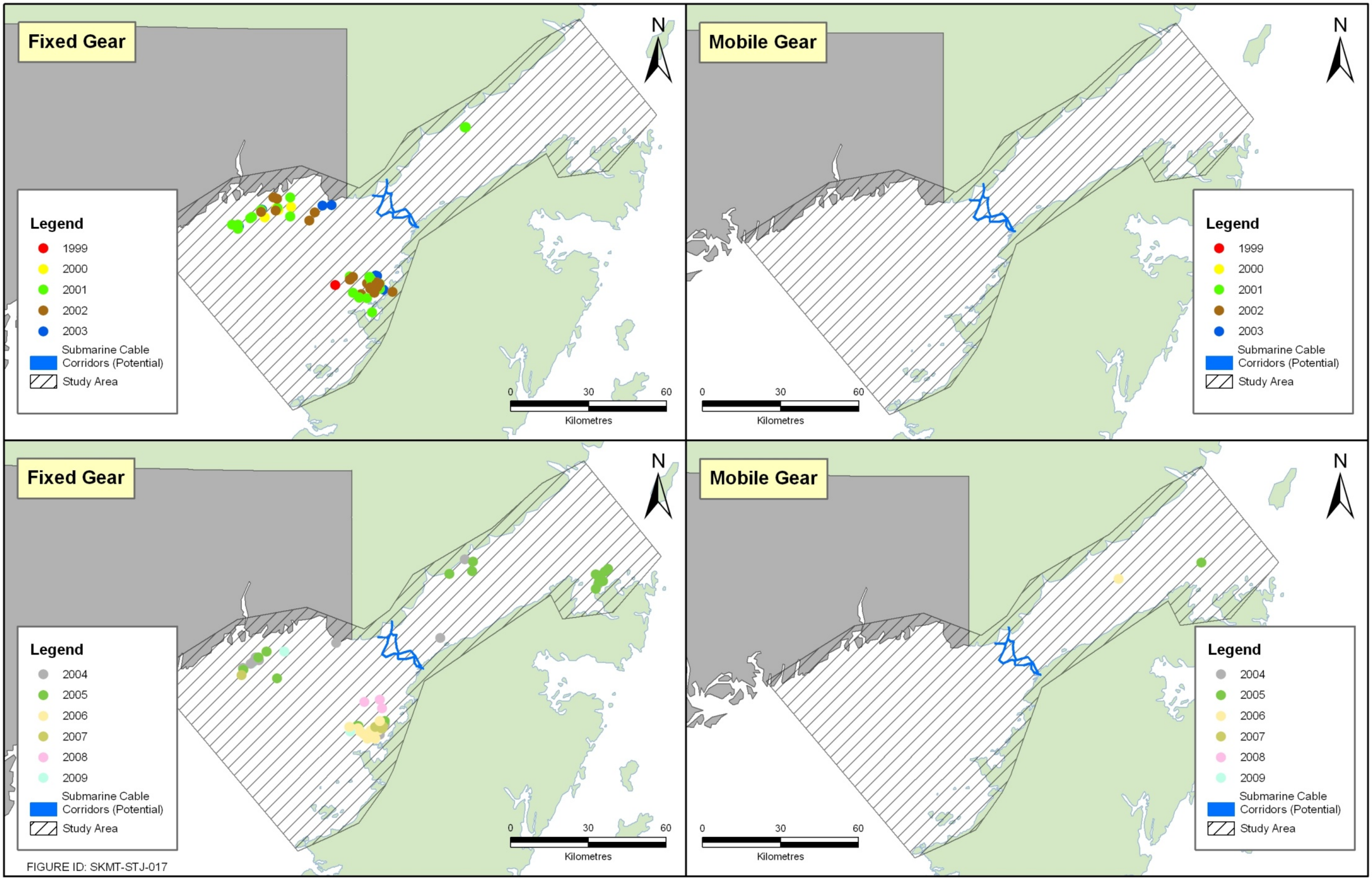

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FIGURE 3.25

Sentinel Fisheries Data and DFO Scientific Surveys - Atlantic Mackerel (1999 to 2009)

3.3.2.4 Salmonid Fishes

Anadromous salmonid fishes spend a portion of their life cycle in the marine environment and return to freshwater to spawn. There are three species of salmonids known to descend from the freshwater environments to the Strait of Belle Isle: brook trout, Arctic char and Atlantic salmon.

Anadromous brook trout (*Salvelinus fontinalis)* typically descend from the river in May and June and can spend up to two months at sea, feeding heavily (Scott and Scott 1988). While at sea they appear to stay in shallow, inshore waters, moving up to eight km from the estuary. Brook trout return to freshwater in July and August. Although brook trout appear in virtually all rivers in the Study Area, not all brook trout in a population will migrate to the sea. The degree of anadromy in brook trout populations appears to be entirely by choice and migrations to sea are highly variable between locations and populations (Curry et al. 2006). There are many reports of trout adopting a schooling behavior while at sea and undertaking migrations along the coasts (NSDFA 2010). In some rivers there is not one defined migration period and trout can move several times between freshwater and the ocean during the spring/summer/fall period and some sea trout may over winter at sea (Smith and Saunders 1958). Owing to the abundant food resources in the ocean, sea trout tend to grow faster and fish are larger than freshwater populations.

Anadromous Arctic char (*Salvelinus alpinus)* descend to the sea in the springtime after several years of early life in the freshwater environment (Scott and Scott 1988). Typically, anadromous char stay within several kilometers of the natal river estuary and return to freshwater in early fall. Within the Study Area anadromous Arctic char have only been reported occurring in Parkers River (Figure 3.26) at the northern tip of the Northern Peninsula (Dempson 1982). In 2009 a *Five Year Strategic Recovery Plan for the Sea Run Arctic Char in Parkers River (Western Brook)* was produced by the Save Our Char Committee working in conjunction with a variety of agencies, including the DFO and Nordic Economic Development Corporation (NORDIC Economic Development Corporation 2010).

Similar to anadromous Arctic char, Atlantic salmon (*Salmo salar)* descend to the sea in the spring time after several years of early life in the freshwater environment. Known as smolts, these juvenile salmon spend up to 108 hours in the estuary, generally lasting only one or two tidal cycles in the area (Tyler et al. 1978). Unlike anadromous char or brook trout, salmon will spend one or more winters at sea before returning to their natal river. Atlantic salmon that mature after one year in the ocean are known as grilse as compared to two sea winter salmon that mature after two years in the ocean and often travel to the waters off Greenland during the maturation period.

There are 14 rivers that flow into the Study Area that are listed as 'Salmon Rivers' in Schedule I of the *Newfoundland and Labrador Fishery Regulations* (Figure 3.26). Scheduled salmon rivers are designated by DFO. Table 3.15 presents the mean salmon angling data (catch and effort), 2004 to 2008, for each of these rivers (DFO 2010, Unpublished Data).

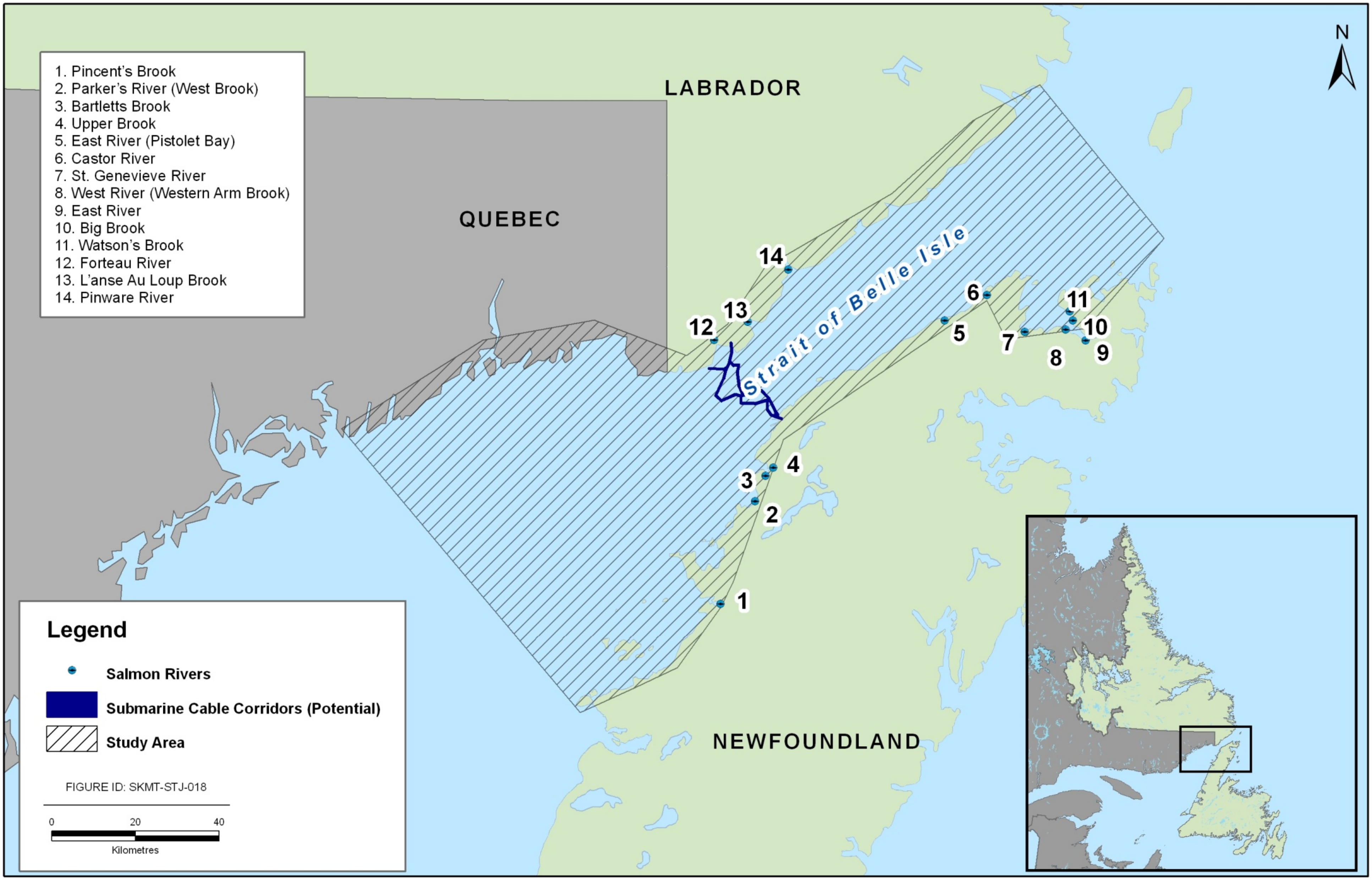

FIGURE 3.26

Location of Scheduled Salmon Rivers in the Study Area

Table 3.15 Mean Angling Catch and Effort Statistics for 14 Salmon Rivers in the Study Area, 2004 to 2008 (DFO 2010, Unpublished Data)

River	Effort (Rod Days)	Small* (Fork Length < 63 cm)	Large* (Fork Length ≥ 63cm)	Total* (<63 cm + >63 cm) Small + Large)	Catch Per Unit Effort (CPUE)
Pincent's Brook	34	10	0	10	0.29
Parker's River (West Brook)	33	15	0	15	0.47
Bartletts Brook	38	14	0	14	0.37
Upper Brook	35	8	0	8	0.23
East River (Pistolet Bay)	25	3	0	3	0.10
Castor River	1929	1031	43	1073	0.56
St. Genevieve River	1267	525	39	563	0.44
West River (Western Arm Brook)	**	**	**	**	**
East River	19	8	0	8	0.43
Big Brook	43	23	1	24	0.56
Watson's Brook	56	12	0	12	0.22
Forteau River	851	399	60	459	0.54
L'anse Au Loup Brook	14	3	0	3	0.19
Pinware River	2010	1406	357	1763	0.88

* Includes Retained and Released Salmon
** Closed to angling

These data show that salmon populations still reside in all these rivers and, in certain cases, such as Castor River, St. Genevieve River and Pinware River, the average angling catch is over 500 salmon annually.

Atlantic salmon smolt and adults have been enumerated at a counting fence on West River (Western Arm Brook) since 1974 (DFO 2010, Unpublished Data) and smolt counts have ranged from 6,232 in 1976 to 23,845 in 1997 and adult salmon counts have ranged from 120 in 1984 to 1,935 in 2008 (Table 3.16). Typically, the smolt migration in Western Arm Brook begins in late May, peaks in mid June and is over by late July. Adult migrations to Western Arm Brook usually begin in mid to late June, peak in mid July and are over by early September. The exact timing of salmonid migrations is dependent on water temperatures and flows during any given year.

Table 3.16 Enumerated Atlantic Salmon Passing Through Counting Fence, Western Arm Brook, 1974 to 2009 (DFO 2010, Unpublished Data)

Year	Adult Counts		Juvenile Counts
	Small Salmon	Large Salmon	Smolt
1974	382	4	11854
1975	631	1	9600
1976	520	0	6232
1977	362	3	9899
1978	293	1	13071
1979	1578	0	8349
1980	435	3	15665
1981	451	1	13981
1982	394	3	12477
1983	1141	4	10552
1984	120	0	20653
1985	416	1	13417
1986	525	0	17719
1987	378	1	17029
1988	251	1	15321
1989	455	0	11407
1990	444	0	10563
1991	233	1	13453
1992	480	8	15405
1993	947	8	13435
1994	954	31	9283
1995	823	33	15144
1996	1230	50	14502
1997	509	55	23845
1998	1718	128	17139

Table 3.16 (Cont'd) Atlantic Salmon Counts, Western Arm Brook, 1974 to 2009

	Adult Counts		
	Small Salmon	**Large Salmon**	**Smolt**
1999	1046	22	13500
2000	1486	120	12706
2001	559	28	16013
2002	1465	48	14999
2003	1406	23	12086
2004	1151	74	17323
2005	1019	43	8607
2006	1300	44	20826
2007	793	17	16621
2008	1920	15	17444
2009	1063	21	18492

The information available from angling statistics and counting fence data does indicate that portions of the Study Area are important marine habitats for stages in the life history of salmon produced in the 14 scheduled salmon rivers in the area. Spawning locations for Atlantic salmon were identified within the CCRI database, and are presented in Figure 3.22. Spawning locations were identified primarily on the Labrador side of the Strait.

Recent work by Whoriskey et al. (2008) has provided additional information on the importance of the Strait of Belle Isle as a migration route to Greenland for Atlantic salmon. The use of sonic tags in the study in 2006 and 2007 has demonstrated that significant numbers of smolts from the Miramichi, Restigouche and Cascapedia rivers in New Brunswick passed through the Strait of Belle Isle. In both years, most smolts passed through the Strait during a 10 to 11 day window starting on 10 July. Sonic tags were also applied to smolts from Western Arm Brook. These fish, which normally mature as grilse and would not migrate to Greenland, appeared to remain longer in the Study Area and were also concentrated closer to shore on both sides of the Strait (Whoriskey, 2010, pers. comm.). Results from the work of Whoriskey et al. (2008) indicate that the Strait of Belle Isle is an important migration route for post smolts migrating from rivers in the Gulf of St. Lawrence to Greenland. In addition to being an important area for juveniles, Atlantic salmon which have already spawned (kelts) from the Miramichi River, and from the Saint John Quebec North Shore River have also been detected moving through the Study Area (Whoriskey 2010, pers. comm.). Primary migration routes for Atlantic salmon in the North Atlantic are presented in Figure 3.27 (adapted from Reddin 2006).

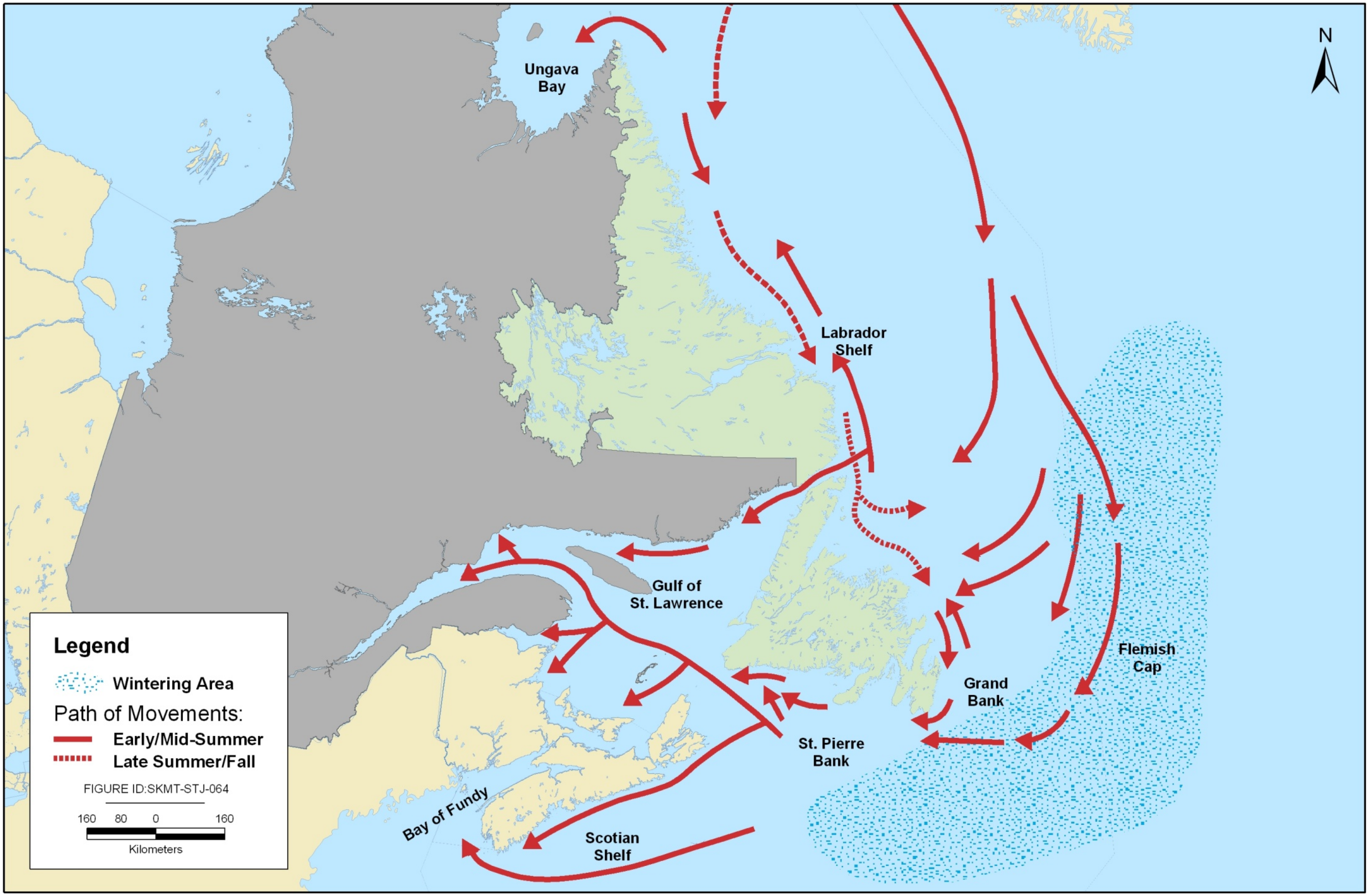

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FIGURE 3.27

Atlantic Salmon Migration Routes (from Reddin 2006)

3.3.3 Shellfish

Shellfish captured in the Strait of Belle Isle Study Area between 1999 and 2009 by DFO scientific surveys and sentinel fisheries are outlined in Table 3.17.

Table 3.17 Shellfish Captured in the Strait of Belle Isle Study Area by DFO Scientific Surveys and Sentinel Fisheries (1999 to 2009)

Group (Family)	Common Name	Scientific Name
Oregoniidae	Snow crab	*Chionoecetes opilio*
	Toad crab	*Hyas araneus and H. coarctatus*
Paguridae	Hermit crab	*Pagurus arcuatus*
Cancridae	Rock crab	*Cancer irroratus*
Panopeidae	Say mud crab	*Dyspanopeus sayi*
Hippolytidae	Arctic Eualid	*Eualus fabricii*
	Circumpolar Eualid	*E. gaimardii*
		E. gaimardii gaimardii
		E. gaimardii belcherii
	Greenland shrimp	*E. macilentus*
	Spiny lebbeid	*Lebbeus groenlandicus*
	Shrimp	*L. microceros*
	Polar lebbeid	*L. polaris*
	Friendly blade shrimp	*Spirontocaris lilljeborgii*
	Punctate blade shrimp	*S. phippsii*
	Parrott shrimp	*S. spinus*
Pandalidae	Northern shrimp	*Pandalus borealis*
	Pink shrimp	*P. montaguii*
Crangonidae	Arctic argid	*Argis dentata*
	Norwegian shrimp	*Pontophilus norvegicus*
	Sars shrimp	*Sabinea sarsii*
	Sevenline shrimp	*S. septemcarinata*
	Sculptured shrimp	*Sclerocrangon boreas*

Other shellfish found in the Study Area include Iceland scallop, American lobster, and sea cucumber (*Cucumaria frondosa*). There has also been interest in an Arctic surf clam fishery in the area of the Strait of Belle Isle in the past and fisheries development studies have been undertaken to determine viability (Taylor, 2010, pers. comm.).

The CCRI database was also examined for relevant information on marine fish and fish habitat in the Strait of Belle Isle. Commercial fishery locations were established for surf clam, sea urchin, scallop, whelk, toad crab, squid, and lobster. Recreational fishing locations were determined for surf clam, and mussel. Observations of surf clam, sea urchin, scallop, whelk, and mussel were also pointed out. Shellfish distribution information from the CCRI data are presented in Figure 3.28.

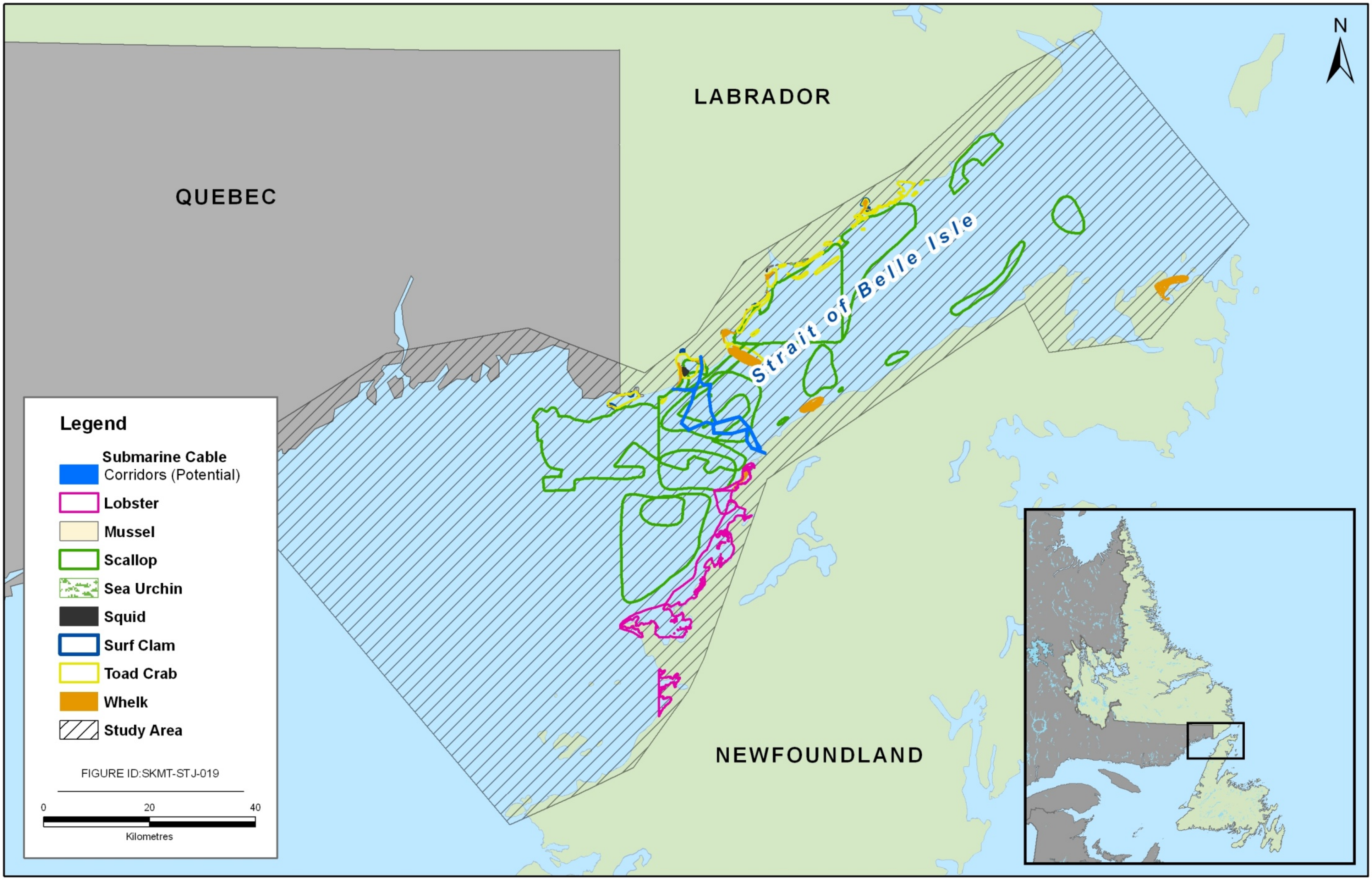

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FIGURE 3.28

Shellfish Locations Obtained from the CCRI

3.3.3.1 Iceland Scallop

Iceland scallop are distributed in waters of the sub-Arctic (Naidu et al. 2001), and are typically found in water depths of 55 to 180 m off Newfoundland and Labrador (DFO 2009a). The currents of the Belle Isle Strait make the area favourable for these filter feeders. Iceland scallop are generally associated with hard bottom substrates including sand, gravel, shell fragments and stones (Naidu et al. 2001). In the Strait of Belle Isle area, there are three distinct scallop beds (Figure 3.29) that are considered to be one stock for DFO assessment purposes (DFO 2009a).

The Iceland scallop has been historically an important fishery in the Strait of Belle Isle since 1969, with peak catches in 1972, 1985 and 1994. The fishery has been regulated by a Total Allowable Catch (TAC) since 1996 (Naidu et al. 2001). The TAC has been 1,000 t since 2000, however catches only averaged 400 t during this period (DFO 2009a). As a result of catch declines in the late 1990s, a scallop refugium was established in 2000, to increase recruitment and promote survival of newly settled scallops in the absence of fishing. This refugium was an 8 km wide corridor across the Strait, encompassing a total area of 365.3 km^2 (Figure 3.29; DFO 2009a).

The most recent research survey on Iceland scallop in the Strait of Belle Isle took place in 2007. Results of this survey demonstrated no clear trend in biomass since 1995, with a Minimum Dredgable Biomass (MDG) of 5700 t (DFO 2009a). It was also determined that there was no difference in density between inside and outside the established refugium, with natural mortality being higher inside of the refugium. A higher density of predatory starfish (*Leptasterias polaris*) was reported inside the refugium. Prior to the establishment of the refugium, shell height was larger in that area and this has remained unchanged between the 2000 and 2007 surveys, suggesting that the establishment of the refugium has had no effect on shell height (DFO 2009a). Given the lack of positive effects of the refugium, the area was re-opened to fishing in 2009 (Stansbury, 2010, pers. comm). Locations of scallop beds and the refugium with respect to the Study Area are presented in Figure 3.29.

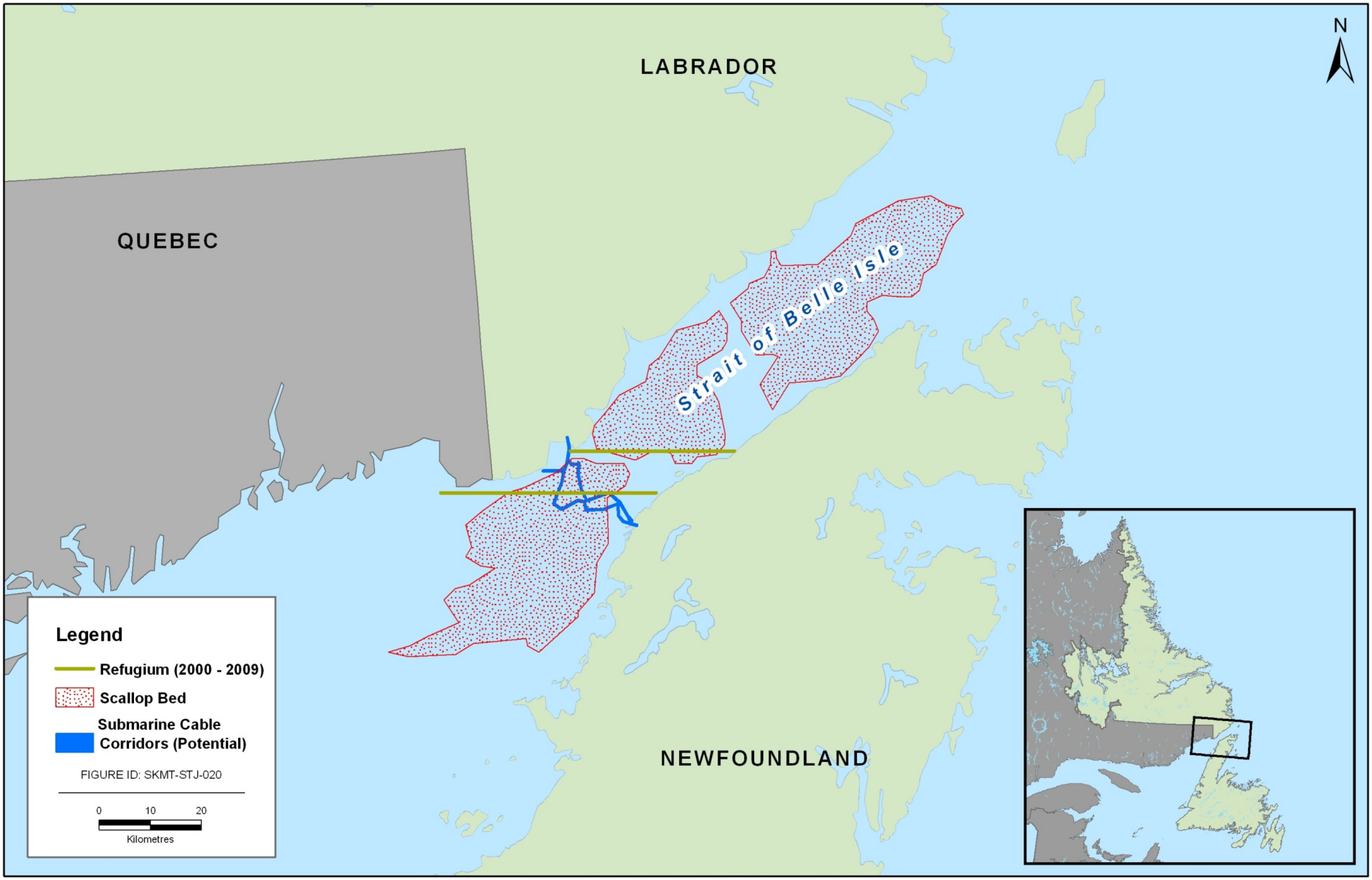

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FIGURE 3.29

Strait of Belle Isle Scallop Beds and Refugium

3.3.3.2 Snow Crab

Snow crab (*Chionoecetes opilio*), also known as queen crab, are distributed within Canadian waters between the southern tip of Nova Scotia and mid Labrador coast (DFO 2009c). This includes the Gulf of St. Lawrence and the Study Area within the Strait of Belle Isle. Snow crab generally prefer deep, cold waters.

Large, commercial size, male crab are generally found on mud or sand substrates, whereas smaller crab are associated with harder substrates (DFO 2005b). Prey items include fish, clams, polychaete worms, brittle stars, shrimp and other crustaceans, while predators of snow crabs include groundfish, seals and other snow crab (DFO 2003).

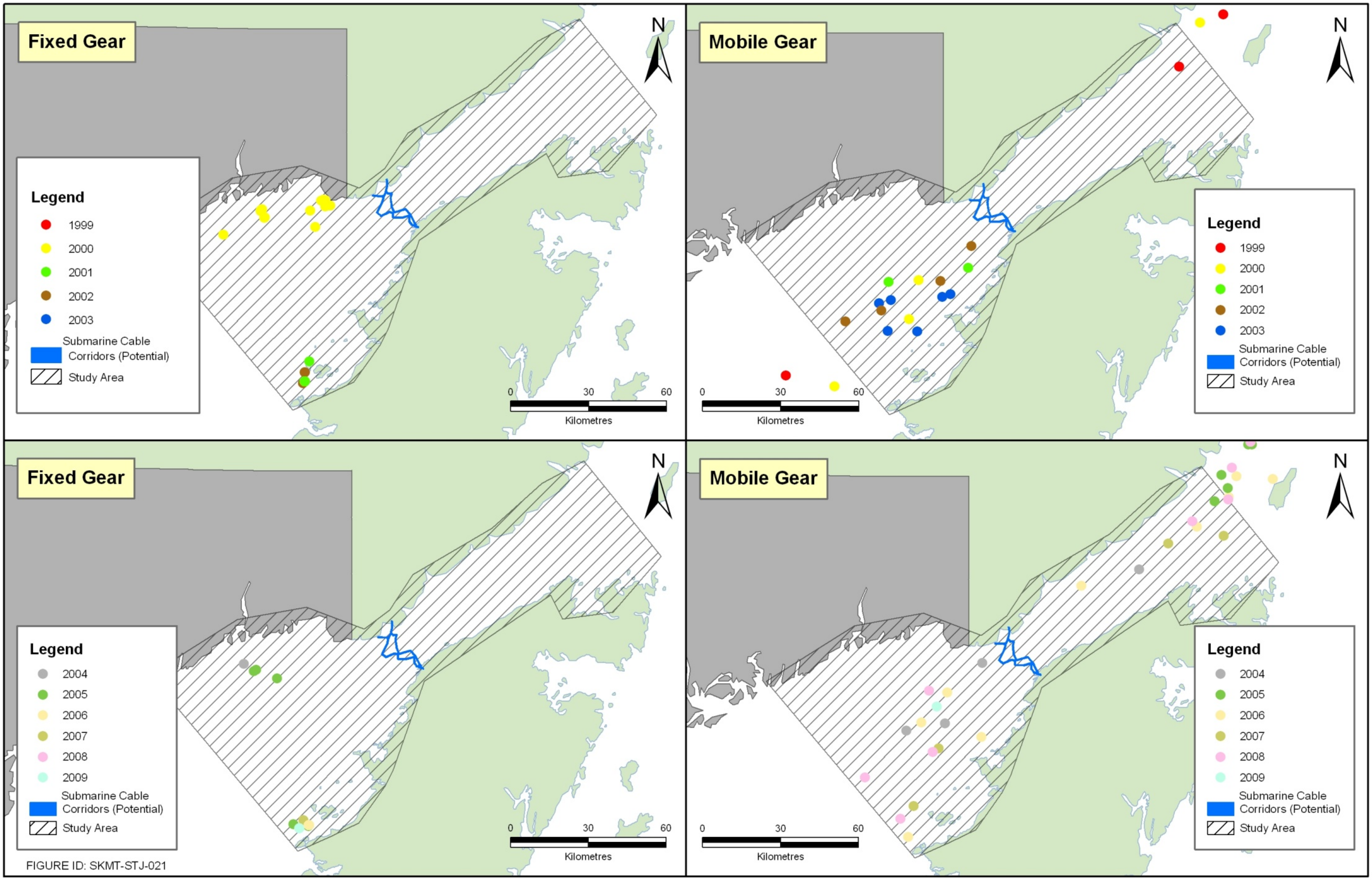
Crab are crustaceans and therefore grow by moulting which normally occurs in the spring. Females will moult until they reach sexual maturity (approximately 40 to 75 mm carapace width), whereas males will continue to moult until they reached their terminal moult size, between 40 to 115 mm carapace width (DFO 2005b). In spring, mating pairs migrate to shallow waters. After spring hatching, snow crabs go through a larval stage in which the larvae float and eventually settle to the bottom. It is possible that larvae from the Labrador coast waters are transported to the northern Gulf of St. Lawrence by the currents in the Strait of Belle Isle (Lambert, 2010, pers. comm.).

In the Gulf of St. Lawrence, males of commercial size generally live in waters between 60 m to 220 m depth but migrate to shallower waters during the moulting and reproductive periods (DFO 2009c). Catch distribution from 2002 to 2009 for commercial fishery and scientific research surveys suggest that snow crab are not abundant at depths greater than 200 m (Bourdages et al. 2010).

Crab Fishing Area 13, which includes the Study Area, was under a moratorium between 2003 and 2007, re-opening to commercial fishing in 2008. This closure was put in place due to a significant drop in biomass (DFO 2009c). While there is some concentration of fishing effort in the eastern part of the Study Area, historically, the Strait of Belle Isle has not been an area of high fishing effort for snow crab (Lambert, 2010, pers. comm.).

According to the most recent DFO stock assessment (DFO 2009c), the biomass for this species seems to be increasing within the Crab Fishing Area 13. The commercial fishery in 2008 showed an increase in Catch Per Unit Effort and the 2008 survey results indicate that mating success was about average. Although the amount of commercial crab recruited to the population in 2008 was low, abundance index of adolescent crab (78 mm to 95 mm) increased in the northern part, and trends show increasing levels of adolescent crab of size 40 mm to 62 mm, as well as 62 mm to 78 mm, which suggested a positive outlook on recruitment to the fishery (DFO 2009c).

Preliminary results from the most recent multidisciplinary survey in the northern Gulf of St. Lawrence (Bourdages et al. 2010) confirmed this fact, since the mean number of snow crab per tow has increased considerably while mean weight per tow only increased slightly. This suggests that there is a fairly large density of small (non-commercial sized) individuals, indicating overall biomass stability. The absence of fishing and low catches during scientific surveys suggests a low quantity of commercial sized snow crab within the Strait of Belle Isle. Capture locations of snow crab in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.30.



nalcor energy

FIGURE 3.30

Sentinel Fisheries Data and DFO Scientific Surveys - Snow Crab (1999 to 2009)

3.3.3.3 Toad Crab

Toad crab or spider crab are represented by two species *Hyas araneus* and *H. coarctatus*. Toad crab are known to occur along the Labrador coast and in the Strait of Belle Isle (DFA 2002b).

Toad crab are found on various substrates with *H. araneus* preferring soft bottom substrates and *H. coarctatus* preferring harder substrates (Squires 1990). The Department of Fisheries and Aquaculture (DFA) undertook catch and release exploratory surveys off the coast of Labrador in 2001 and 2002, which included the Strait of Belle Isle Study Area (DFA 2002c). The results of these surveys provided evidence of an abundance of commercial size toad crabs in the Strait of Belle Isle area, and established that there are potential economic benefits. In the Study Area, toad crabs were fished in depths between 12.3 and 84.1 m.

A follow up survey by the DFA (2002b) to establish a size profile of toad crabs surveyed the area between L'Anse au Loup and L'anse au Diable during August 29, 2002 and September 17, 2002. The results of this survey found that approximately 99 percent of the toad crabs captured were *H. araneus*, captured in depths between 12.8 m and 69.5 m. Approximately 84 percent of those captured were males of commercial size. Most of the females captured (98.1 percent) during this survey were egg-bearing at the time of capture. However, due to a lack of comparable data, it is difficult to determine the precise time of year that spawning occurs (DFA 2002b).

Capture locations of snow crab in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.31.

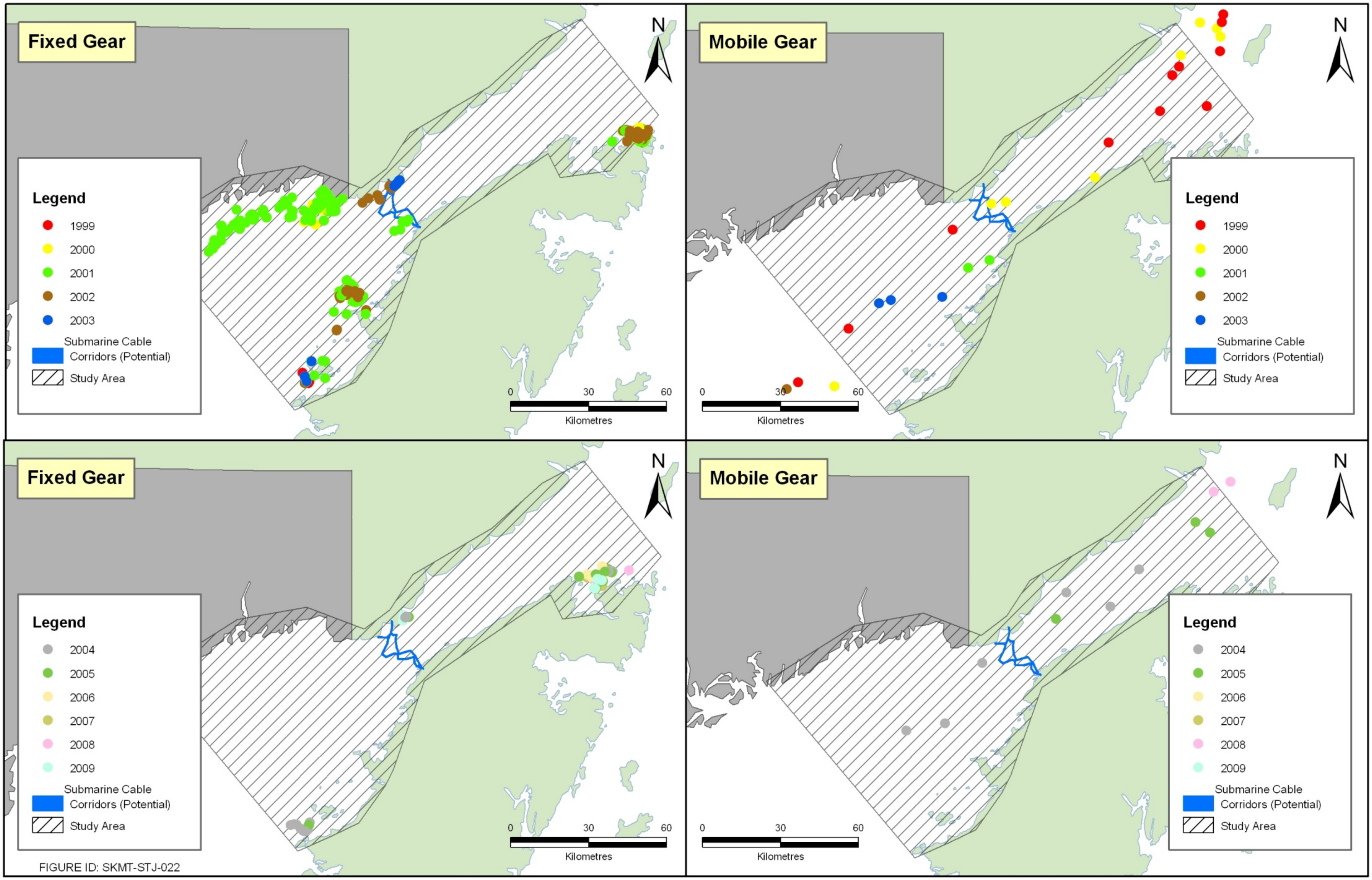


FIGURE 3.31

Sentinel Fisheries Data and DFO Scientific Surveys - Toad Crab (1999 to 2009)

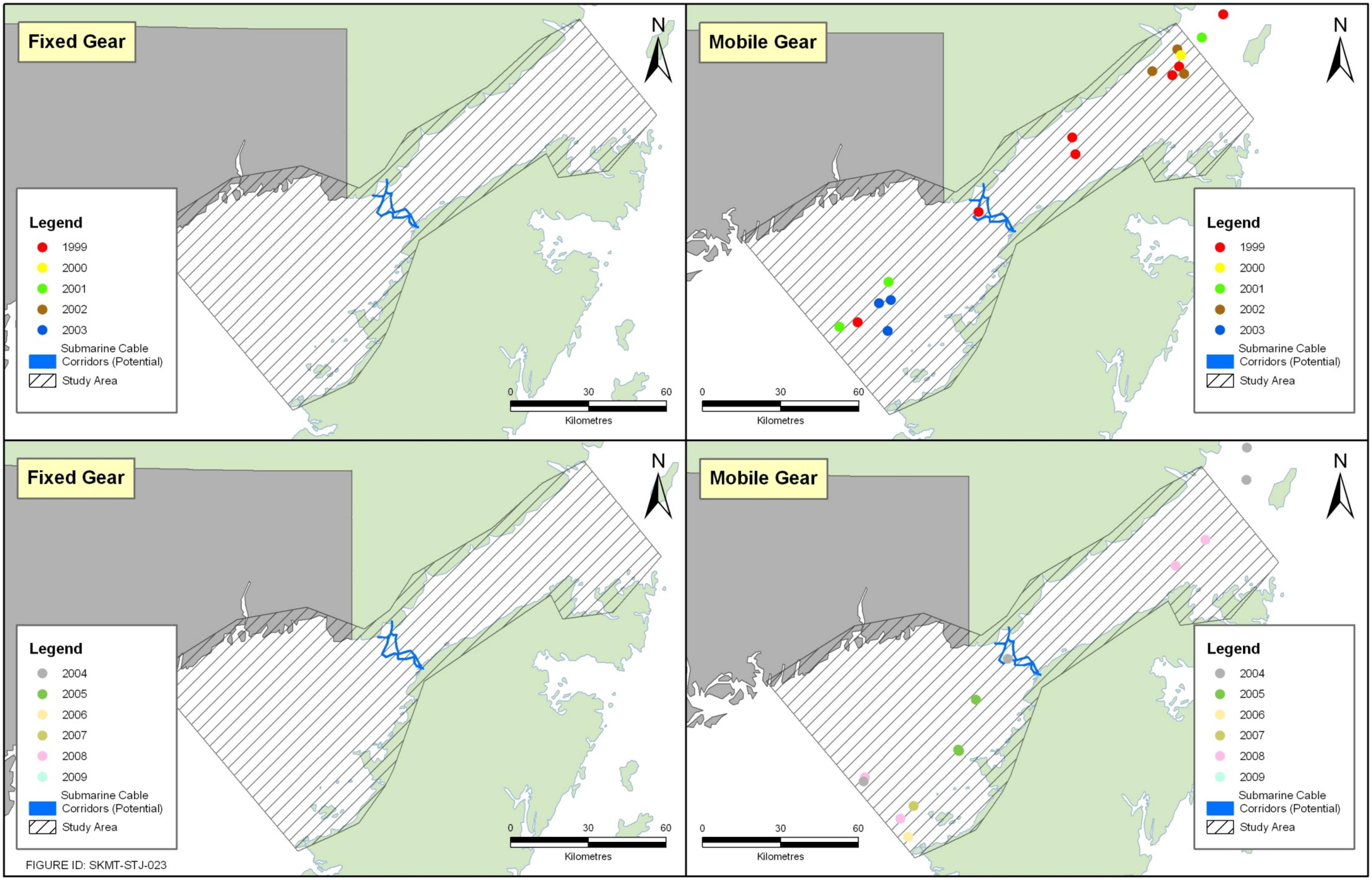
3.3.3.4 Shrimp

The Strait of Belle Isle is known to contain concentrations of various species of shrimp, many of which are only marginally found in the Gulf of St. Lawrence (DFO 2007a). There are approximately 20 species of shrimp from three different families (Hippolytidae, Pandalidae, and Crangonidae) found in the Strait of Belle Isle. In the Gulf of St. Lawrence, shrimp occur at depths from 150 to 350 m (DFO 2010a).

Shrimp are unique in that they change sex over their life cycle, starting as males until they reach sexual maturity at approximately 2.5 years, and then becoming females at 4 to 5 years of age (DFO 2010a). Mating occurs in the fall, and females carry eggs beneath their abdomen for approximately 8 months (September to April). Upon hatching, larvae are pelagic in the spring and settle to the bottom by late summer (DFO 2010a). Migrations of shrimp occur both annually and diurnally, and are associated with breeding and feeding, respectively. Females bearing eggs migrate to shallow water in the winter and shrimp leave the ocean floor to feed on planktonic organisms at night (DFO 2010a).

Results from the identification of EBSAs in the Gulf of St. Lawrence determined that the Strait of Belle Isle is an IA for benthic invertebrates, partially due to high abundance of shrimp (Savenkoff et al. 2007). DFO (2009e) has identified the area as being important for shrimp of the species *Lebbeus groenlandicus*. As well, the Strait of Belle Isle represents the only area in the Gulf of St. Lawrence where *Eualus gaimardii gaimardii* have been observed (DFO 2009e). It is also somewhat significant for other species of shrimp which are otherwise limited in distribution (Greenland lebbeid, circumpolar eualid, and pink shrimp – *Pandalus montaguii*).

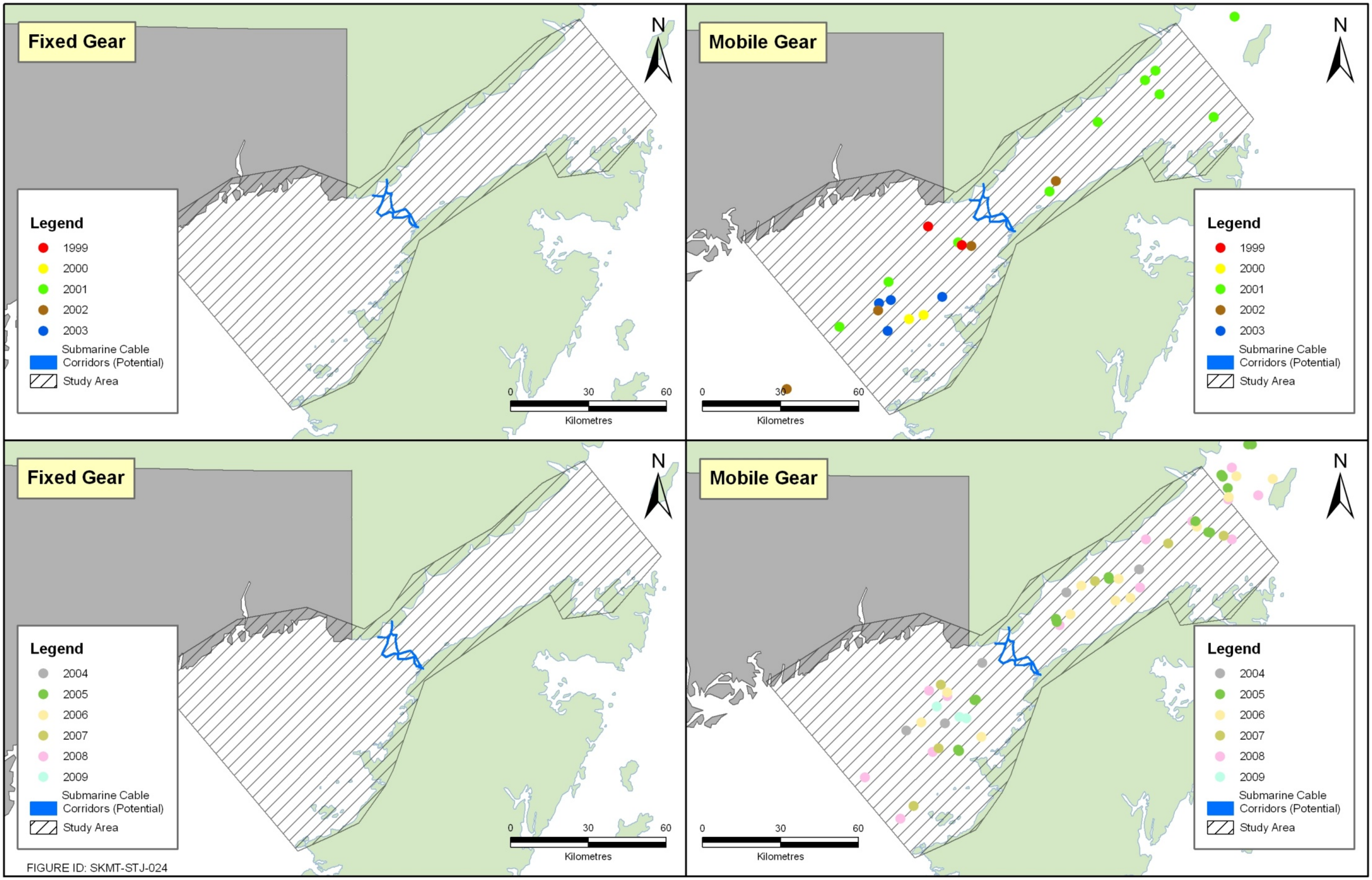
Capture locations of Northern shrimp, pink shrimp, *Eualus gaimardii gaimardii*, and *Lebbeus groenlandicus* in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figures 3.32 – 3.35. Note that shrimp fishing occur primarily to the south of the proposed submarine cable corridors (Canning and Pitt 2010).



nalcor energy

FIGURE 3.32

Sentinel Fisheries Data and DFO Scientific Surveys - Northern Shrimp (1999 to 2009)



nalcor energy

FIGURE 3.33

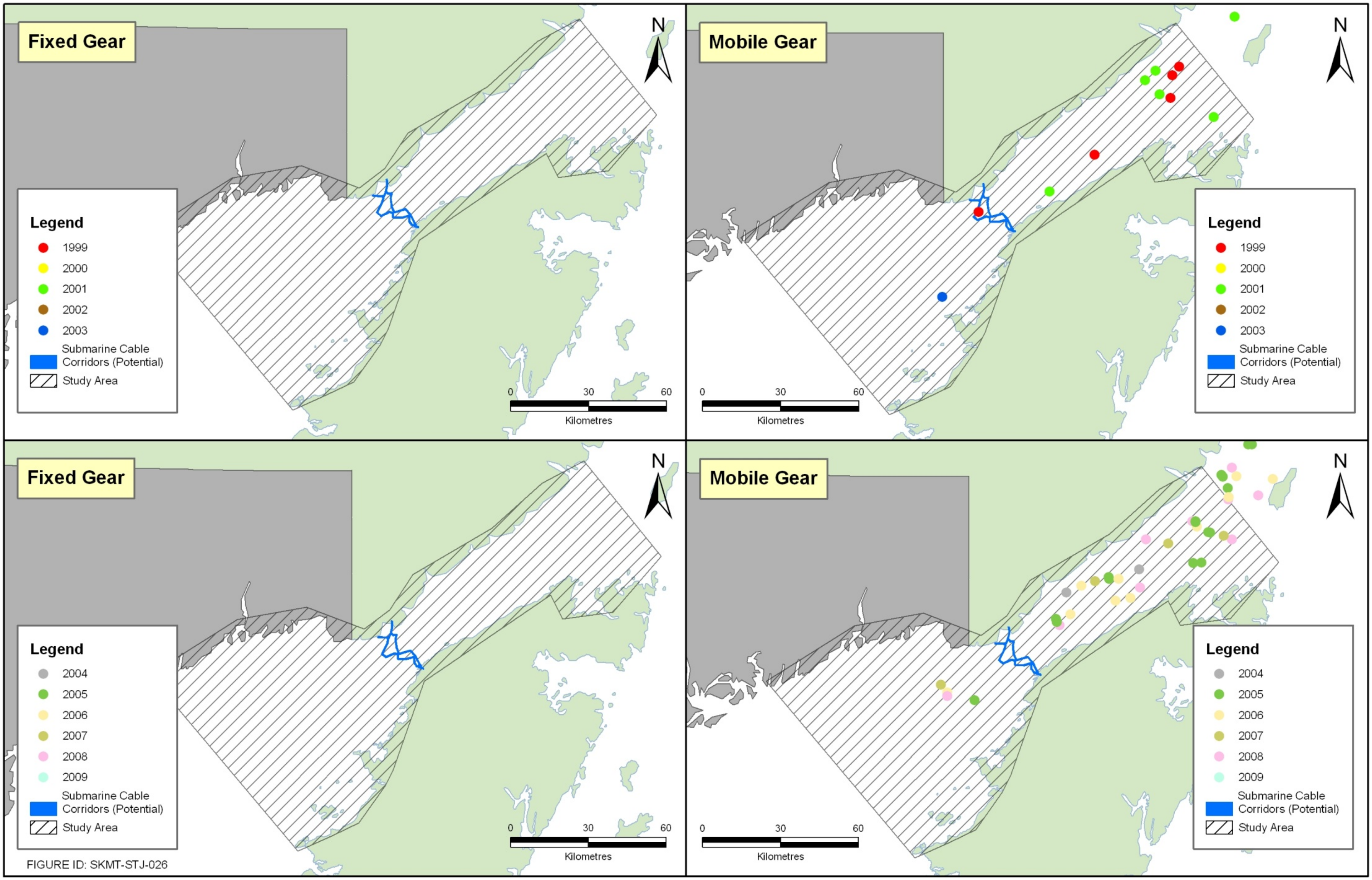
Sentinel Fisheries Data and DFO Scientific Surveys - Pink Shrimp (1999 to 2009)

FIGURE ID: SKMT-STJ-025

nalcor energy

FIGURE 3.34

Sentinel Fisheries Data and DFO Scientific Surveys - *Eualus gaimardii gaimardii* (1999 to 2009)



nalcor energy

FIGURE 3.35

Sentinel Fisheries Data and DFO Scientific Surveys - *Lebbeus groenlandicus* (1999 to 2009)

3.3.3.5 American Lobster

American lobster is a benthic decapod (ten legs) crustacean. The distribution range of lobster is from Cape Hatteras (North Carolina) to the Strait of Belle Isle, however they are more abundant in the Gulf of Maine, and close to Nova Scotia in the southern Gulf of St. Lawrence (St. Lawrence Global Observatory 2010).

Adult lobsters are generally found in water depths of less than 50 meters. However, they have been observed at depths of up to 700 meters. Lobsters prefer to live in cracks and shelters, and therefore are often found on rocky bottoms covered with algae. They also dig burrows under large stones to hide in. Algae make it easier for lobsters to hide, and they attract several organisms on which lobsters feed. Occasionally, adult lobsters can also be found on other types of bottoms such as mud, sand or gravel, but these are not preferential habitat. When there are no cracks or algae to shelter, lobsters dig a bowl-like depression in the soft substrates. Adult lobsters often stay close to the coasts in the summer because the water is warmer, and then migrate to open water in the winter to escape the turbulence (St. Lawrence Global Observatory 2010).

Young lobsters (less than 40 mm) stay generally close to the coasts at depths of less than 10 meters, on gravel and cobble bottoms. They can also be found on bottoms covered with mussel shells and algae. Young lobsters do not migrate to open water in winter. They remain hidden in their shelter during this season. Growth of lobsters occurs by molting of the exterior shell, which decreases with age (Collins et al. 2009). Mating occurs between July and September, and eggs are released approximately 1 year after mating. Hatching occurs during a four month period extending from late May through most of September. Larvae are planktonic before settling to the bottom.

The adult lobster is thought to have few natural predators and commercial harvesting accounts for most adult mortality. Diet typically consists of rock crab, polychaetes, molluscs, echinoderms, and various finfish.

Collins et al. (2009) reviewed fishery data and management on the west coast of Newfoundland, including in the Study Area. The results were, however inconclusive in terms of an overall assessment of the resource. Information on lobster in the area is typically comprised entirely of fishery-related data, and would require an intensive biological sampling program to determine resource status (Collins et al. 2009).

Within the Study Area, there are several areas that have been closed to commercial scallop fishing activity in order to protect and conserve the lobster stocks. St. John Bay and St. Genevieve Bay have been closed to commercial scallop fishing year round, while St. Margarets Bay and Pistolet Bay is closed from May 12th to December 31st. Both of these closures were established in 1996. According to Anderson et al. (2000), these closures were still in effect in March of 2000.

3.3.3.6 Sea Cucumber

The orange footed sea cucumber is a bottom dwelling echinoderm present throughout the Strait of Belle Isle.

To determine if a viable fishery could be sustained within the Strait of Belle Isle, stock assessments were conducted by DFO in 2005. A bottom tow was conducted in October 2005 within the Strait of Belle Isle to examine size index and other variables to compare with sea cucumber from the St. Pierre Bank. Results of this study demonstrated that *C. frondosa* from the Strait of Belle Isle were smaller in linear dimension with a thicker body wall on average than the St. Pierre Bank sea cucumber stock (Grant 2006). Information regarding sea cucumber within the Study Area is limited, as the DFO project for sea cucumber resource assessment is not yet complete (Power, 2010, pers. comm.).

The DFA have also undertaken surveys in the Strait of Belle Isle region to determine the viability of a possible sea cucumber fishery in the area (Melindy, 2010, pers. comm.), however, results of these surveys were not available.

3.3.4 **Species of Special Conservation Concern**

There are a number of marine fish species of special conservation concern that occur within the Strait of Belle Isle. These species have either been designated under the *Species at Risk Act (SARA)* and/or have been designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The general purpose of *SARA,* which was established in 2003, is to prevent species from becoming extinct, and to manage the recovery of species that have been given designations under the Act.

COSEWIC is a committee of experts which is responsible for the assessment and classification of species as being either extinct, extirpated, endangered, threatened, of special concern, data deficient, or not at risk. COSEWIC provides recommendations to the federal government, whose officials then review the assessments and decide which species are added to the official list of protected species (Schedule 1 under *SARA*). Species listed under Schedule 1 of *SARA* are legally protected under the Act, and measures are developed to protect these species and their critical habitat. Recovery strategies are required for those species designated as 'Endangered', 'Threatened' and 'Extirpated', while management plans are required for species designated as 'Special Concern'.

As designation by *SARA* and by COSEWIC are very different in terms of legal protection, the following sections have been sub-divided to reflect these differences. The sections include a discussion of *SARA* designated marine fish species known to occur in the Study Area, COSEWIC designated marine fish species known to occur in the Study Area, and other species of special conservation concern which describes the COSEWIC designated marine fish that occur rarely in the Study Area.

3.3.4.1 ***SARA* Designated Marine Fish Species**

Marine fish species of special conservation concern that occur within the Strait of Belle Isle, and that are legally protected under Schedule 1 of SARA, are outlined in Table 3.18 and include three species of wolffish (Atlantic, Northern and spotted).

A detailed discussion of these three species follows Table 3.18 including reasons for their designations, habitat preferences, and capture locations in the Study Area.

Table 3.18 Marine Fish Species Found Within The Study Area Having SARA Designations

Common Name	Population	SARA Designation
Atlantic wolffish (*Anarhichas lupus*)	Atlantic Ocean	Schedule 1 – Special Concern (2004)
Northern wolffish (*Anarhichas denticulatus*)	Arctic and Atlantic Ocean	Schedule 1 – Threatened (May 2001)
Spotted wolffish (*Anarhichas minor)*	Arctic and Atlantic Ocean	Schedule 1 – Threatened (May 2001)

Atlantic Wolffish

Atlantic wolffish (*Anarhichas lupus*), also known as striped wolffish, is a large (up to 1.5 m) bottom-dwelling predator listed under *SARA* as a species of Special Concern. The species was last assessed by COSEWIC in 2000 (COSEWIC 2000) and was listed under *SARA* in 2004. It is found on both sides of the Atlantic Ocean, and in the northwest Atlantic ranges from west Greenland in the north to the coast of New Jersey in the south. It is present along the northeast coast of Newfoundland and in the Gulf of St. Lawrence, including the Strait of Belle Isle Study Area (Scott and Scott 1988; COSEWIC 2000).

Atlantic wolffish habitat varies by area and are most often found along boulder fields or on hard clay substrate and occasionally on sand/mud substrates (COSEWIC 2000). Atlantic wolffish prefer depths between 100 to 150 m, although they have been found in waters as deep as 500 m. Temperature preference ranges from -1˚C to 10˚C (COSEWIC 2000).

The diet of the Atlantic wolffish consists primarily of bottom invertebrates, including echinoderms, molluscs, crustaceans and small amounts of fish. Maturity is attained between 5 and 11 years of age. During spawning, which occurs in September, the female lays a large cluster of eggs which are guarded by the parental male until hatching occurs in mid-December. Atlantic wolffish do not migrate large distances, but do make limited seasonal migrations from deep to shallower waters prior to spawning (COSEWIC 2000).

According to COSEWIC (2000), Atlantic wolffish are considered “Species of Special Concern” due to its life history characteristics of slow-growth and late-maturation. Populations have declined significantly since the 1970s, due to overfishing and habitat alteration. Threats to this species include by-catch mortality by offshore trawlers and longliners. Other activities which disturb the ocean bottom, such as trawling may also damage spawning habitat (DFO 2010b).

Under the *SARA*, a management plan has been developed, and has been implemented in association with the recovery strategies for the other wolffish species considered “Threatened” under *SARA* (Kulka et al. 2007). Capture locations of Atlantic wolffish in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.36.

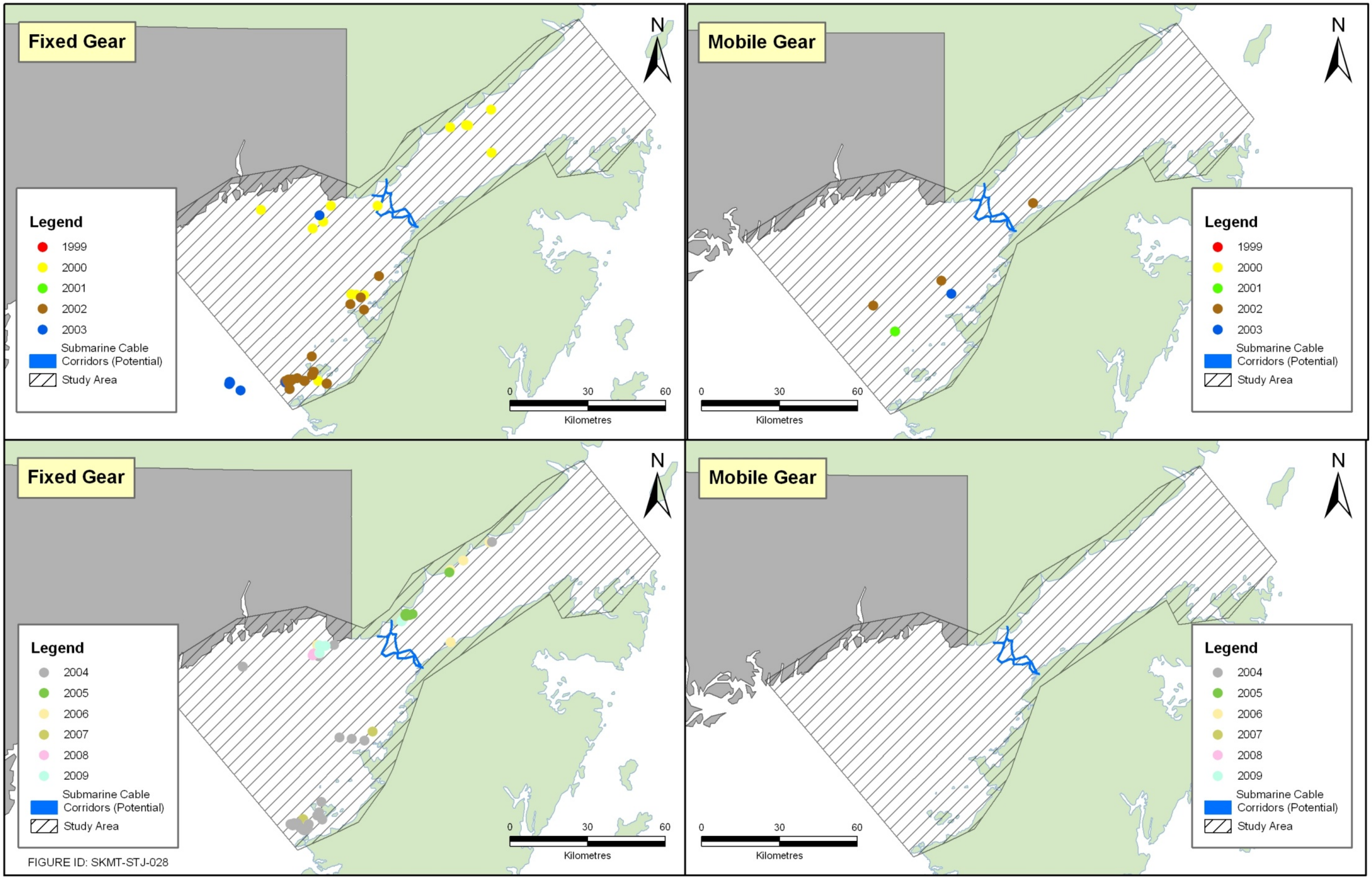


FIGURE ID: SKMT-STJ-028

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FIGURE 3.36

Sentinel Fisheries Data and DFO Scientific Surveys - Atlantic Wolffish (1999 to 2009)

Northern Wolffish

Northern wolffish (*Anarhichas denticulatus*), is a large benthopelagic predator listed under *SARA* as Threatened and was last assessed by COSEWIC in 2001 (COSEWIC 2001a). It is found from Newfoundland to Scotland, and in the northwest Atlantic it is primarily found off northeastern Newfoundland, with some stray fish found elsewhere. It is non-schooling, non-migratory, and considered to be a territorial fish species. The northern wolffish has never been part of a targeted fishery, but is sometimes captured as by-catch (COSEWIC 2001a).

Northern wolffish are found in deep waters with a range of depths from 100 m to 900 m in offshore waters and prefer soft bottom substrate, at temperatures below 5˚C. Spawning of northern wolffish occurs late in the year, producing large eggs which lay on the bottom (COSEWIC 2001a).

According to COSEWIC (2001a), reasons for designation of Northern wolffish as "Threatened" under *SARA* include an over 95 percent decline in population over three generations. As well, there is evidence that the number of locations this species is captured has also decreased. Threats to the species are mostly fisheries related, and include by-catch and alteration of habitat by trawling (COSEWIC 2001a).

Under the *SARA*, a recovery plan has been developed for Northern wolffish, and includes two other species of wolffish also found in the northwest Atlantic (Kulka et al. 2007). Capture locations of Northern wolffish in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.37.

Spotted Wolffish

Spotted wolffish (*Anarhichas minor*) can be identified from other wolffish by the dark spots on the body, firm musculature, and the arrangement of teeth on the roof of their mouth (COSEWIC 2001b). Spotted wolffish, like the Northern wolffish, is listed as Threatened under Schedule 1 of *SARA* and was last assessed by COSEWIC in 2001 (COSEWIC 2001b). Spotted wolfish are often found offshore in boulder/sand/mud habitat in depths ranging from 50 to 600 m (COSEWIC 2001b). They are usually found in cool and cold temperatures less than 5˚C (COSEWIC 2001b).

Like the other wolffish species, spotted wolffish make very limited migrations, and only on a seasonal basis. Spawning occurs in summer, and females produce a large mass of eggs which lay on the bottom (COSEWIC 2001b). Maturation begins at about seven to ten years of age and spotted wolffish have the slowest growth rate of all the wolffish species (COSEWIC 2001b).

Designated as "Threatened" under *SARA*, it has been demonstrated that the populations in Newfoundland waters have decreased by 96 percent since 1978. Threats to the species are mostly fisheries related, and include by-catch and alteration of habitat by trawling (COSEWIC 2001b).

Under the *SARA*, a recovery plan has been developed for spotted wolffish, and includes two other species of wolffish also found in the northwest Atlantic (Kulka et al. 2007). Capture locations of spotted wolffish in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.38.

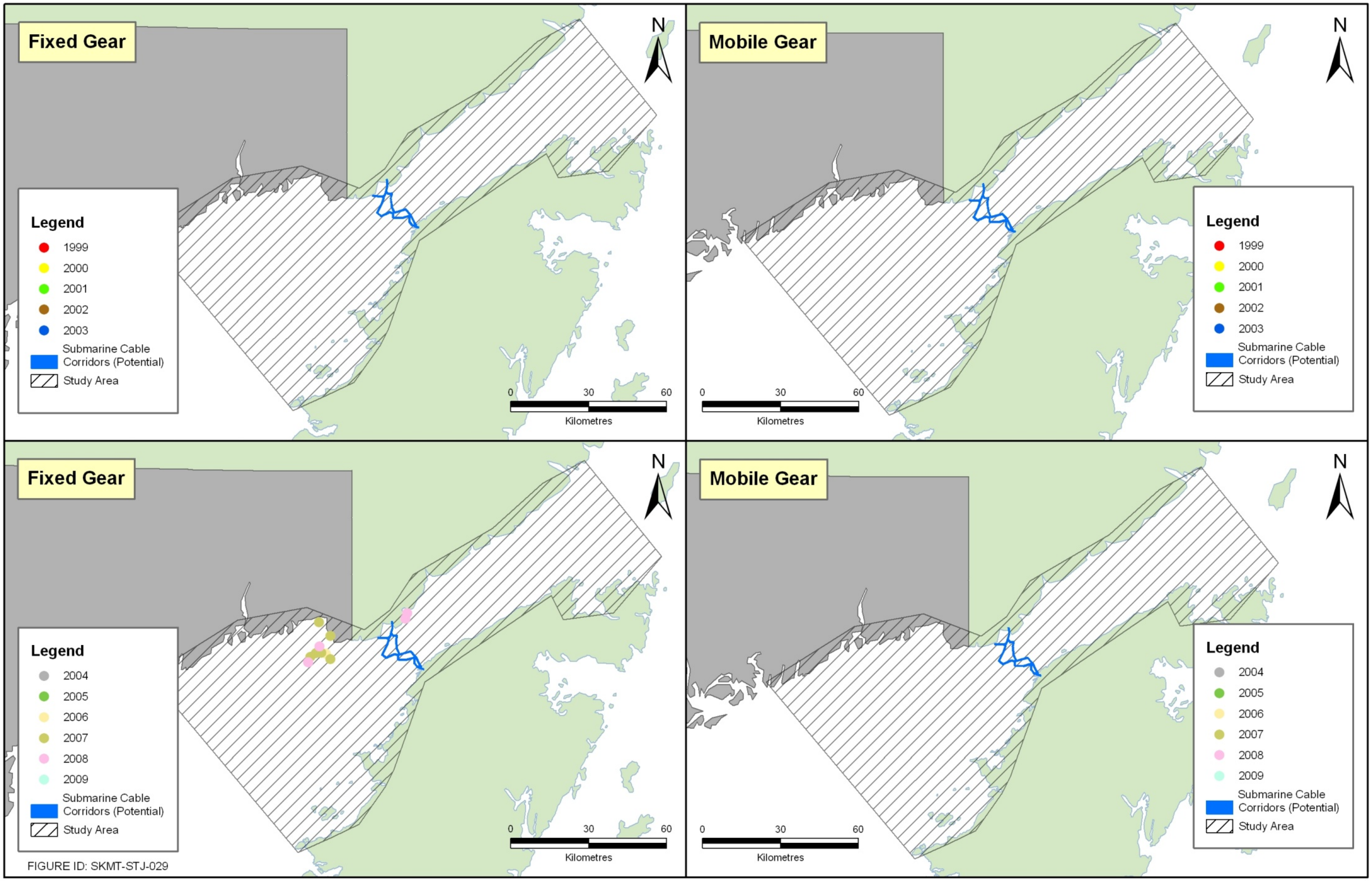

FIGURE ID: SKMT-STJ-029

FIGURE 3.37

Sentinel Fisheries Data and DFO Scientific Surveys - Northern Wolffish (1999 to 2009)

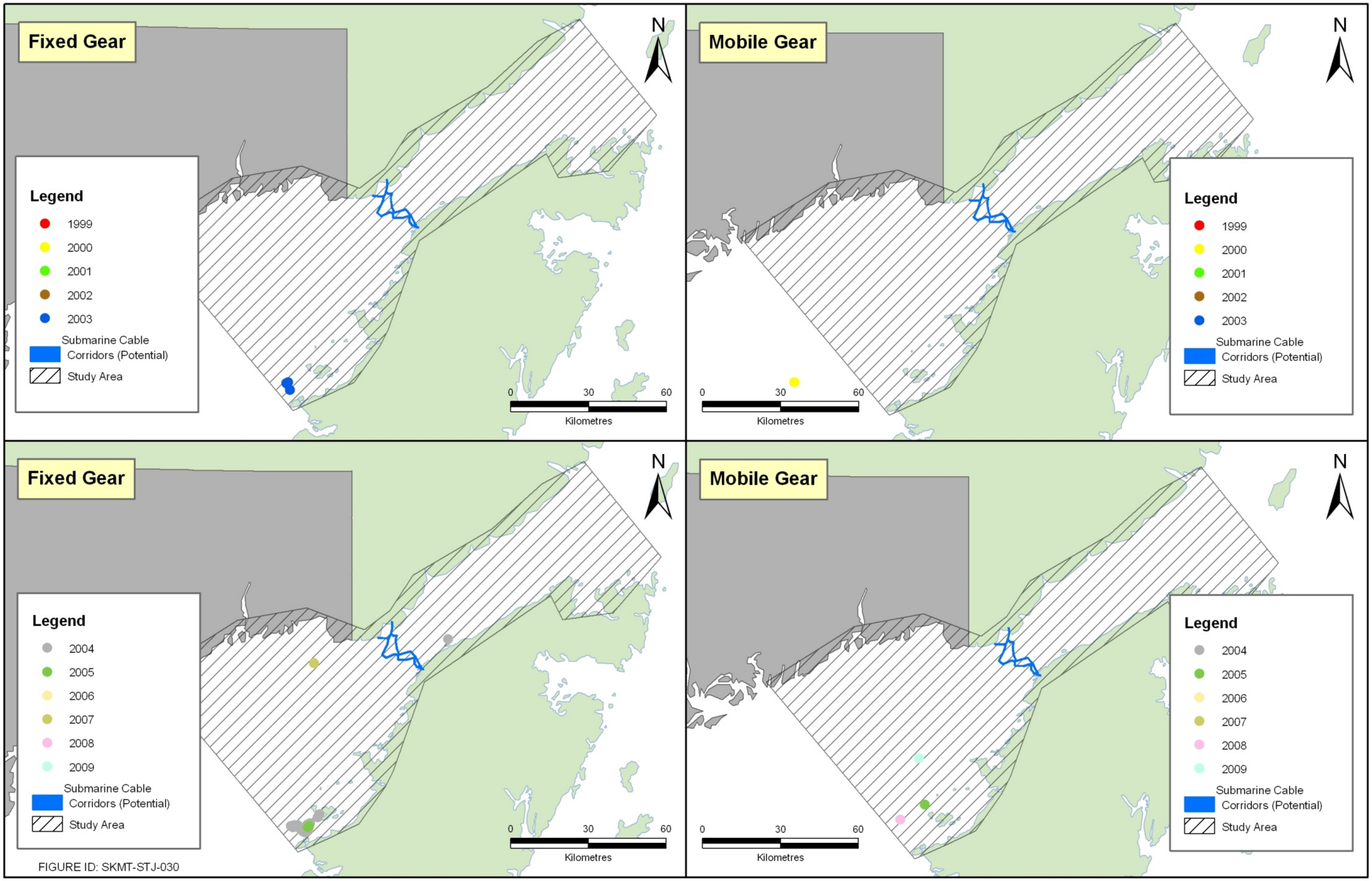

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FIGURE 3.38

Sentinel Fisheries Data and DFO Scientific Surveys - Spotted Wolffish (1999 to 2009)

3.3.4.2 COSEWIC Designated Marine Fish Species

Marine fish species of special conservation concern that have been assessed and designated by COSEWIC that are known to occur in the Study Area include Atlantic cod, American eel, American plaice, spiny dogfish and basking shark. These species do not have the legal protection that species listed on Schedule 1 of *SARA* are provided. These species and their COSEWIC designation are outlined in Table 3.19.

A detailed discussion of these five species follows Table 3.19 including reasons for their COSEWIC designation, habitat preferences, and capture locations, where available, in the Study Area.

Table 3.19 Marine Fish Species Found Within The Study Area Having COSEWIC Designations

Common Name	Population	COSEWIC Designation
Atlantic cod (*Gadus morhua*)	Laurentian North Population	Endangered (April 2010)
American eel (*Anguilla rostrata*)	Atlantic Ocean	Special Concern (April 2006)
American plaice (*Hippoglossoides platessoides*)	Newfoundland and Labrador Population	Threatened (April 2009)
Spiny dogfish (*Squalus acanthias*)	Atlantic population	Special Concern (April 2010)
Basking shark (*Cetorhinus maximus*)	Atlantic population	Special Concern (November 2009)

Atlantic Cod

Atlantic cod found within the Strait of Belle Isle Study Area are generally from the northern Gulf of St. Lawrence population of cod (i.e., Laurentian North population) (NAFO Areas 3Pn 4RS). These cod are known to migrate extensively on an annual basis (DFO 2009b). During winter, these cod are found off southwestern and southern Newfoundland in depths greater than 366 m (DFO 2009b). On the basis of migration patterns, Yvelin et al. (2005) suggested that this stock consisted of three components in the Gulf of St. Lawrence. While all three components had the same over-wintering location in southern Newfoundland, tagging studies have shown a portion of the population remained in that area throughout the year. The other two components of the population migrated north to one of two regions: off the coast of Western Newfoundland or in the northern Gulf of St. Lawrence, including the Strait of Belle Isle (Yvelin et al. 2005).

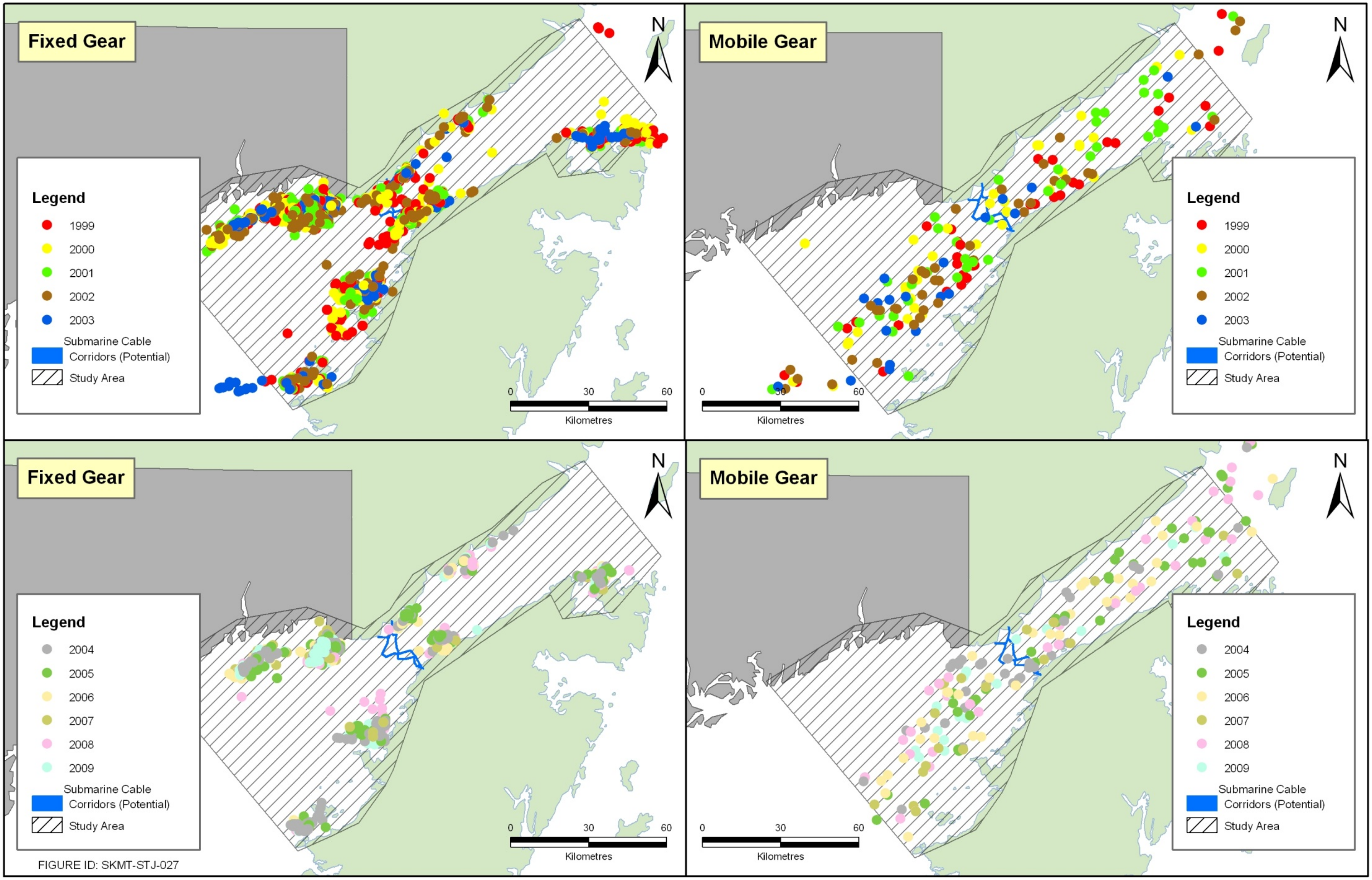
Northern Gulf of St. Lawrence cod typically migrate to the west coast of Newfoundland, NAFO Division 4R (Figure 3.17), between April and May (DFO 2009b). Spawning of Atlantic cod occurs in a variety of depths (Hutchings et al. 1993; Smedbol and Wroblewski 1997) and they are known to spawn in inshore, nearshore and offshore waters (Hutchings et al. 1993; Morgan and Trippel 1996). Studies in 2001 on spawning females within the Gulf of St. Lawrence indicated that spawning occurs more predominantly in April in the northern Gulf of St. Lawrence (Méthot et al. 2005). Results from these studies demonstrated that during 2001 a higher percentage of spawning Atlantic cod females occurred in 4R than other parts of the Gulf of St. Lawrence, and that only spent females were captured in 4R in April (Méthot et al. 2005). Results from tagging studies show that the Atlantic cod found in the Study Area mix with Burgeo Bank cod (3Ps) every winter, occasionally mix with 2J3KL (Newfoundland and Labrador population) cod in the Strait of Belle Isle, and mix with 4TVn (Laurentian South population) stock in the northwest portion of the Gulf of St. Lawrence (DFO 2009b).

Results from the sentinel tagging surveys (Bérubé and Fréchet 2001) show that most catches in the Strait of Belle Isle occur between July to October. These are found further south in 4R and 3Pn between September and December (Bérubé and Fréchet 2001). Although cod from the Strait of Belle Isle are mainly from the 4RS and 3Pn stock (Figure 3.17), Atlantic cod from other stocks have been present in the area. Only a few cod were tagged and released with acoustic transmitters off Bonavista (NAFO Division 3L; Figure 3.17) and only a few of these were detected in the Strait of Belle Isle Study Area (Brattey, 2010, pers. comm.) suggesting that the Bonavista cod stock does not undertake extensive migrations to the Study Area.

As juveniles, cod associate with complex habitats, such as boulders/large rock, cobble, macroalgae and eelgrass in inshore environments. This is specifically for protection from predators, such as larger conspecifics and other piscivorous fish and sea birds (Laurel et al. 2003). Distribution of Atlantic cod changes with age; juvenile nursery areas are primarily inshore shallow areas along the coast of southern Labrador and eastern Newfoundland. Young of the year are found mainly inshore, with year 1 cod starting to appear offshore. By age 3 and 4 they have distribution to offshore areas overlapping with older fish.

COSEWIC considered the species a single unit and designated it as being of 'Special Concern' in April 1998. When the species was split into separate populations in May 2003, the Laurentian North population was designated Threatened. The status was re-examined and designated Endangered in April 2010. The reason for this latest designation was the population decline of 76 to 89 percent in the past three generations. The main cause of the decline in abundance was overfishing and there has been no indication of recovery (COSEWIC 2010a). To date, this recommendation by COSEWIC has not been accepted and therefore Atlantic cod are not legally protected by *SARA*.

Capture locations of Atlantic cod in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.39. It is apparent that Atlantic cod are widely distributed throughout the Study Area and were a major component of the catch in both the scientific and sentinel surveys. Spawning locations within the Study Area for Atlantic cod were identified in the CCRI database (Figure 3.18). Spawning locations were identified near Red Bay on the Labrador side and in Pistolet Bay and in an area mid-way between Flower's Cove and Cooks Harbour on the Newfoundland side.



nalcor energy

FIGURE 3.39

Sentinel Fisheries Data and DFO Scientific Surveys - Atlantic Cod (1999 to 2009)

American Eel

In 2006 COSEWIC recommended that the American eel (*Anguilla rostrata*) be designated as a species of 'Special Concern' (COSEWIC 2006) and is currently being considered for listing under *SARA*. The main reason for the recommendation was the substantial decline in abundance (99 percent) of eels in the upper St. Lawrence and Lake Ontario. As the species is panmictic, (i.e., all spawners in a single breeding unit), the status of eels in Canadian waters could be affected by the status of the species in other areas (e.g., the USA). Reasons for the decline in eel abundance include habitat alteration, dam construction (habitat loss and turbine mortality), commercial fisheries, and environmental conditions in the ocean, acid rain, and contaminants (COSEWIC 2006).

American eel spend the majority of their lives in freshwater rivers and estuaries. After 10 to 20 years in freshwater environments, they begin their salt water migration to the only known spawning ground – the Sargasso Sea in the mid North Atlantic Ocean. After spawning the adults die and the larvae drift northward along the east coast of North America, as far north as Labrador and Greenland (Environment Canada 2005). Larvae metamorphose into 'glass eels' which then actively swim towards coastal areas where, in the estuaries, they change into elvers, about 65 to 100 mm in length. Elvers swim up rivers during high flows and then retreat to the substrate during low flows (COSEWIC 2006). Juvenile eels use the continental shelves for migration back into rivers and adult eels (known as silver eels) are found on the continental shelves during spawning migration (Cairns et al. 2008), thus both life cycle stages pass through the Strait of Belle Isle during the pre- and post-spawning migration.

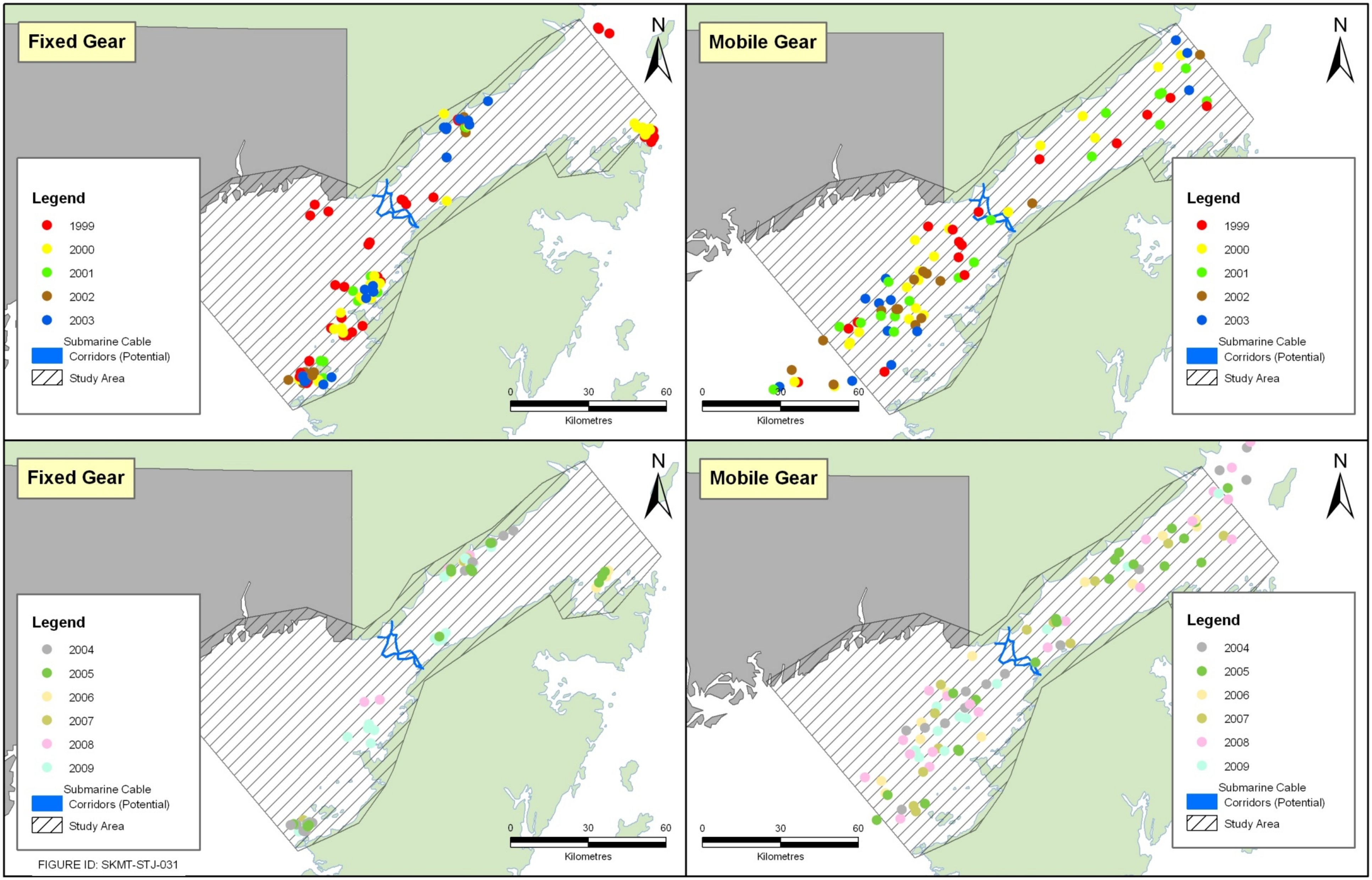
It has been long known that American eels are present in Labrador rivers, and, in the 1990s, there were attempts to develop a fishery. A harvesting pilot project was completed in the Strait of Belle Isle in 2002. This effort was undertaken by the Southern Labrador Development Association (SLDA) in association with the DFA, and funded under the Fisheries Diversification Project (FDP). The objective of the project was to determine resource levels and identify effective harvesting techniques (DFA 2002a). During the pilot project, four rivers (Forteau River, L'Anse au Loup River, Pinware River, and Black Bay Brook) within the Strait of Belle Isle were fished for American eels, between July 2002 and September 2002. Seventy percent of eels caught during the study (197) were harvested in Forteau River.

American Plaice

American plaice are sedentary, non-schooling flatfish that occur on both sides of the Atlantic Ocean. In the western Atlantic, American plaice range almost as far north as the Arctic Circle and as far south as Rhode Island (COSEWIC 2009). It was once one of the most abundant flatfish in the Northwest Atlantic and was commonly sold as flounder or sole commercially. The abundance of American plaice in the Gulf of St. Lawrence region has declined by about 86 percent, and reasons for the decline are related to overfishing and high levels of natural mortality. As a result, American plaice was classified as 'Threatened' by COSEWIC in April of 2009; however, the species is not listed under *SARA* (COSEWIC 2009). While there are still small directed fisheries in the Gulf of St. Lawrence for American plaice, there is no quota management in the northern Gulf, including the Strait of Belle Isle region.

The bodies of American plaice are flattened laterally and they burrow in the sediment to deter predators or to ambush prey. Eggs and larvae are pelagic for the first few weeks, and the suitability of habitat primarily depends on prey availability and temperature. Larvae metamorphose at between 20 to 40 mm in length, when the left eye migrates to the right side and the body laterally flattens. After this occurs, juveniles settle to the bottom at depths ranging from 100 m to 200 m, usually on small particle sediments that allow the fish to bury themselves. As adults, the substrate habitat is less stringent, and particle size usually varies with body size. Adults have been found in waters with a broad range of salinities and temperature, but mostly preferring temperatures -0.5 to 4˚C, and usually are found at depths 100 to 300 m. There is no evidence of a spawning migration although American plaice have been shown to move to slightly deeper, warmer waters during the winter. In the Gulf of St. Lawrence this means moving to deeper channels (COSEWIC 2009).

Capture locations of American plaice in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.40.



nalcor energy

FIGURE 3.40

Sentinel Fisheries Data and DFO Scientific Surveys - American Plaice (1999 to 2009)

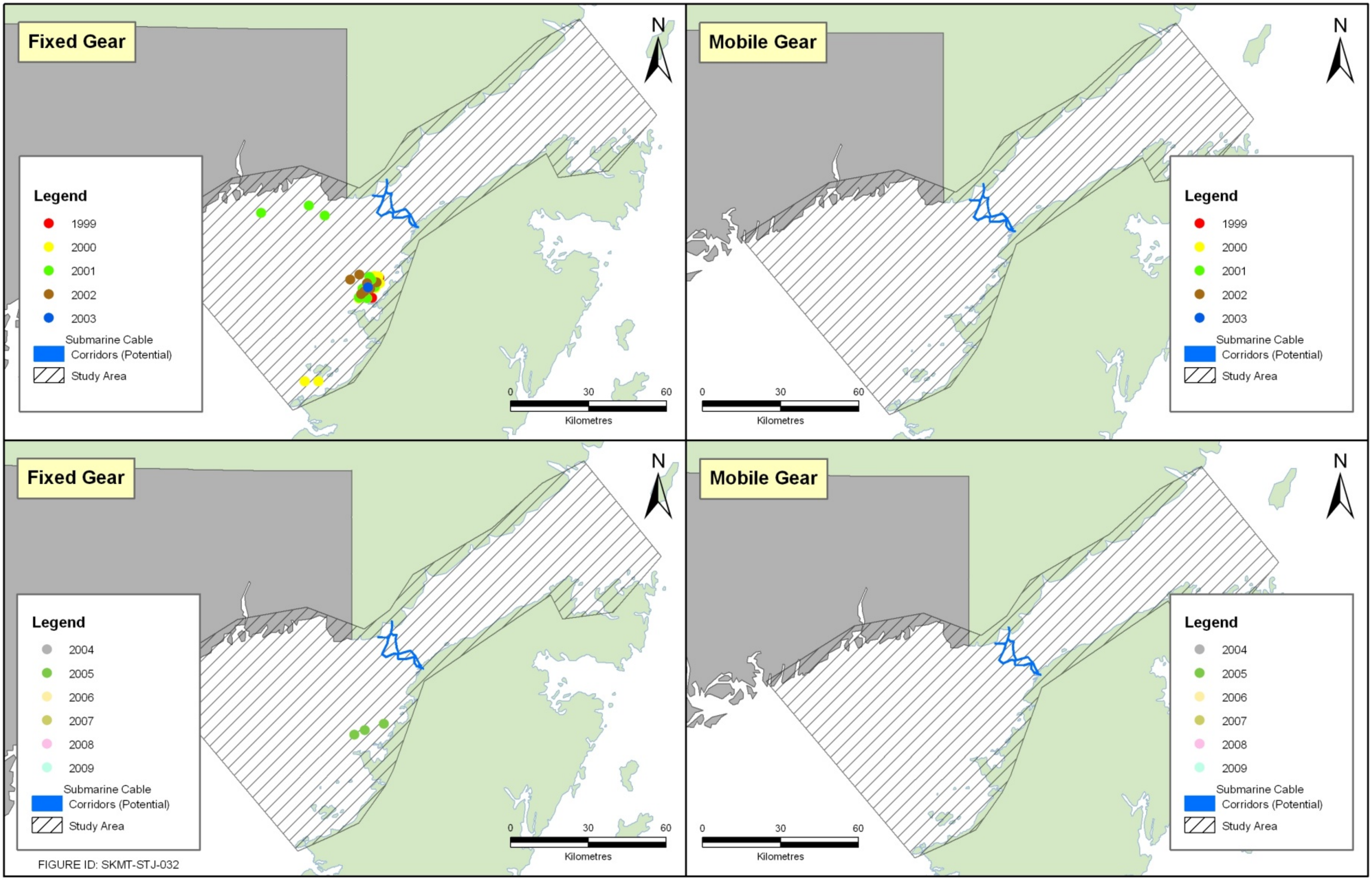
Spiny Dogfish

The spiny dogfish is a small demersal (bottom dwelling) shark occurring widely in temperate regions of the world's oceans (COSEWIC 2010c). The Atlantic population, which occurs from Labrador to Cape Hatteras has recently (April 2010) been recommended as a species of 'Special Concern' by COSEWIC. The species has not been added to *SARA's* legal list of protected species (COSEWIC 2010c).

This shark species has one of the longest known gestational periods for any vertebrate, carrying young for a period of 18 to 24 months before birth (COSEWIC 2010c). On average, six pups are born every two years. Spiny dogfish have few natural predators, but have been targeted in fisheries, and are also subject to by-catch fishing mortality. Spiny dogfish are considered a habitat generalist and occur at the highest abundances in Canadian waters around southwest Nova Scotia. They are found in a variety of habitats, from nearshore in enclosed bays and estuaries to shelf edge waters out to at least 900 m (Kulka 2006) and can be found throughout the water column, but are typically found associated with the bottom. They are normally concentrated at a range of bottom depths from 10 to 200 m in water temperatures ranging 7 to 15˚C and are therefore at the northern limit of their distribution in the Strait of Belle Isle. As previously mentioned, during the establishment of EBSAs in the Gulf of St. Lawrence, the Strait of Belle Isle area was found to have high feeding concentrations of pelagic fish species, including spiny dogfish (Savenkoff et al. 2007).

Although abundance of this species is still relatively high in Canadian waters, life characteristics such as low fecundity and long generation time (23 years), as well as uncertainty regarding abundance of mature females has led to the designation by COSEWIC. It has also been demonstrated that spiny dogfish are vulnerable to overfishing (COSEWIC 2010c).

Capture locations of spiny dogfish in the Study Area from 1999 to 2009 by DFO scientific surveys and sentinel fisheries are presented in Figure 3.41.



nalcor energy

FIGURE 3.41

Sentinel Fisheries Data and DFO Scientific Surveys - Spiny Dogfish (1999 to 2009)

Basking Shark

The basking shark (*Cetorhinus maximus*) is the second-largest living fish, growing to a maximum of 15 m in length (COSEWIC 2010b). Basking sharks have been sighted in the vicinity of the Strait of Belle Isle (Lawson, 2010, pers. comm.), though they have not been captured in DFO scientific surveys or sentinel fisheries (DFO 2010). COSEWIC assessed the species in November 2009 (COSEWIC 2010a) and recommended it be considered as a species of 'Special Concern' under *SARA*. Basking shark have not yet been listed under Schedule 1 of *SARA*.

Basking sharks are planktivores, and areas with high concentrations of zooplankton (small crustaceans and fish larvae drifting in the water column) appear to be their favoured habitat, typically including fronts where water masses meet, headlands, and around islands and bays with strong tidal flow. They spend much of their time near the surface, although there is recent evidence that basking sharks may also use deepwater habitats greater than 1000 m (COSEWIC 2010b)

Basking shark are typically late maturing (females mature at 16 to 20 years), have long gestation periods (2.6 years to 3.5 years) and low fecundity (roughly 6 offspring per litter). As a result of its low productivity the basking shark is highly vulnerable to human-caused mortality (COSEWIC 2010b).

Basking sharks found within Atlantic Canada are shared populations with the USA, Europe, Caribbean and northern South America. Populations in Canadian waters are estimated between 4,918 and 10,125 individuals, with a great deal of uncertainty surrounding this estimate (COSEWIC 2010b). The species is caught incidentally in fisheries in Atlantic Canada, although removals in fisheries with observer coverage have decreased since the 1980s. This is consistent with a reduction in overall fishing effort. Information on by-catch from other fisheries is not available. Collisions with ships are also considered a threat to this species.

Basking shark were not captured in the Strait of Belle Isle during DFO scientific surveys or fixed gear sentinel fisheries from 1999 to 2009.

3.3.4.3 Other Species of Special Conservation Concern

There are other fish species that occur within the Strait of Belle Isle and have been considered by COSEWIC, none of which have been provided legal protection under *SARA*. However, they have been captured in very low numbers during DFO scientific surveys and sentinel fisheries and rarely occur within the area. An overview of these species is provided in Table 3.20.

Table 3.20 COSEWIC Designated Species that Occur Rarely in the Strait of Belle Isle

Species	Risk Category	Reason for Designation (COSEWIC)
Acadian Redfish (*Sebastes fasciatus*)	COSEWIC Threatened (April 2010)	Abundance of mature individuals has declined 98% since 1984, somewhat more than one generation, and the decline has not ceased. Directed fishing and bycatch are the main known threats. Harvesting in parts of this population (Gulf of St. Lawrence) is currently limited to an index fishery, but commercial fisheries remain open in other areas (Laurentian Channel). Bycatch in shrimp fisheries has been substantially reduced since the 1990s by use of separator grates in trawls, but could still be frequent enough to affect recovery. (COSEWIC 2010a)

Table 3.20 (Cont'd) COSEWIC Designated Species that Occur Rarely in the Strait of Belle Isle

Species	Risk Category	Reason for Designation (COSEWIC)
Deepwater Redfish (*Sebastes mentella*)	COSEWIC Endangered (April 2010)	Abundance of mature individuals has declined 99% in areas of highest historical abundance over about two generations. However, since the 1990s, there has been no long-term trend in one area, and trends have been stable or increasing in other areas where large declines have been previously observed. Directed fishing and bycatch are the main known threats. Fisheries in parts of the range of this designatable unit (DU) are currently closed, but remain open in other areas. Bycatch in shrimp fisheries has been substantially reduced since the 1990s by use of separator grates in trawls, but could still be frequent enough to affect population recovery.
Porbeagle Shark (*Lamna nasus*)	COSEWIC – Endangered (May 2004)	Abundance of this oceanic shark declined greatly since the 1990s, when Canada had entered the fishery. This was following an earlier collapse and partial recovery. Fishery for this species is closed in some areas where adults occur, but remains open, and consists mainly of juvenile landings. The porbeagle shark is particularly vulnerable to over exploitation due to its life history characteristics, including late maturity, and low fecundity.
White Shark (*Carcharodon carcharias*)	COSEWIC – Endangered (April 2006)	Canada is considered to be the northern limit of this top predator. There have been only 32 records of this species over 132 years for all of Atlantic Canada, and no abundance trend information exists. It is estimated that the population has declined around 80% over 14 years in the North West Atlantic, outside Canadian waters. Vulnerability of this species is perhaps due to its long generation time (approximately 23 years), low reproductive rates (gestation is 14 months, and average fecundity is 7 live-born young). By-catch in the pelagic longline fishery is the primary threat to this species.
Shortfin Mako (*Isurus oxyrinchus*)	COSEWIC – Threatened (April 2006)	There does not appear to be any reason to assume that the Canadian Atlantic "population" is demographically or genetically independent from the larger Atlantic population, so the status of the species in Atlantic Canada should reflect the status throughout the North Atlantic. Two analyses suggest recent declines in North America as a whole (40% - 1986-2001; 50% - 1971-2003). This large shark (maximum length 4.2 m) is late maturing (7-8 years), and therefore vulnerable to mortality from by-catch in longline and other fisheries.
Cusk (*Brosme brosme*)	COSEWIC – Threatened (May 2003)	Has declined over 90% over 3 generations and occurs in fewer and fewer survey trawls. Fishing, although now capped, was unrestricted until 1999 and still remains a source of mortality.

4.0 SUMMARY

Nalcor Energy is proposing to develop the Labrador – *Island Transmission Link*, a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula.

In preparation for, and support of, the Project's environmental assessment, this *Marine Fish and Fish Habitat: Information Review and Compilation* has been completed with the objective to gather, summarize and present existing and available information on fish and fish habitat in the Strait of Belle Isle, for use as environmental baseline information in the EA.

This study has assembled environmental baseline information related to marine fish and fish habitat in the Strait of Belle Isle by compiling and reviewing existing and available information from the literature as well as data from relevant government and non-governmental agencies. Experts were consulted during the process to provide the study team with information and data relevant to the Study Area, and to supplement information existing in the literature.

4.1 Climate and Weather

Weather in the vicinity of the Strait of Belle Isle is influenced by storm tracks, wind direction and the presence of sea ice. During summer, low pressure systems track across southern Labrador or the North Shore of Quebec and average temperatures are 12˚C while rainfall averages 300 mm. During winter, low pressure systems are more intense, taking two major tracks: south or southeast of Newfoundland, and through the Gulf of St. Lawrence through the Strait, or Lower North Shore of Quebec. In winter, average temperatures are near -10 ˚C while snowfall amounts are near 400 mm. Winds are frequently aligned with the Strait, with a predominant southwest (from) wind direction.

4.2 Physical and Chemical Oceanography

The bathymetry of the Strait of Belle is delineated into five physiographic zones: the Labrador Coastal Zone, the Labrador Trough (maximum depths of 115 m and a width of 1 to 2 km), Centre Banks South and North (depths ranging 15 to 85 m), the Newfoundland Trough (5 to 12 km wide, 70 to 125 m deep), and the Newfoundland Coastal Zone. Recent bathymetric data was primarily obtained from a geophysical survey program conducted on behalf of Nalcor Energy by Fugro Jacques GeoSurveys Inc. in the Strait of Belle Isle from August to October 2007 and supplemented by data obtained from the Canadian Hydrographic Service.

Water in the Strait of Belle Isle is stratified as a two layer system in summer and a homogeneous layer in fall and winter. In summer, the surface layer, down to 50 to 60 m, has average temperatures between 10 and 11˚C, and salinities between 30.6 and 32 psu. Bottom layer temperatures range between -0.4 and 3.5˚C, and salinity between 31.5 and 32 psu. Conditions in the fall and winter are colder and saltier, with one homogeneous layer forming in October.

Currents in the Strait of Belle Isle have a strong tidal component, following the orientation of the Strait, with velocity highest at the surface and decreasing with depth. Meteorological conditions influence surface currents. Water flow moves in two directions through the Strait, with cold water flowing in from the Labrador shelf along the Labrador coast with a southerly flow out along the coast of Newfoundland. Tides in the Strait are semi-diurnal with two complete oscillations per day. Tidal amplitude is modest with mean tides of 1.5 m and large tides up to 2.2 m, with maximum large tides exceeding 3.0 m.

The predominant wave direction on the Labrador shore is from the southwest, with waves of 0 to 0.5 m occurring about 54 percent of the time. Waves closest to the Newfoundland shoreline are predominantly westerly with waves of 0 to 0.5 m occurring about 60 percent of the time.

4.3 Sea Ice and Icebergs

Sea ice in the Strait originates from two sources: locally formed sea ice, and pack ice that has drifted from the Labrador Sea or Arctic regions. Sea ice is often formed from collisions of individual floes creating sea ice several metres thick. Local ice first begins to form in mid to late December while pack ice drifts in by late January, covering the area. Ice moves with the wind and currents with only small portions moving into the Gulf of St. Lawrence.

Large numbers (60 to 90) of icebergs drift into the Strait of Belle Isle each year with the largest numbers occurring in May and June. These typically enter on the Labrador side, move with currents, and exit on the island side. Iceberg scour risk assessment indicates a shoal in the area may prevent larger, deeper icebergs from passing. Evidence of ice scouring however, demonstrates that some large icebergs pass through the Strait, scouring the seabed on the bottom.

4.4 Bottom Substrates and Coastal Habitats

The overburden underlying the Strait averages 0.5 to 1.0 m thick and is composed of a layer of shells/shell fragments overlying sand, gravel, cobbles, and boulders. Sand and gravel waves in the substratum suggests the bottom is mobile, indicative of strong bottom currents. Acoustic classification determined 90 percent of the seabed is comprised of pebbles, cobbles, and boulders. Substrate distributions in shoreline to offshore zones determined that the proportion of bedrock and fines decreased with increasing depth zone while the coarse-small component was greatest in the deepest zone.

From aerial surveys, the ASMP program classified the shoreline on the Newfoundland side of the Strait only. The Lower Intertidal Zone consists primarily of bedrock, with a proportion of mixed coarse material with no sand making up a small proportion of the area, and is mostly platforms with some beaches. The shoreline consists of primarily beaches of various types (boulders, mixed sand-gravel, pebble-cobble and sand). The backshore area on the Newfoundland side of the Strait is dominated by beaches and cliffs.

Shoreline habitats at the alternate landing sites for the proposed submarine cable crossing were also characterized. At the Forteau Point site, substrate in the intertidal zone consists of bedrock, bedrock with sand deposits, and boulders while the backshore consists of grasses, lichens, mosses, shrubs and trees, terminating at the base of cliffs. At the L'Anse Amour site, substrate in the intertidal zone is a beach changing from mostly sand to mostly gravel/cobble while the backshore has three distinct areas: (i) grasses; (ii) grasses with shrubs, and (iii) grasses, shrubs and trees, also terminating at the base of a cliff. On the Newfoundland side, at the Mistaken Cove site the intertidal zone consisted of exposed bedrock and sand/gravel beaches, while the backshore consisted of areas with grass or trees and tuckamore. The Yankee Point location consisted of bedrock with gravel/pebbles or gravel beaches in the intertidal zone, and mostly areas of grass with patches of tuckamore in the backshore area. The shorelines of discrete reaches of coastline in the Strait have been classified from aerial video reconnaissance and six shoreline types were delineated: (i) Bedrock Cliff, (ii) Bedrock Tidal Flats, (iii) Boulder Tidal Flats, (iv) Gravel Beaches, (v) Sandy Beaches, and (vi) Tidal Mud Flats.

4.5 Biological Environment: Plankton, Benthic Invertebrates and Algae

The Strait of Belle Isle is considered an important area in terms of primary production as bottom upwelling brings nutrient-rich bottom water to the surface due to a combination of topography, wind and currents where tidal mixing and upwelling processes results in highly productive conditions. The phytoplankton bloom in the Strait appears to typically occur in late March/early April, immediately following ice melt.

Zooplankton, the link between primary production and higher-level organisms, transfers organic carbon to fish and animals higher in the food chain. The waters from the Labrador shelf, and the circulation into the Gulf of St. Lawrence, provides the region with a larval plankton transport mechanism and snow crab larvae from the Labrador shelf are transported to the northern Gulf of St. Lawrence by the currents in the Strait. Krill, a key species in the food web in the Gulf of St. Lawrence, has a primary retention area in the Northeastern Gulf within the Strait.

Benthic invertebrates, as infaunal (in the seafloor) and epifaunal (on the sea floor or attached to it) components, depend on environmental conditions, bottom type, and oceanographic processes. The Strait of Belle Isle was determined to be an important area for benthic invertebrates mostly due to large aggregations of shrimp species. Information from DFO scientific multispecies surveys identified 20 species of shrimp, species of soft coral, anemones, sponges, tunicates, sea stars, sea urchins, as well as various bivalve and crab species. Macrofaunal surveys along the corridors of the proposed submarine cable crossings in 2008 and 2009 found 35 and 20 taxa, respectively.

Detailed information on algal communities in the Strait area is generally lacking. Macrofloral surveys along the corridors of the proposed submarine cable crossings in 2008 and 2009 (nearshore only) found 9 and 17 taxa, respectively. Coralline algae (various species) occurred the majority of the time within the survey area, while crustose algae also occurred over much of the area. Community Coastal Resource Inventory (CCRI) data identified ‘notable’ areas for aquatic plants including kelp, Irish moss, eel grass and rockweed.

4.6 Biological Environment: Marine Fish Species

A large number of groundfish species were captured in DFO scientific and sentinel fisheries surveys from 1999 to 2009 including: cod species, skate, sculpin, alligator fish, eelpout, snailfish, shanny, and wolffish. CCRI data were also used to develop maps of potential spawning areas for cod, lumpfish, flounder, winter flounder, and sandlance. The biology, distribution, habitat use, and role of the species in commercial fisheries were described for lumpfish, Greenland halibut (turbot), and witch flounder (grey sole).

Pelagic fish captured in the DFO surveys included: Atlantic herring, capelin, Atlantic mackerel, Atlantic sturgeon, spiny dogfish, black dogfish, and other shark species. DFO has also identified the Strait as an Ecologically and

Biologically Significant Area (EBSA) for pelagic fish species due to feeding concentrations. The Strait is also considered an important spawning area for herring. Atlantic herring, capelin, and Atlantic mackerel were discussed in detail in relation to biology, distribution, habitat use, and commercial fisheries. Salmonid fishes including Atlantic salmon, Arctic char, and brook trout were discussed as important migrants through, as well residents within estuaries in, the Study Area. CCRI data identified that many pelagic fish species were caught recreationally (trout, salmon, capelin, herring, mackerel), commercially (salmon, capelin, herring, mackerel, eel, shark) or observed (the above plus char, stickleback, sunfish, swordfish and tuna) in the Study Area. Spawning areas were noted for capelin, herring, mackerel, and salmon.

Shellfish captured in the Strait in the DFO surveys included: crab species including snow crab, hermit crab, toad crab and others, and a wide variety of shrimp species. Other shellfish found in the Study Area include Iceland scallop, American lobster, and sea cucumber. There is interest in an Arctic surf clam fishery in the Strait with fisheries development studies being undertaken. Iceland scallop, snow crab, toad crab, shrimp, American lobster, and sea cucumber were discussed in detail in relation to biology, distribution, habitat use, and commercial fisheries. CCRI data identified commercial fishery locations for surf clam, sea urchin, scallop, whelk, toad crab, squid, and lobster. Recreational fishing locations were identified for surf clam and mussel. Observations of surf clam, sea urchin, scallop, whelk, and mussel distributions were also noted.

There are a number of fish species of special conservation concern occurring within the Strait of Belle Isle. These species have either been designated under *SARA* or have been designated by COSEWIC. Those species listed under Schedule 1 of *SARA* are legally protected under the Act, and measures are developed to protect these species and their critical habitat. Species of that are known to or may occur within the Study Area which have legal protection under Schedule 1 of *SARA* include three species of wolffish (Atlantic, Northern, and spotted). Atlantic cod, American eel, American plaice, spiny dogfish and basking shark have all been assessed by COSEWIC but have not yet been designated under *SARA*.

As illustrated above, the Strait of Belle Isle is home to a wide and diverse range of fish species. Table 4.1 provides a summary of the identified time periods that may be particularly important or sensitive for specific fish species within the Strait of Belle Isle.

Table 4.1 Potentially Important Time Periods for Various Fish Species in the Strait of Belle Isle

Species	Time Period	Explanation
Lumpfish	May and June	Spawning in coastal areas
Greenland halibut	January through March	Spawning
Witch flounder	May to July	Spawning in deeper waters. Begin aggregating in January and February
Capelin	June and July	Spawning in coastal and intertidal waters
Atlantic herring	Mid-July to mid-September	Spawning near the coast in the Strait of Belle Isle
Atlantic salmon	Mid-July	Smolts pass through the Strait of Belle Isle
Atlantic cod	April	Spawning in Northern Gulf of St. Lawrence
Northern wolffish	November to December	Spawning
Spotted wolffish	Summer	Spawning

Sensitive areas within the Strait of Belle Isle include spawning areas; although these have only been identified through anecdotal information such as the CCRI database. The areas of St. John Bay, St. Genevieve Bay, St. Margarets Bay and Pistolet Bay have also been identified as being sensitive areas within the Study Area, due to it being closed to scallop fishery in order to protect American lobster stocks.

5.0 REFERENCES

AMEC Earth and Environmental. 2010. Labrador – Island Transmission Link: Marine Flora, Fauna and Habitat Survey – Strait of Belle Isle Subsea Cable Crossing Corridors. Report prepared for Nalcor Energy, February 2010.

Anderson, T.C., S.D. Lambert, J.M. Simms and T. Taylor-Walsh. 2000. Marine areas with special protection, Newfoundland and Labrador. Can. Manuscr. Rep. Fish. Aquat Sci. No. 2507: vii + 126p.

Ardisson, P.-L. and E. Bourgel. 1992. Large-scale ecological patterns: Discontinuous distribution of marine benthic epifauna. Mar. Ecol. Prog. Ser. 83:15-34.

Barrie, J. and S. Browne. 1980. Nearshore studies of marine benthos in the Makkovik Bay and Cartwright regions. pp. 154-173. *In:* Proceedings 1980 Workshop on Research in the Labrador Coastal and Offshore Region, Goose Bay, Labrador, Sept. 4-6, 1980. Sponsored by Memorial University, Newfoundland and Labrador Dept. of Mines and Energy, and Petro-Canada.

Bérubé, M. and A. Fréchet. 2001. Summary of the northern Gulf sentinel tagging program with emphasis on recaptures from adjacent management units. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/002.

BIO 2010. Hydrographic database and ocean data inventory database. Available at: http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query_f.html/. Accessed July 2010.

Bourdages, H., D. Archambault, B. Bernier, A. Fréchet, J. Gauthier, F. Grégoire, J. Lambert and L. Savard. 2010. Preliminary results in the groundfish and shrimp multidisciplinary survey from August 2009 in the northern Gulf of St. Lawrence. Can. Data Rep. Fish. Aquat. Sci. 1226: xii + 72 p.

Brattey, J. 2010. Personal Communication. Research Scientist, Department of Fisheries and Oceans, St. John's, NL. Email. May 7th, 2010.

Cairns, D.K., V. Tremblay, F. Caron, J.M. Casselman, G. Verreault, B.M. Jessop, Y. de Lafontaine, R.G. Bradford, R. Verdon, P. Dumont, Y. Mailhot, J. Zhu, A. Mathers, K. Oliveira, K. Benhalima, J. Dietrich, J.A. Hallett, and M. Lagacé. 2008. American eel abundance indicators in Canada. Can. Data Rep. Fish. Aquat. Sci. No. 1207. 78 pp.

Canning and Pitt. 2010. Marine Fisheries in the Strait of Belle Isle. Report prepared for Nalcor Energy.

Catto, N.R., H. Griffiths, S. Jones, and H. Porter. 2000. Late Holocene sea level changes, eastern Newfoundland. *Current Research (Newfoundland and Labrador Geological Survey).* 2000-1; 49-59.

C-CORE. 2004. Iceberg Scour Risk in the Strait of Belle Isle. Contract Report Prepared for SGE Acres Limited. C-Core Report R-04-004-011, April 2004. Available: http://www.gov.nf.ca/publicat/fixedlink/pdf/AppendixB.pdf

Collins, R., Stansbury, D., Veitch, P., and Janes, J. 2009. Recent trends and management changes in the American lobster (*Homarus americanus*) fishery in Newfoundland. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/096. iv + 29 p.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2000. COSEWIC assessment and status report on the Atlantic wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp.

COSEWIC 2001a. COSEWIC assessment and status report on the northern wolffish *Anarhichas denticulatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp.

COSEWIC 2001b. COSEWIC assessment and status report on the spotted wolffish *Anarhichas minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp.

COSEWIC 2006. Assessment and Status Report on the American Eel, *Anguilla rostrata*, in Canada. COSEWIC Secretariat, Ottawa, ON. X + 71 pp.

COSEWIC 2009. COSEWIC assessment and status report on the American Plaice *Hippoglossoides platessoides*, Maritime population, Newfoundland and Labrador population and Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 74 pp.

COSEWIC 2010a. Wildlife Species Assessments (detailed version), April 2010 Available at http://www.cosewic.gc.ca. Accessed May, 2010

COSEWIC 2010b. Wildlife Species Search: Basking Shark. Available at: http://www.cosewic.gc.ca. Accessed May 2010.

COSEWIC 2010c. Wildlife Species Search: Spiny Dogfish. Available at: http://www.cosewic.gc.ca. Accessed May 2010.

Chabot, D. 2010. Personal Communication. Research Scientist, Department of Fisheries and Oceans, Mont-Joli, QC. Phone Call. May 13th, 2010.

Chabot, D., A. Rondeau, B. Sainte-Marie, L. Savard, T. Surette, and P. Archambault. 2007. Distribution of benthic invertebrates in the estuary and Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/018.

Curry, R.A., J. van de Sande, and F.G Whoriskey. 2006. Temporal and spatial habitats of anadromous brook charr in the Larval River and its estuary. Environ. Biol. Fish 76:361-370

Dawson, W. B. 1907. The currents in Belle Isle Strait. Report to the Department of Marine and Fisheries, Ottawa, cited in Hatch Mott Mcdonald (2004) and others.

de Lafontaine, Y., S. Demers, and J. Runge. 1991. Pelagic food web interactions and productivity in the Gulf of St. Lawrence: A perspective. pp. 99-123. *In:* (ed.) J-C. Therriault The Gulf of St. Lawrence: Small Ocean or Big Estuary? Canadian Special Publication of Fisheries and aquatic Sciences 113

Dempson, J. B. 1982. Ecology and comparative population dynamics of anadromous Arctic char, *Salvelinus alpinus* (Iinnaeus 1758), in northern Labrador. M.Sc. Thesis, Memorial University of Newfoundland. 190 p.

DFA (Department of Fisheries and Aquaculture). 2002a. American Eel Harvesting Pilot Project – Labrador Straits. Fisheries Diversification Program. FDP-293.

DFA (Department of Fisheries and Aquaculture). 2002b. Toad Crab Biological Study – Labrador Straits. Fisheries Diversification Program. FDP-273.

DFA (Department of Fisheries and Aquaculture). 2002c. Toad Crab Exploratory Survey – Labrador. Fisheries Diversification Program. FDP-273-1.

DFO (Fisheries and Oceans). 2003. Snow Crab. Available at: http://www.dfo-mpo.gc.ca/media/back-fiche/2003/snowcrab-eng.htm. Accessed: April 2010.

DFO (Fisheries and Oceans). 2005a. The Gulf of St. Lawrence. A Unique Ecosystem, Oceans and Science Branch, Fisheries and Oceans Canada, © Her Majesty the Queen in Right of Canada, 2005. Cat. No. FS 104-2/2005, ISBN 0-662-69499-6

DFO (Fisheries and Oceans). 2005b. Stock assessment report on Newfoundland and Labrador snow crab. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2005/017.

DFO (Fisheries and Oceans). 2005c. Witch Flounder (Divs. 4RST). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/011.

DFO (Fisheries and Oceans). 2006a. Assessment of Lumpfish in the Gulf of St. Lawrence (3Pn, 4RST) in 2005. DFO Can. Sci. Advis. Sec., Sci., Advis. Rep. 2006/034.

DFO (Fisheries and Oceans). 2006b. Assessment of the west coast of Newfoundland (Division 4R) herring stocks in 2005. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2006/021.

DFO (Fisheries and Oceans). 2006c. Proceedings of the Zonal Workshop on the identification of Ecologically and Biological Significant Areas (EBSA) within the Gulf of St. Lawrence and Estuary. DFO Can. Sci. Advis. Sec. Proceedings Series. 2006/011.

DFO (Fisheries and Oceans). 2007a. Ecologically and Biologically Significant Areas (EBSA) in the Estuary and Gulf of St. Lawrence: identification and characterization. DFO Can. Sci. Advis. Sec., Sci. Adv. Rep. 2007/016.

DFO (Fisheries and Oceans). 2007b. Hydrographic Database: Temperature-Salinity Climatologies. Available at: http://www.mar.dfo-mpo.gc.ca/science/ocean/tsdata.html/. Accessed July 2010.

DFO (Fisheries and Oceans). 2008a. Assessment of the Atlantic Mackerel stock for the Northwest Atlantic (Subareas 3 and 4) in 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/041.

DFO. (Fisheries and Oceans) 2008b. Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin Stock in 2007. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2008/037.

DFO (Fisheries and Oceans). 2008c. State of the Ocean 2007: Physical Oceanographic Conditions in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/016.

DFO (Fisheries and Oceans). 2009a. An Assessment of the Iceland Scallop (*Chlamys islandica*) Resource in the Strait of Belle Isle and the Lilly Carson Canyons. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/043.

DFO (Fisheries and Oceans). 2009b. Assessment of cod stock in the northern Gulf of St. Lawrence (3Pn,4RS) in 2008. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/010.

DFO (Fisheries and Oceans). 2009c. Assessment of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17, 12A, 12B, 12C and 16A) Snow crab stocks in 2008. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/027.

DFO (Fisheries and Oceans). 2009d. Assessment of the Greenland halibut stock in the Gulf of St. Lawrence (4RST) in 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/020.

DFO (Fisheries and Oceans). 2009e. Conservation objectives for the Ecologically and Biologically Significant Areas (EBSA) of the Estuary and Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/049.

DFO (Fisheries and Oceans). 2009f. Operational Remote Sensing. Available at: http://www.mar.dfo-mpo.gc.ca/science/ocean/ias/seawifs/seawifs_4.html/. Accessed July 2010.

DFO (Fisheries and Oceans). 2009g. Underwater world: Witch Flounder. Available at: http://www.dfo-mpo.gc.ca/Science/publications/uww-msm/articles/witchflounder-pliegrise-eng.htm. Accessed May 2010.

DFO (Fisheries and Oceans). 2009h. State of the Ocean 2008: Physical Oceanographic Conditions in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/019.

DFO (Fisheries and Oceans). Unpublished Data. 2010. Angling statistics for selected rivers and counting fence data from Western Arm Brook.

DFO (Fisheries and Oceans). 2010a. Assessment of shrimp stocks in the Estuary and Gulf of St. Lawrence in 2009. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2010/008.

DFO (Fisheries and Oceans). 2010b. Atlantic wolffish. Available from: http://www.dfo-mpo.gc.ca/species-especes/species-especes/wolffish-loup-at-eng.htm/

DFO (Fisheries and Oceans) 2010c. Canadian Hydrographic Service, Tides, Currents and Water Levels. Available at: http://www.waterlevels.gc.ca/english/Canada.shtml)

DFO (Fisheries and Oceans) 2010d. DFO Scientific Survey and Sentinel Fisheries Database.

Enfotec Technical Services. 1998. The Ice Regime of the Gulf of St. Lawrence. Report prepared for the Association of Maritime Arbitrators of Canada, Ottawa, ON. Available at: http://www.amac.ca/enfotec1.htm

Environment Canada. 2005. The decline of the American eel in the St. Lawrence river. Available at: http://www.qc.ec.gc.ca/csl/inf/inf052_e.html. Accessed April 2010.

Environment Canada. 2010a. Canadian Climate Normals; Plum Point and Flowers Cove, Newfoundland and Labrador, Blanc Sablon, Quebec. Available at: http://climate.weatheroffice.ec.gc.ca/climate_normals/stnselect_e.html/. Accessed July 2010.

Environment Canada. 2010b. Ice Climatology. Available at: http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=7E34FF80-1/. Accessed July 2010.

Farquaharson, W.I. 1970. Tides, tidal streams, and currents in the Gulf of St. Lawrence. Second Edition, Part 1, Tides and Tidal Streams, AOL Report 170-5. Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth, NS.

Farquharson, W.I. and W.B. Bailey. 1966. Oceanographic study of Belle Isle Strait 1963. Bedford Inst. Oceanogr. Rep. 66-9, Dartmouth, N.s., 78 pp.

Fréchet, A., J. Gautheir, P. Schwab, F. Collier, and J. Spingle. 2006. Tagging of Lumpfish (*Cyclopterus lumpus*) in the Northern Gulf of St. Lawrence from 2004 to 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/084.

Fugro-Jacques GeoSurveys Inc. 2010. Marine habitat in the Strait of Belle Isle: Interpretation of 2007 geophysical (sonar) survey information for the submarine cable crossing corridors. Report prepared for Nalcor Energy.

Garrett, C. and B. Petrie. 1981. Dynamical aspects of the flow through the Strait of Belle Isle. Journal of Physical Oceanography. 11(3): 376-393.

Garrett, C. and B. Toulany. 1981. Variability of the flow through the Strait of Belle Isle. J. Mar. Res. 39: 163-189.

Garrett, C. and B. Toulany. 1982. Sea level variability due to meterological forcing in the Northeast Gulf of St. Lawrence. Journal of Geophysical Research. 87(C3): 1968-1978.

Gilkinson, K. 1986. Review and assessment of the literature on marine benthic molluscs (Amphineura, Bivalvia, Gastropoda) in Newfoundland and Labrador waters. NAFO Science Council Studies, 10: 93-108

Grant, S.M. 2006. Biological Resource Assessment of the Orange Footed Sea Cucumber (*Cucumaria frondosa*) Occurring in the Strait of Belle Isle. Submitted to the Canadian Centre for Fisheries Innovation, St. Anthony Basin Resources Inc. and Fisheries and Oceans Canada.

Gregoire, F., C. Savenkoff, and D. Chabot. 2006. Atlantic mackerel (*Scomber scombrus* L.) fishery, biology, diety composition and predation in NAFO subareas 3 and 4 in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/096.

Gregoire, F., J. Gauthier, C. Savenkoff, C. Levesque, J.-L. Beaulieu. and M.-H. Gendron. 2008. Commercial fishery, by-catches and biology of capelin (*Mallotus villosus*) in the Estuary and Gulf of St. Lawrence (NAFO Divisions 4RST) for the 1960 -2007 period. Can. Sci. Advis. Sec. Research Doc. 2008/084

Hardy. 1985. Evaluation of biological community studies of the southern and southeastern Newfoundland shoreline. Report by Hardy Associates (1978) Ltd. to Petroleum Directorate, Government of Newfoundland and Labrador, St John's, Newfoundland. 251 p.

Harrison, W.G. and W.K.W. Li. 2008. Phytoplankton growth and regulation in the Labrador Sea: Light and nutrient limitation. Journal of Northwest Atlantic Fisheries Science, 39: 71-82.

Hatch Mott McDonald 2004. Fixed link between Labrador and Newfoundland. Pre-feasibility study final report. Available at: http://www.gov.nf.ca/publicat/fixedlink/. Accessed March 2010.

Huntsman, A.G.,W.B. Bailey and H.B. Hachey. 1954. The general oceanography of the Strait of Belle Isle. J. Fish. Res. Board Can. 11: 198-260.

Hutchings, J.A., R. A. Myers and G.R. Lilly. 1993. Geographic variation in the spawning of Atlantic cod, *Gadus morhua*, in the Northwest Atlantic. Can. J. Fish. and Aquat. Sci. 50: 2457-2467.

Jacques Whitford Environment Limited (JWEL). 2000. Churchill River Power Project. LHP 98-14. Benthic Habitat and Communities in the Strait of Belle Isle. Prepared for the Labrador Hydro Project. JWEL Study 1211.

Kelly, J. R. Power, L. Noble, J. Meade, J. Kelly, K. Reid, S. Kuehnemund, C. Carley, C. Grant, M. Roberge, E. Lee, M. Teasdale. 2009 (Draft). A System for Characterizing and Quantifying Coastal Marine Habitat in Newfoundland and Labrador. Fisheries and Oceans Canada, Marine Environment and Habitat Management, St. John's NL. v + 81 pp (Draft, February 2009).

Kulka, D.W. 2006. Abundance and distribution of demersal sharks on the Grand Banks with particular reference to the NAFO Regulatory Area. Northwest Atlantic Fishery Organisation SCR Doc 06/20

Kulka, D., C. Hood and J. Huntington. 2007. Recovery Strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and Management Plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada [Proposed]. Fisheries and Oceans Canada: Newfoundland and Labrador Region. St. John's, NL. x + 103 pp.

Lambert, J. 2010. Personal Communication. Biologist, Department of Fisheries and Oceans, Mont-Joli, QC. Email. April 16th, 2010.

Laurel, B.J., R.S. Gregory and J.A. Brown. 2003. Predator distribution and habitat patch area determine predation rates on Age-0 juvenile cod *Gadus spp*. Mar. Ecol. Prog. Ser. 251: 245-254.

Lawson, J. 2010. Personal Communication. Research Scientist, Marine Mammals Section, Department of Fisheries and Oceans, St. John's, NL. Meeting. April 19th, 2010.

Lee, E. and M. Teasdale. 2008. Development of a coastal, marine, estuarine, and deep water fish habitat classification system for the Newfoundland and Labrador Region. Fisheries and Oceans Canada. Draft Report.

LeDrew B. 1984. Southeastern Newfoundland marine resources: a literature review. Report to Newfoundland Department of Development by LeDrew Environmental Management Ltd., and Oceans Ltd., St. John's, Newfoundland. 413 p.

MacLaren. 1977. Report on biological literature review of the Labrador Sea region. Report for Imperial Oil Ltd., by MacLaren Atlantic Ltd., St John's, Newfoundland. 109 p.

McQuinn, I. H., M.O. Hammill, and L. Lefebvre. 1999. An assessment and risk projections of the west coast of Newfoundland (NAFO division 4R) herring stocks (1965 to 2000). DFO Can. Stock Assess. Sec. Res. Doc. 99/119.

Melindy, S. 2010. Personal Communication. Labrador and Aboriginal Affairs, Happy Valley-Goose Bay, NL. Phone Call. April 7th, 2010.

Méthot, R., M. Castonguay, Y. Lambert, C. Audet, and S.E. Campana. 2005. Spatiotemporal distribution of spawning and stock mixing of Atlantic cod from the northern Gulf of St. Lawrence and southern Newfoundland stocks on Burgeo Bank as revealed by maturity and trace elements of otoliths. J. Northw. Atl. Fish. Sci. 36: 31-42.

Morgan, M.J. and E.A. Trippel 1996. Skewed sex ratios in spawning shoals of Atlantic cod (*Gadus morhua*) ICES Journal of Marine Science. 53: 820-826.

Mullins, C. 2010. Personal Communication. Coordinator, Oceans and Coastal Management, Department of Fisheries and Oceans, St. John's, NL. Phone Call. March 31st, 2010.

Naidu, K.S., F.M. Cahill and M.E. Seward. 1996. Abundance of Iceland scallops in NAFO Div. 4R (Strait of Belle Isle) Declines Further in 1995. DFO Atlantic Fisheries Res. Doc. 96/49. 22p.

Naidu, K.S., F.M. Cahill, and E.M. Seward. 2001. The scallop fishery in Newfoundland and Labrador becomes beleaguered. DFO Can. Sci Advis. Sec. Res. Doc. 2001/064.

NORDCO Ltd. 1978. Current Metering Program, 1978, Strait of Belle Isle. Report to Newfoundland and Labrador Hydro.

Nordic Economic Development Corporation. 2000. Community Coastal Resource Inventory – Labrador Straits. Report prepared for Department of Fisheries and Oceans.

Nordic Economic Development Corporation. 2010. Save Our Char Committee. Five year strategic recovery plan for the sea run Arctic char in Parkers River (Western Brook). Available At: http://www.nedc.nf.ca/socc/5yearplan.pdf/. Accessed April 2010.

Nova Scotia Department of Fisheries and Aquaculture (NSDFA). 2010. Available at: http://www.gov.ns.ca/fish/sportfishing/species/spec.shtml/. Accessed May 2010.

Nova Scotia Research Foundation. 1974. Final report on the bottom and sub-bottom surveys in the Strait of belle Isle, Newfoundland. Prepared for Teshmont Engineering Consultants, Winnipeg, MN.

Petrie, B. and B. Toulany. 1988. The transport of water, heat and salt through the Strait of Belle Isle. Atmosphere-Ocean. 26(2): 234-251.

Power, D. 2010. Personal Communication. Biostatistics Technician, Department of Fisheries and Oceans, St. John's, NL. Email. May 3rd, 2010.

Reddin, D.G. 2006. Perspectives on the marine ecology of Atlantic salmon (*Salmo salar*) in the Northwest Atlantic. Can. Sci. Advis. Sec. Res. Doc. 2006/018.

Savenkoff, C., M. Castonguay, R. Méthot, D. Chabot, and M.O. Hammill. 2005. Input data and parameter estimates for ecosystem models of the northern Gulf of St. Lawrence (2000– 2002). Can. Tech. Rep. Fish. Aquat. Sci. 2588

Savenkoff, C., F. Gregoire, M. Castonguay, J.M. Hanson, D. Chabot, and D.P. Swain. 2006. Main prey and predators of Atlantic herring (*Clupea harengus L.*) in the Gulf of St. Lawrence during the mid-1980s, mid-1990s, and early 2000s. Can. Tech. Rep. Fish. Aquat. Sci. 2643: vi+28 pp.

Savenkoff, C., M.-N. Bourassa, D. Baril, and H.P. Benoît. 2007. Identification of Ecologically and Biologically Significant Areas for the Estuary and Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/015.

Scott W. B., and M. G. Scott. 1988. Atlantic Fishes of Canada. Can. Bull. Fish. Aquat. Sci. 210: 731p.

Sikumiut Environmental Management Ltd. 2008. Labrador Shelf Strategic Environmental Assessment. Prepared for the Canada-Newfoundland Labrador Offshore Petroleum Board.

Smedbol, R.K. and J.S. Wroblewski. 1997. Evidence for inshore spawning of northern Atlantic cod (*Gadus morhua*) in Trinity Bay, Newfoundland. 1991-1993. Can. J. Fish Aquat. Sci. 54: 1777-1786.

Smith, M.W. and J.W. Saunders. 1958. Movement of brook trout (*Salvelinus fontinalis*, Mitchell) between and within fresh and salt water. J. Fish. Res. Bd. Can. 15:1403-1449.

SNC-Lavalin, FENCO Ltd. 1980. Strait of Belle Isle crossing: submarine cable scheme. Contract report for Lower Churchill Development Corporation.

SNC-Lavalin, 1982. Strait of Belle Isle crossing: submarine cable scheme. Contract report for Lower Churchill Development Corporation.

Sourisseau, M., Y. Simard, and F.J. Saucier. 2004. Aggregation and advection of macro-zooplankton in the St. Lawrence System. ICES CM 2004/P:06.

South, G.R., A. Whitlatch and R. Hooper. 1979. Biological bibliography of the Labrador Sea and coastal Labrador. Report to Total Eastern Exploration Ltd., St John's, Newfoundland. 328 p.

Stansbury, D. 2010. Personal Communication. Section Head, Shellfish, Science Branch. Department of Fisheries and Oceans, St. John's, NL. Email, September 30, 2010

St. Lawrence Global Observatory. 2010. American Lobster. Available *at: http://slgo.ca/en/lobster/context.html*. Accessed May 2010.

Squires, H.J. 1990. Decapod crustacean of the Atlantic coast of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences, 221: 532 pp.

Swail, V.R., V.J. Cardone, M. Ferguson, D.J. Gummer, E.L. Harris, E.A. Orelup, and A.T. Cox. 2006. The MSC50 wind and wave reanalysis. 9^{th} International Wind and wave Workshop, September 25-29, 2006. Victoria, BC.

Taylor, C. 2010. Personal Communication. Director Labrador Region, Fisheries and Aquaculture, Happy Valley-Goose Bay,NL. Phone Call, May 10^{th}, 2010.

Thompson, R.J. and D.A. Aggett. 1981. Biological and oceanographic descriptions of the Labrador Sea region. Report to Can. National Parks Service, Ottawa, ON.130 p.

Toulany, B., B. Petrie, and C. Garrett. 1987. The frequency-dependent structure and dynamics of flow fluctuations in the Strait of Belle Isle. J. Phys. Oceunogr. 27: 185-196.

Tyler, P., J. E. Thorpe and W. M. Shearer. 1978. Ultrasonic tracking of the movements of Atlantic salmon smolts (*Salmo salar* L.) in the estuaries of two Scottish rivers. J. Fish. Biol. 12: 575-586.

Whoriskey, F. Personal Communication. 2010. V.P. Research and Environment. Atlantic Salmon Federation. NB. Email. March 29th, 2010.

Whoriskey, F., G. Chaput, P. Cameron, D. Moore and M. Hambrook. 2008. Sonic tracking of North American Atlantic salmon smolts to sea: correlates of specific survivals and lessons on the migration pathway. ICES WGNAS Working Paper 36.

Woodworth-Lynas, C.M.T., J.Y. Guigné and E.L. King. 1992. Surficial and bedrock geology beneath the Strait of Belle Isle in the vicinity of a proposed power-cable crossing. Newfoundland Department of Mines and Energy, Geological Survey Branch Report 92-2, 53 pp.

Yvelin, J.-F., A. Fréchet and J.-C. Brêthes. 2005. Migratory routes and stock structure of cod from the Northern Gulf of St. Lawrence (3Pn,4RS). DFO Can. Sci. Advis. Sec., Res. Doc. 2005/055 56p

APPENDIX A

Annotated Bibliography

Marine Fish and Fish Habitat in the Strait of Belle Isle:

Information Compilation and Review

Annotated Bibliography

(Google Earth, 2010)

Prepared By:
Sikumiut Environmental Management Ltd.
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Prepared For:
Nalcor Energy
Hydro Place, 500 Columbus Drive
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November 10th, 2010

AMEC Earth and Environmental. 2007. Physical environmental description for the cable crossing at the Strait of Belle Isle. Prepared for Newfoundland and Labrador Hydro and Fugro Jacques Geosurveys Inc.

This report gave a physical description of the environment in the vicinity of the Strait of Belle Isle. This entailed description of the climate and weather, winds, surficial geology and bedrock geology, physical oceanography among other sources of information. This report provided the main source of information for the physical environment section since it gave an exhaustive literature search of most aspects.

AMEC Earth and Environmental. 2010. Labrador – Island Transmission Link: Marine flora, fauna and habitat survey – Strait of Belle Isle subsea cable crossing corridors. Report prepared for Nalcor Energy.

Surveys completed in the vicinity of the proposed cable crossing corridors in 2008 and 2009 gave a good overview of the marine benthic fauna and flora present in the Study Area.

Anderson, T.C., S.D. Lambert, J.M. Simms and T. Taylor-Walsh. 2000. Marine areas with special protection, Newfoundland and Labrador. Can. Manuscr. Rep. Fish. Aquat Sci. No. 2507: vii + 126p.

A technical report describing marine areas in Newfoundland and Labrador that have, or have had, some level of protection, including closed areas for: fisheries conservation; fisheries management; contaminated fisheries; as well as coastal parks, heritage, and wildlife areas. Within the study area, the report describes St. John Bay, St. Margarets Bay, St. Genevieve Bay, and Pistolet Bay as areas closed for conservation, and also describes the area of Milan arm (Pistolet Bay) which was closed to bivalve harvesting due to polluted waters.

Ardisson, P.-L. and E. Bourgel. 1992. Large-scale ecological patterns: discontinuous distribution of marine benthic epifauna. Mar. Ecol. Prog. Ser. 83:15-34.

This article contains information on a benthic littoral fauna survey completed over a 12 year period. The study area is primarily focused in the estuary and North-West Gulf of St. Lawrence, however three sites were sampled in the Quebec region of the Strait of Belle Isle study area. The article presents a listing of several benthic species found in the three sampling sites within the Strait of Belle Isle study area, as well as their distribution throughout the rest of the Gulf of St. Lawrence.

Bérubé, M. and Fréchet, A. 2001. Summary of the northern Gulf sentinel tagging program with emphasis on recaptures from adjacent management units. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/002.

Reports on the results from the sentinel tagging surveys in the northern Gulf of St. Lawrence. This report demonstrates that most catches in the Strait of Belle Isle occur between July to October. These are found further south in 4R and 3Pn between September and December.

Bourdages, H., D. Archambault, B. Bernier, A. Fréchet, J. Gauthier, F. Grégoire, J. Lambert and L. Savard. 2010. Preliminary results in the groundfish and shrimp multidisciplinary survey from August 2009 in the northern Gulf of St. Lawrence. Can. Data Rep. Fish. Aquat. Sci. 1226: xii + 72 p.

This article discusses the preliminary results of trawl surveys from 2009 in the Gulf of St. Lawrence. Some of the survey points were within the Strait of Belle Isle study area. This article includes maps of trawl locations for species such as cod, Greenland halibut, redfish, northern shrimp, and snow crab to name a few.

Bourdages H., D. Archambault, B. Bernier, A. Frechet, J. Gauthier, F. Gregoire, J. Lambert and L. Savard. 2008. Preliminary results from the groundfish and shrimp multidisciplinary survey from August 2007 in the northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2008/046.

This article discusses results of trawl surveys from 2007 in the Gulf of St. Lawrence. Some of the survey points were within the Strait of Belle Isle study area. This article needs permission from the authors before it can be cited.

Brattey, J., and B. Healey. 2004. An exploratory analysis of the northern Gulf of St. Lawrence (3Pn4RS) Atlantic cod (Gadus morhua) tagging database. Can. Sci. Advis. Sec. Res. Doc. 2004/044.

This report looks at migrations of tagged Atlantic cod in the Gulf of St. Lawrence. The article reports re-captures in the Strait of Belle Isle study area. This report must not be cited without the permission of the authors.

C-CORE (2004). Iceberg Scour Risk in the Strait of Belle Isle. Contract Report Prepared for SGE Acres Limited. C-Core Report R-04-004-011, April 2004. Available: http://www.gov.nf.ca/publicat/fixedlink/pdf/AppendixB.pdf.

Report on iceberg scour and grounding rates in the Strait of Belle Isle.

Collins, R., Stansbury, D., Veitch, P., and Janes, J. 2009. Recent trends and management changes in the American lobster (Homarus americanus) fishery in Newfoundland. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/096. iv + 29 p.

This report has an overview of the management of the lobster fisheries in Newfoundland. This area does encompass the Strait of Belle Isle study area (Lobster Fishing Area LFA 14B and 14C). It gives the historical landings for St. John Bay lobster fisheries and size frequency distributions for those captured in St. John Bay including ovigerous, non-ovigerous and old-notched females, as well as males. This report also outlines the proportion of recruits captured in the commercial fishery.

Chabot, D., A. Rondeau, B. Sainte-Marie, L. Savard, T. Surette, and P. Archambault. 2007. Distribution of benthic invertebrates in the Estuary and Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/018.

This report, although in French, contains a great deal of information on benthic invertebrates in the study area. This study was an attempt to gather all the relevant information from DFO surveys in the

Maurice-Lamontagne Institute (MLI) and the Gulf Fisheries Centre (GFC). Distribution of 44 benthic invertebrate taxa is presented and relative abundance where possible.

Dawson, W.B. 1907. The currents in Belle Isle Strait. Report to the Department of Marine and Fisheries, Ottawa, cited in Hatch Mott McDonald (2004) and others.

Dawson (1907) was one of the first to report on the currents in the Strait of Belle Isle, describing the flow of water from the Labrador shelf to the Gulf of St. Lawrence and vice versa.

Dempson, J.B. 1982. Ecology and comparative population dynamics of anadramous Arctic char, Salvelinus alpines (Linnaeus 1758), in northern Labrador. M.Sc. Thesis, Memorial University of Newfoundland. 190 p.

This Masters thesis examines populations of Arctic char in Labrador, and outlines the presence of Arctic char in Parker's River in the Strait of Belle Isle Study Area.

DFA (Department of Fisheries and Aquaculture). 2002a. American eel harvesting pilot project – Labrador Straits. Fisheries Diversification Program. FDP-293.

Harvesting project to look at the feasibility and viability of harvesting American eel in several rivers in the region of the Strait of Belle Isle.

DFA (Department of Fisheries and Aquaculture). 2002a. Toad Crab Biological Study – Labrador Straits. Fisheries Diversification Program. FDP-273.

This report is an overview of the surveys of Toad Crab in the Strait of Belle Isle, in order to establish a size profile of the species in the area. This study sampled a total of 2,400 toad crabs, and has proved to be useful in helping resource management decisions.

DFA (Department of Fisheries and Aquaculture). 2002b. Toad Crab Exploratory Survey – Labrador. Fisheries Diversification Program. FDP-273-1.

This is a report on the Toad Crab exploratory surveys completed in 2001 and 2002 in Labrador, including the Labrador Straits area. It gives the total Catch Per Unit Effort, as well as the average size, width, percentage of males and females, and the percentage of softshell crab. The results of these surveys (along with those in 2000) demonstrated the possible value of the Toad Crab fishery in the area.

DFO (Fisheries and Oceans), 2001. Capelin of the Estuary and Gulf of St. Lawrence. DFO – Science Stock Status Report B4-03 (2001).

Report on the stock status of capelin based on data from landings in commercial fisheries in 1999 and 2000, as well as groundfish and shrimp research surveys conducted in 1999 and 2000.**DFO (Fisheries and Oceans), 2004. Identification of Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2004/006.**

Although this report does not contain any information on the Strait of Belle Isle, it provides an outline of the characteristics of Ecologically and Biologically Significant Areas (EBSAs). The Strait of Belle Isle has been identified as a potentially high priority EBSA.

DFO (Fisheries and Oceans), 2004. The Northern Gulf of St. Lawrence (3Pn, 4RS) cod in 2003. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/019.

This stock status report from 2003 outlines the biological characteristics of the Northern Gulf of St. Lawrence Atlantic cod stock, the historical fisheries in the area, and the status of the resource based on sentinel fixed gear fisheries, trawl surveys and tagging.

DFO (Fisheries and Oceans), 2004. West Coast of Newfoundland Atlantic Herring (Division 4R) in 2003. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/017.

Stock status report of NAFO division 4R Atlantic herring, which encompasses the Strait of Belle Isle study area (NAFO Subdivision 4Ra). This report includes information on spawning and feeding areas in 4R, as well as commercial landings in 2003, biomass and abundance indices.

DFO (Fisheries and Oceans), 2005a. Capelin of the Estuary and Gulf of St. Lawrence (4RST) in 2004. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/002.

Report regarding the status of the capelin stock in the Gulf of St. Lawrence, based on fisheries data and scientific trawl data. From preliminary investigation of this report, it appears that only research survey data exists for capelin in the Belle Isle Strait study area, and no fisheries data are included in this report.

DFO (Fisheries and Oceans), 2005b. Snow Crab of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17 and 12A, 12B and 12C) in 2004. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2005/027.

A report on the snow crab stocks in the Gulf of St. Lawrence area. This report has information regarding snow crab in Snow Crab area 13 which is the Strait of Belle Isle area.

DFO (Fisheries and Oceans), 2005c. The Gulf of St. Lawrence. A Unique Ecosystem, Oceans and Science Branch, Fisheries and Oceans Canada, © Her Majesty the Queen in Right of Canada, 2005. Cat. No. FS 104-2/2005, ISBN 0-662-69499-6

This article is an active document and provides an overview of the Gulf of St. Lawrence area, including the Strait of Belle Isle study area. It includes a great deal of information on the studies that have taken place, and physical and biological aspects of the region.

DFO (Fisheries and Oceans), 2005d. The Northern Gulf of St. Lawrence (3Pn, 4RS) cod in 2004. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/003

Report regarding the status of the Atlantic cod in the Gulf of St. Lawrence in 2004, based on fisheries data and scientific trawl data. It provides an indication of the migratory routes for the Atlantic cod in this area, and also provides landings from commercial fisheries between 1997 and 2004. The resource status is estimated based on information collected from sentinel fisheries, scientific trawl data and tagging returns.

DFO (Fisheries and Oceans), 2005e. West Coast of Newfoundland Atlantic Herring (Division 4R) in 2004. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/016.

This research document includes results of surveys conducted in NAFO division 4R, and herring landings by commercial fisheries. The map of scientific survey results indicates the presence of Atlantic herring in the Strait of Belle Isle study area in 2004

DFO (Fisheries and Oceans), 2005f. Witch Flounder (Divs. 4RST). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/011.

This report is a resource status report on Witch Flounder in the Southern and Northern Gulf of St. Lawrence. It includes information about commercial fisheries landings, and provides an estimate of the resource status using catches from 2004 research vessel surveys and sentinel surveys. The sentinel surveys seem to have captured Witch Flounder in the Strait of Belle Isle study area based on the map that is presented in this report.

DFO (Fisheries and Oceans), 2006a. Assessment of Lumpfish in the Gulf of St. Lawrence (3Pn, 4RST) in 2005. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/034.

A stock assessment report on the lumpfish resource in the Northern Gulf of St. Lawrence, including the Strait of Belle Isle Study Area.

DFO (Fisheries and Oceans), 2006b. Assessment of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17 and 12A, 12B and 12C) Snow Crab Stocks in 2005. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2006/019.

A report on the snow crab stocks in the Gulf of St. Lawrence area. This report has information regarding snow crab in Snow Crab area 13 which is the Strait of Belle Isle area.

DFO (Fisheries and Oceans), 2006c. Assessment of the west coast of Newfoundland (Division 4R) herring stocks in 2005. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2006/021.

This is the most recent Atlantic herring stock status report, based on data from commercial purse seine fisheries and bottom trawl surveys. It provides an overview of the resource, and its biology in the Northern Gulf of St. Lawrence, including the study area – in the Strait of Belle Isle.

DFO (Fisheries and Oceans), 2006c. Proceedings of the Zonal Workshop on the Identification of Ecologically and Biologically Significant Areas (EBSA) within the Gulf of St. Lawrence and Estuary. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2006/011.

An overview of discussion topics of the workshop on Ecologically and Biologically Significant Areas (EBSA) in the estuary and Gulf of St. Lawrence. The discussion identified knowledge and data gaps in the Strait of Belle Isle area. It also outlines the importance of the Strait of Belle Isle area in terms of physical aspects, areas important to fish, macroinvertebrates, and maps areas of importance for feeding, reproduction and aggregation of marine mammals

DFO (Fisheries and Oceans), 2007a. Ecologically and Biologically Significant Areas (EBSA) in the Estuary and Gulf of St. Lawrence: identification and characterization. DFO Can. Sci. Advis. Sec., Sci. Adv. Rep. 2007/016.

This report does not include a great deal of information on the Strait of Belle Isle area, but does provide an overview of the physical and biological environment.

DFO (Fisheries and Oceans), 2007b. State of the Ocean 2006: Physical Oceanographic Conditions in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/036.

This is one of a series of reports (DFO 2008; DFO 2009) that provides annual oceanographic data in the Gulf of St. Lawrence. This report gives an overview of the oceanographic conditions in the Gulf of St. Lawrence during 2006. It doesn't include a lot of detail about the Strait of Belle Isle, however it does include some information on surface water temperature, Cold Layer Thickness and surface water salinity. It does mention that in 2006-2007, there would be a thicker cold surface layer in the Gulf of St. Lawrence due to an increased inflow of Labrador Shelf water through the Strait of Belle Isle.

DFO (Fisheries and Oceans). 2008a. Assessment of the Atlantic Mackerel stock for the Northwest Atlantic (Subareas 3 and 4) in 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/041.

Recent stock assessment report for the stock of Atlantic mackerel within the Strait of Belle Isle and other areas.

DFO. (Fisheries and Oceans) 2008a. Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin Stock in 2007. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2008/037.

This is the most recent capelin stock status report, based on data from commercial purse seine fisheries, by-catch in shrimp trawls, and bottom trawl surveys. It gives an overview of the resource, and its biology in the Northern Gulf of St. Lawrence, including the study area – in the Strait of Belle Isle.

DFO (Fisheries and Oceans), 2008b. State of the Ocean 2007: Physical Oceanographic Conditions in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/016.

This report provides an overview of the oceanographic conditions in the Gulf of St. Lawrence during 2007, although doesn't include a lot of detail about the Strait of Belle Isle, with the exception of some information on surface water temperature, cold layer thickness and surface water salinity. It gives some information regarding the decrease in CIL index due to the larger than-normal winter intrusion of Labrador Shelf water from the Strait of Belle Isle. The intrusion of cold and saline water from the Labrador Shelf through the Strait of Belle Isle occupied a slightly larger area in March 2008 compared to 2007, and it extended to the surface.

DFO (Fisheries and Oceans). 2009a. An Assessment of the Iceland Scallop (Chlamys islandica) Resource in the Strait of Belle Isle and the Lilly Carson Canyons. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/043.

This report gives an assessment of the Iceland Scallop in two areas (Strait of Belle Isle and the Lilly Carson Canyons). It gives an overview and history of the Scallop fishery in that NAFO division 4R. The assessment is based on Commercial Catch Per Unit Effort (CPUE) and biomass assessments based on resource assessment surveys of scallop habitat. The resource assessment also gives an estimate of natural mortality and predation by starfish. Details on a refugium for scallops established in 2000 is provided and an assessment of how this has worked in achieving its goals.

DFO (Fisheries and Oceans). 2009b. Assessment of cod stock in the northern Gulf of St. Lawrence (3Pn,4RS) in 2008. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/010.

This report provides an assessment of the cod stock in the Strait of Belle Isle (part of NAFO division 4R), and includes information and results from the surveys conducted in this area. It also includes information on spawning, migration and dispersal, species biology, ecosystem status and the fishery in the area.

DFO (Fisheries and Oceans). 2009c. Assessment of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17, 12A, 12B, 12C and 16A) Snow crab stocks in 2008. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/027.

This report includes some information on the Snow Crab stocks in Area 13 (which encompasses the Strait of Belle Isle study area). Though it does show the presence of Snow crab near the study area, it has limited information on survey vessel data. It does give some information on the resource status in 2008, and the fishery.

DFO (Fisheries and Oceans). 2009d. Assessment of the Greenland Halibut Stock in the Gulf of St. Lawrence (4RST) in 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/020.

This assessment of the Greenland Halibut Stock in the Gulf of St. Lawrence contains an analysis of the stock based on DFO Survey data, sentinel fishery data, as well as commercial fishery logbooks and statistics. The resource biomass estimate doesn't continue right up into the Strait of Belle Isle, but there may be some important information about the stock that may migrate there.

DFO (Fisheries and Oceans). 2009e. Conservation objectives for the Ecologically and Biologically Significant Areas (EBSA) of the Estuary and Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/049.

This report gives a summary of important species in the Strait of Belle Isle area, including specific Shrimp species, as well as important invertebrates. The report also summarizes the importance of the Strait of Belle Isle for spawning (i.e., herring stocks).

DFO (Fisheries and Oceans). 2009f. State of the Ocean 2008: Physical Oceanographic Conditions in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/019.

This report gives an overview of the oceanographic conditions in the Gulf of St. Lawrence during 2008, although doesn't include a lot of detail about the Strait of Belle Isle. It does include some information on sea surface temperature collected via remote sensing, and some air temperatures for Blanc-Sablon, as well as water thickness and Cold Layer thickness from the intrusion of cold water from the Labrador Current in the St. Lawrence Gulf.

DFO (Fisheries and Oceans). 2009g. Stock Assessment of Atlantic Halibut of the Gulf of St. Lawrence (Divisions 4RST) in 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/023.

This stock assessment is based on DFO Survey data, and shows Catch Per Unit Effort (CPUE) in the Gulf of St. Lawrence for Atlantic Halibut. The research survey shows that there were few Atlantic halibut captured far up in the strait area, but had much higher CPUE further south in the Gulf of St. Lawrence.

DFO (Fisheries and Oceans). 2009h. Zonal Science Peer Review of the American eel (Anguilla rostrata) prior to assessment by COSEWIC; 11-12 October, 2005. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2009/028.

This is an overview of the peer review process of the American Eel status. It specifically notes that American Eels have not been verified in the Labrador region, and there is no data to verify their presence in the Strait of Belle Isle. However, there has been some interest in a fishery in the area, suggesting that there must be American eels in that area.

DFO (fisheries and Oceans). 2010a. Assessment of shrimp stocks in the Estuary and Gulf of St. Lawrence in 2009. DFO Can. Sci. Advis. Rep. 2010/008.

An overview of shrimp stocks in the Gulf of St. Lawrence, however does not give a great deal of detail about the Strait of Belle Isle region, does provide some useful information about species biology.

DFO (Fisheries and Oceans), 2010a. Atlantic Salmon Recreational Fishery Statistics. Unpublished Information.

This information includes the annual Atlantic salmon catch (grilse and large salmon) and effort (rod days) for 14 rivers in the Study Area from 1994 – 2009.

DFO (Fisheries and Oceans), 2010b. Records of Atlantic Salmon Enumerated in a Counting Fence at Western Arm Brook. Unpublished Information.

This information includes the annual Atlantic salmon count (grilse and large salmon) at Western Arm Brook (located in the Study Area) from 1974 – 2009.

DFO (Fisheries and Oceans). 2010c. Stock Assessment of Newfoundland and Labrador Atlantic Salmon - 2009. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/068.

This is a stock assessment of Atlantic salmon in Newfoundland and Labrador and includes information for Salmon Fishing Areas 14A and 14B, which encompasses the Strait of Belle Isle study area.

Farquharson, W.I. and W.B. Bailey. 1966. Oceanographic study of Belle Isle Strait 1963. Bedford Institute of Oceanography. Rep. 66-9, Dartmouth, N.S., 78 pp.

This reports on the results of the early oceanographic studies in the Strait of Belle Isle by the Bedford Institute of Oceanography in the early 1960’s.

Fréchet, A., J. Gautheir, P. Schwab, F. Collier, and J. Spingle. 2006. Tagging of Lumpfish (Cyclopterus lumpus) in the Northern Gulf of St. Lawrence from 2004 to 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/084.

This report reviews information collected from tagging studies of lumpfish conducted in 2004 and 2005 in the northern Gulf of St. Lawrence. These studies were conducted to determine migration patterns of lumpfish in the region since very little information about migration patterns exists, and fishing activity is localized and seasonal.

Fréchet, A., J. Gauthier, P. Schwab, H. Bourdages, C. Tournois, J. Spingle, M. Way and F. Collier. 2007. The status of cod in the Northern Gulf of St. Lawrence (3Pn,4RS) in 2006. DFO Can. Sci. Advis. Sec., Res. Doc. 2007/068. 89 p.

This report gives an overview of the status of the cod stocks in the Northern Gulf of St. Lawrence in 2006. This status report is based on information provided by Sentinel Fisheries in the area, as well as DFO trawl data, and commercial landings, and tagging data. This report is extensive, including a great deal of information on biology of the Atlantic cod stock in these areas. Among information provided in this report includes biomass, spawning biomass, fecundity, and age distribution.

Garrett, C. and B. Petrie. 1981. Dynamical aspects of the flow through the Strait of Belle Isle. Journal of Physical Oceanography. 11(3): 376-393.

This report has an analysis of current meter and sea level data collected in the Strait of Belle Isle area in 1980.

Garrett, C. and B. Toulany. 1981. Variability of the flow through the Strait of Belle Isle. J. Mar. Res. 30: 163-189.

One of the early reports on currents and flow through the Strait of Belle Isle.

Garrett, C. and B. Toulany. 1982. Sea Level Variability Due to Meterological Forcing in the Northeast Gulf of St. Lawrence. Journal of Geophysical Research. 87(C3): 1968-1978.

One of the early reports on physical oceanography in the Gulf of St. Lawrence, including the area in the Strait of Belle Isle.

Grant, S.M. 2006. Biological Resource Assessment of the Orange Footed Sea Cucumber (Cucumaria frondosa) Occurring in the Strait of Belle Isle. Submitted to the Canadian Centre for Fisheries Innovation, St. Anthony Basin Resources Inc. and Fisheries and Oceans Canada.

A survey was conducted to determine the fisheries viability of the Orange Footed Sea Cucumber (Cucumaria frondosa) in the Strait of Belle Isle. It is based on a drag survey in the Strait of Belle Isle area. The survey looked at morphometrics, sex ratios and reproductive strategies and biology of the Sea Cucumber in the Strait of Belle Isle.

Gregoire, F., C. Savenkoff, and D. Chabot. 2006. Atlantic mackerel (Scomber scombrus L.) fishery, biology, diet composition and predation in NAFO subareas 3 and 4 in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/096.

This report looks at the structure of the Gulf of St. Lawrence ecosystem, specifically in the northern Gulf region in terms of mackerel (i.e., the major role it plays in the ecosystem). This report gave information about changes in dynamics of diet and predation in the northern Gulf of St. Lawrence.

Gregoire, F., L. Lefebvre, J. Guerin, J. Hudon and J. Lavers. 2004. Atlantic herring (Clupea harengus harengus) on the West coast of Newfoundland (NAFO Division 4R) in 2003. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/078.

This research document includes results of surveys conducted in NAFO division 4R, and herring landings by commercial fisheries. The map of scientific survey results indicates the presence of Atlantic herring in the Strait of Belle Isle study area in 2003. This document must not be cited without the permission of the authors.

Gregoire, F., J. Gauthier, C. Savenkoff, C. Levesque, J.-L. Beaulieu. and M.-H. Gendron. 2008. Commercial fishery, by-catches and biology of capelin (Mallotus villosus) in the Estuary and Gulf of St. Lawrence (NAFO Divisions 4RST) for the 1960 -2007 period. Can. Sci. Advis. Sec. Research Doc. 2008/084.

This research document includes information on capelin in the Gulf of St. Lawrence, and specifically in the study area. Information is based on commercial fisheries data, captures through bottom surveys (DFO trawl data), purse seines (1994-2007) and by-catch from the Shrimp Fishery (1991-2007).

Gregory, D.N. 2004. Climate: A database of temperature and salinity observations for the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/076.

This article must not be cited without permission from the author. It describes the Ocean Science hydrographic database (Climate) which can be accessed at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html/. This database includes information for temperature-salinity profiles.

Hatch Mott McDonald, 2004. The Strait of Belle Isle Fixed Link. 2004. Available at: http://www.gov.nf.ca/publicat/fixedlink/. Accessed March 2010.

This study report provides general information on the physical environment of the study area including: climate, air temperature, precipitation, wind, degree days and icing. It also includes oceanographic information on: bathymetry, currents, waves, sea ice and icebergs. Detailed information on bedrock geology, surficial geology and geological faults is also provided

Huntsman, A.G., W.B. Bailey and H.B. Hachey. 1954. The general oceanography of the Strait of Belle Isle. J. Fish. Res. Board Can. 11: 198-260.

Reports on very early studies of the oceanography in the Strait of Belle Isle.

JWEL 2000. Churchill River Power Project. LHP 98-14. Benthic Habitat and Communities in the Strait of Belle Isle. Prepared for the Labrador Hydro Project. JWEL Study 1211.

This report was in support of the Labrador Hydro Project, and reviewed existing information of benthic habitat in the Strait of Belle Isle. Though it does provide some information, the RoxAnn data only categorize areas in the Strait of Belle Isle into three habitat types "Scallop Ground", "Possible Scallop Ground" and "Not Scallop Ground".

Lavoie, D., M. Starr, B. Zakardjian and P. Larouche. 2007. Identification of ecologically and biologically significant areas (EBSA) in the Estuary and Gulf of St. Lawrence : Primary production. DFO Can. Sci. Advis. Secr. Res. Doc. 2007/079.

This report outlines the oceanography of the Strait of Belle Isle, and identifies its unique characteristics. It was noted in this report that not a lot of information was collected on chlorophyll 'a', phytoplankton and primary production in the Strait area, however, some measurements have been taken in the study area. Simulations of nitrate, chlorophyll 'a' and primary production were created, and maps produced to show these characteristics in the Strait during different time periods based on the few samples that were collected in the area and in the rest of the Gulf of St. Lawrence.

Le Bris A., Fréchet A., Brethes J.-C. 2009. Estimation du taux d'exploitation du stock de morue franche (Gadus morhua) du nord du golfe du Saint-Laurent (3Pn,4RS), a partir de donnees de marquage/ Estimation of the exploitation rate of the northern Gulf of St. Lawrence (3Pn,4RS) Atlantic Cod (Gadus morhua) stock, based on tagging data. Secr. Can. De consult. Sci. du MPO. Doc. De rech. 2009/012. v + 35p.

This report analyzes the exploitation of the Northern St. Lawrence Atlantic cod stocks using data from species tagged in the sentinel fisheries in the region between the years 1995 to 2007.

McQuinn, I. H., Hammill, M. O., and Lefebvre, L. 1999. An assessment and risk projections of the west coast of Newfoundland (NAFO division 4R) herring stocks (1965 to 2000). DFO Can. Stock Assess. Sec. Res. Doc. 99/119.

Using data from commercial fisheries, acoustic sampling, fishermen knowledge and other data sources, the authors assessed the stocks of NAFO division 4R Atlantic herring stocks. Data is included on herring catches from commercial fisheries from 1965 to 1998, and are separated by month and by NAFO area subdivision where data exists. Spawning areas are acknowledged and migration routes were mapped out for two spawning stocks (Autumn and Spring spawners) based on available information.

Méthot, R., M. Castonguay, Y. Lambert, C. Audet, and S.E. Campana. 2005. Spatiotemporal distribution of spawning and stock mixing of Atlantic cod from the northern Gulf of St. Lawrence and southern Newfoundland stocks on Burgeo Bank as revealed by maturity and trace elements of otoliths. J. Northw. Atl. Fish. Sci. 36: 31-42.

This article reports on studies of spawning stocks of Atlantic cod in the northern Gulf of St. Lawrence and the southern Newfoundland stocks which took place primarily in 2001. These reports indicate spawning of Atlantic cod in the northern Gulf of St. Lawrence, which may include the Strait of Belle Isle.

Naidu, K.S., F.M. Cahill, and E.M. Seward. 2001. The scallop fishery in Newfoundland and Labrador becomes beleaguered. DFO Can. Sci Advis. Sec. Res. Doc. 2001/064.

A research document describing the fishery for scallops around Newfoundland and Labrador. There is a section outlining the Strait of Belle Isle fishery, and research completed in the area. It also explains the area of Scallop Fishing Area 14A in the Strait of Belle Isle, as being an important scallop refugium.

NORDCO Ltd., 1978. Current metering program, 1978, Strait of Belle Isle. Report to Newfoundland and Labrador Hydro.

Early reports of current moorings in the Strait of Belle Isle, in support of the proposed submarine cable crossing.

Nordic Economic Development in Northern Newfoundland. 2010. Introduction to the Save Our Char Committee (SOCC). Available at: http://www.nedc.nf.ca/SOCC.asp/ Accessed: April 2010.

This website has information about Arctic char in the Pistolet Bay area, including a Strategic Recovery Plan (Available at: http://www.nedc.nf.ca/socc/5yearplan.pdf/).

Petrie, B. and B. Toulany. 1988. The transport of water, heat and salt through the Strait of Belle Isle. Atmosphere-Ocean. 26(2): 234-251.

This article is an analysis of data collected in 1980 in the Strait of Belle Isle area, on currents, temperature and salinity. Flow and tide gauges were moored in the strait as well as the Gulf of St. Lawrence.

Saint Lawrence Global Observatory. 2010. Sentinel Fisheries – Mobile Gear. Available at: http://ogsl.ca/en/sentinel/data/mobile.html. Accessed: April 2010.

This website includes interactive maps of catches of Cod, Turbot and Redfish captured in Sentinel fisheries from 1999 to 2009. Provides catches in terms of weight and numbers.

Savard, L., and H. Bouchard. 2004. Estuary and Gulf of St. Lawrence shrimp (Pandalus borealis) stock status in 2003. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/091.

Stock status of shrimp in the Gulf of St. Lawrence. Survey results from scientific trawl data in the Gulf of St. Lawrence was used to create biomass estimates. The article indicates trawls were taken in the Strait of Belle Isle study area. This article must not be referenced without prior permission from the authors.

Savenkoff, C., F. Gregoire, M. Castonguay, J.M. Hanson, D. Chabot, and D.P. Swain. 2006. Main prey and predators of Atlantic herring (Clupea harengus L.) in the Gulf of St. Lawrence during the mid-1980s, mid-1990's, and early 2000s. Can. Tech. Rep. Fish. Aquat. Sci. 2643: vi+28 pp.

This report provides a model of the northern and southern Gulf of St. Lawrence ecosystems based on its structure and function in relation to Atlantic herring populations (Clupea harengus L.).

Savenkoff, C., M. Castonguay, R. Méthot, D. Chabot, and M.O. Hammill. 2005. Input data and parameter estimates for ecosystem models of the northern Gulf of St. Lawrence (2000– 2002). Can. Tech. Rep. Fish. Aquat. Sci. 2588

Provides an outline of the available data in the northern Gulf of St. Lawrence that was used to develop an ecosystem model. It includes information on whales, fish, primary/secondary productivity, and benthic invertebrates to name a few. Where data doesn't exist for the region of the Gulf of St. Lawrence, input parameters were used from other ecosystems, or other data sources.

Savenkoff, C., M.-N. Bourassa, D. Baril, and H.P. Benoît. 2007. Identification of Ecologically and Biologically Significant Areas for the Estuary and Gulf of St. Lawrence. DFO. Can. Sci. Advis. Sec. Res. Doc. 2007/015.

Report summarizing the results of workshops and studies surrounding EBSAs for the Gulf of St. Lawrence. This used a variety of thematic layers to determine Important Areas (IAs). The Strait of Belle Isle region was determined to be important for several layers, including primary production, pelagic fishes, benthic invertebrates, and marine mammals.

Sourisseau, M., Y. Simard, and F.J. Saucier. 2006. Krill aggregation in the St. Lawrence system, and supply of krill to the whale feeding grounds in the estuary from the gulf. Mar. Ecol. Prog. Ser. 314: 257-270.

This report outlines the results of a simulation of krill aggregations in the St. Lawrence system, in relation to currents and other oceanographic information.

Starr, M., M. Harvey, P.S. Galbraith, D. Gilbert, D. Chabot, and J.-C. Therriault. 2002. Recent intrusion of Labrador Shelf waters into the Gulf of St. Lawrence and its influence on the plankton community and higher trophic levels. International Council for the Exploration of the Sea. Theme Session on Environmental Influence on Trophic Interactions. CM 2002/N:16

This article looks at the recent intrusion (2001) of colder Labrador Shelf waters in through the Strait of Belle Isle to the Gulf of St. Lawrence. The report identifies these changes and its effect on plankton in the Gulf of St. Lawrence.

Toulany, B., B. Petrie, and C. Garrett. 1987. The frequency-dependent structure and dynamics of flow fluctuations in the Strait of Belle Isle. J. Phys. Oceanogr. 27: 185-196.

Along with other reports in the same time frame, this report gives an analysis of current dynamics in the Strait of Belle Isle.

Whoriskey, F., G. Chaput, P. Cameron, D. Moore, and M. Hambrook. 2010. Sonic tracking of North American Atlantic salmon smolts to sea: correlates of stage-specific survivals and lessons on the migration pathway. ICES WGNAS working paper 36. Unpublished Source.

This working paper outlines results from Atlantic salmon smolt tracking by sonic telemetry from five Canadian rivers in the Gulf of St. Lawrence and through the Strait of Belle Isle.

Woodworth-Lynas, C.M.T., J.Y. Guigné and E.L. King. 1992. Surficial and bedrock geology beneath the Strait of Belle Isle in the vicinity of a proposed power-cable crossing. Newfoundland Department of Mines and Energy, Geological Survey Branch Report 92-2, 53 pp.

Reports on surficial geology and bedrock geology in the vicinity of the proposed power-cable crossing. This report was useful for the determination of surficial geology and substrates for fish habitat in the area.

Yvelin, J.-F., A. Fréchet and J.-C. Brêthes. 2005. Migratory routes and stock structure of cod from the Northern Gulf of St. Lawrence (3Pn,4RS). DFO Can. Sci. Advis. Sec., Res. Doc. 2005/055 56p.

A report on tagging studies completed by Department of Fisheries and Oceans and Department of Agriculture, Fisheries and Food Quebec in the 1980's, as well as results from Sentinel fisheries tagging in the Northern Gulf of St. Lawrence since 1995. This study area encompasses the Strait of Belle Isle. The results of these tagging studies were used to map migratory routes of Atlantic cod in the Northern Gulf of St. Lawrence.

Personal Communications

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APPENDIX B

Study Team Profiles

Study Team Profiles

Larry LeDrew M. Sc., Senior Scientist – Project Manager. Larry has over 30 years experience in the science and environmental field. Mr. LeDrew has conducted fisheries research for government (DFO) and has been responsible for environmental assessment and research for over 20 years with Newfoundland and Labrador Hydro (Nalcor). Larry has had extensive involvement in the management of environmental issues associated with electricity generation and transmission and most recently, prior to his retirement from Nalcor in July, 2008, was the environmental assessment Lead for the Lower Churchill Hydroelectric Generation Project. In this position Larry was also responsible for the development, and implementation of the transmission line selection process employed for the Project. For this study Larry was Project Manager responsible for client relations, team coordination and report review.

Dave Scruton, M. ES Senior Scientist – Advisor – Marine Fish and Fish Habitat, report preparation and review. David has 33+ years of experience as research scientist and research manager working with federal and provincial governments and as an environmental consultant. He coordinated and conducted a diverse research program on knowledge of relationships between fish and their habitats, effects of human activities on fish and fish habitat, means to mitigate and compensate for habitat losses, and application of knowledge to development of models and tools for predictions, impact assessment, and habitat development. He led and managed a number of large national and international programs on fish habitat research and conducted collaborative research with the utility sector, pulp and paper companies, fishing industry, and transportation sector. He was, and still is, active in academia as an adjunct professor and supervisor of graduate students. He has authored over 200 scientific and technical publications including: 70+ in scientific journals, 40+ technical reports, 10+ special publications, 7 book chapters, 70+ conference proceedings, and 20 + popular articles or internal reports. Since joining Sikumiut as Senior Scientist, he has assumed project lead on several ongoing environmental effects monitoring programs, baseline studies, and developed a discussion paper on the biological and ecological evolution of hydroelectric reservoirs. He is also representing Sikumiut and Canada on an international expert group (IEG) to assist groups in Sweden to resolving fish passage issues at hydroelectric developments. Dave's role was as senior Advisor and report preparation and review.

Tim Anderson B.Sc. Senior Scientist – Project Lead - Marine Fish and Fish Habitat. Tim has had over 35 years experience in various aspects of fisheries and habitat management in Newfoundland and Labrador. Tim's familiarity with the operations, organization structure, personnel and physical infrastructure associated with Department of Fisheries and Oceans (DFO) –NL Region, will be a major asset to the Team. Tim is an experienced writer, familiar with a wide range of environmental matters, making him ideally suited to the review and analysis of information on marine fish and fish habitat. Through his former role as Division Manager Oceans Branch, DFO, he oversaw the implementation of the Oceans Program in Newfoundland and Labrador. As part of his duties Tim was the NL representative on the interregional committee that was responsible for the implementation of the Gulf of St. Lawrence Integrated Management Project (GOSLIM) which included the Strait of Belle Isle. The initial focus of the GOSLIM initiative was to describe the Gulf of St. Lawrence ecosystem, including identification of ecologically and biologically sensitive areas, and document activities and issues from a broad Gulf-wide perspective. The intent of this process was to develop Ecosystem Objectives to guide future management. The resultant studies and reports will be an important source of information for the review of marine fish and fish habitat. In addition, Tim was responsible for the development of the Community-based Coastal Resource Inventory Program in Newfoundland and Labrador. This program aimed to document information on coastal resources in a computerized database and present the results on coastal inventory maps. As part of this program inventories were conducted throughout all of Newfoundland and Labrador, including separate projects on either side of the Strait of Belle Isle. Tim also initiated the development of a freshwater and marine habitat inventory and was responsible for the regional Canadian Environmental Assessment Act Public Registry. Tim led the review of the Marine Fish and Fish Habitat component of the work and participated in report preparation.

Suzanne Thompson, B. Sc. M.E.S. Candidate, Biologist – research, data compilation, analysis and report preparation. Suzanne has a Bachelor of Science in Biology, and is currently completing a Masters in Environmental Science. Her course work has been focused in aquatic sciences, with interests in Fisheries Resource Management, Ecology, Environmental Risk Assessment, and Environmental Policy and Regulations. Suzanne has practical field experience in both freshwater and marine environments and has contributed to the collection and analysis of environmental baseline data, as well as environmental effects monitoring, including water and sediment quality, fish population surveys, stream habitat surveys, littoral zone habitat mapping in lacustrine environments. Suzanne has also contributed to the analysis of socioeconomic data, assisting in the preparation of reports, and Environmental Protection Plans. She is fully familiar and has experience with habitat quantification approaches in freshwater (fluvial and lacustrine) and marine habitats and is knowledgeable in the requirements for evaluating habitat alteration, disruption, and destruction (HADDs). Suzanne conducted the review of the literature and compiled the available datasets. In association with the study leads, she conducted the analysis and summarized data, prepared the draft report and the annotated bibliography.

Grant Vivian, B. Tech., Dipl. Geomatics, Geomatics Lead. As Geomatics Lead of Sikumiut, Grant's primary responsibilities include traditional resource development, environmental field work, strategic planning, GIS design and analysis, report writing, and project management. Grant became an integral part of Sikumiut's environmental team upon arrival where he has completed several large baseline projects including winter lake mapping using Ground Penetrating Radar, a science new to the region of Labrador. His previous work experience relates directly to the northern regions where he used satellite technology to process high resolution river ice charts and iceberg maps off the coast of Newfoundland and Labrador. Grant has valuable international experience working independently in surveying and GIS technology where he gained extensive knowledge in dimensional control concepts for structural design. His technical expertise spans a broad spectrum of Geomatics including cartographic map analysis, satellite image processing, underwater acoustical systems, surveying and GIS technologies, and computer aided drafting (CAD). Grant prepared the geo-referenced maps depicting the distribution of the various species of fish as well as fish habitat mapping.

APPENDIX C

Coastal Environment Maps (ASMP Data)

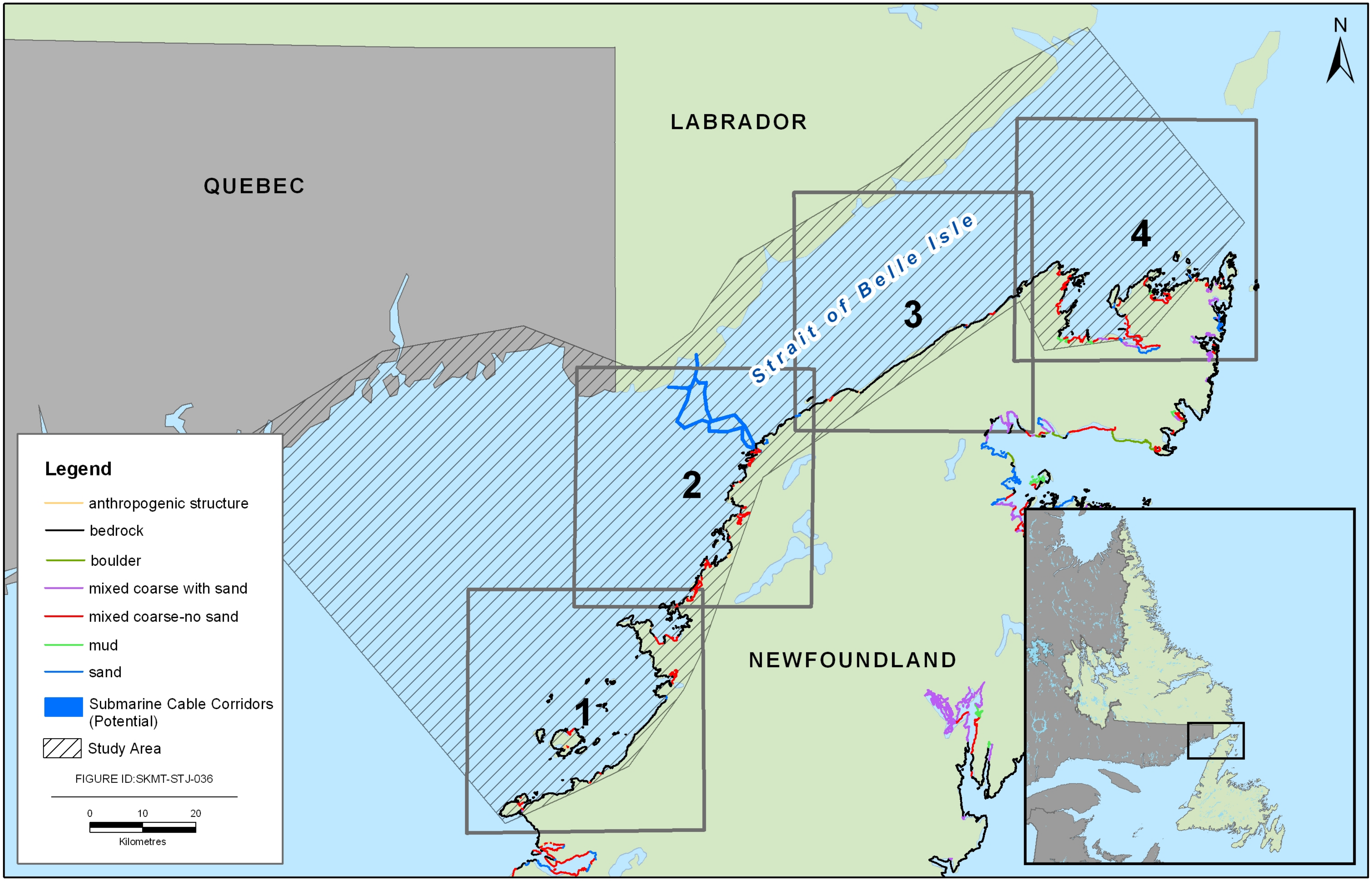

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FIGURE C-1

Shoreline Classification Index Map

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

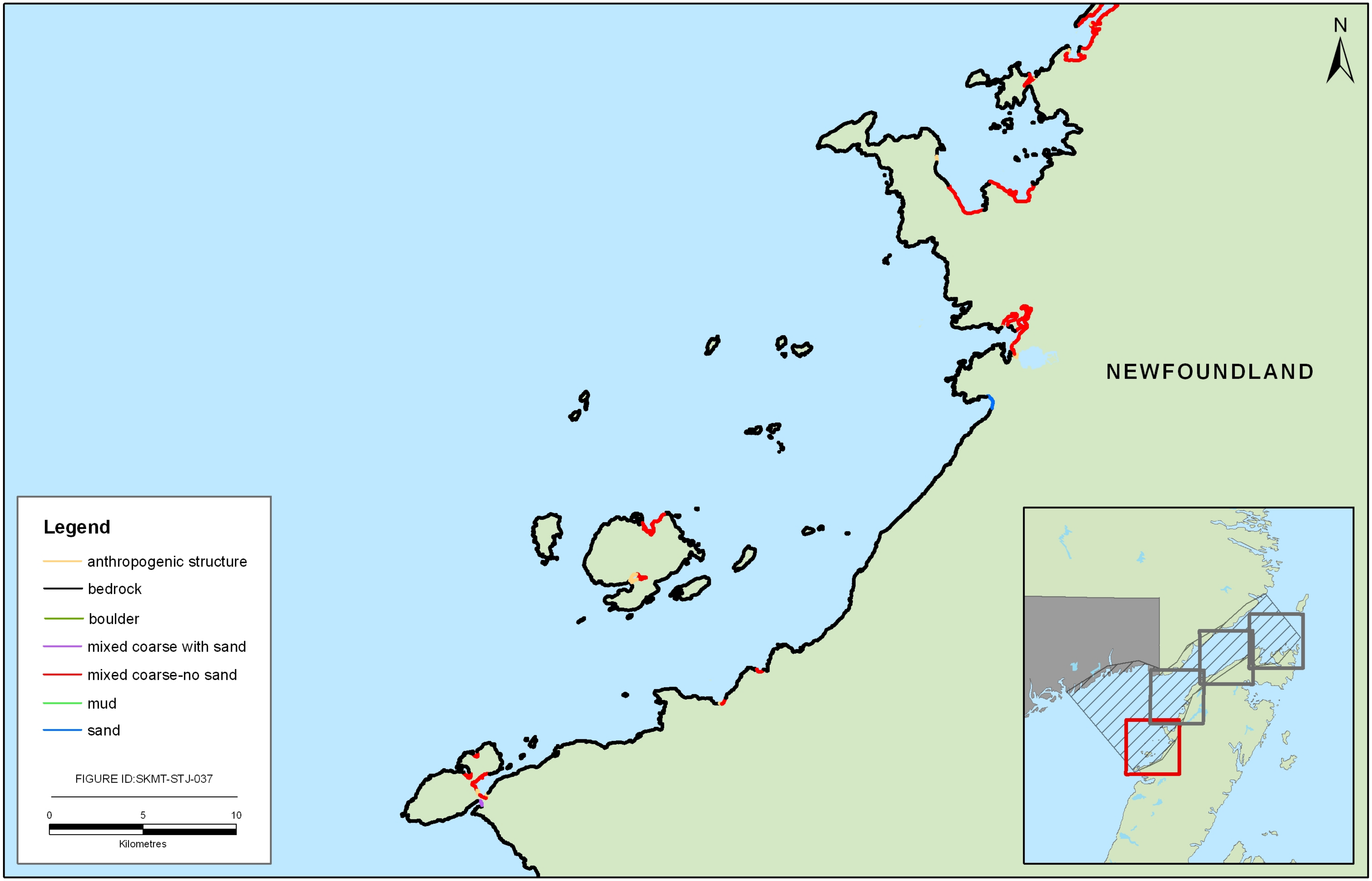

FIGURE C-2

Shoreline Classification (Map 1)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

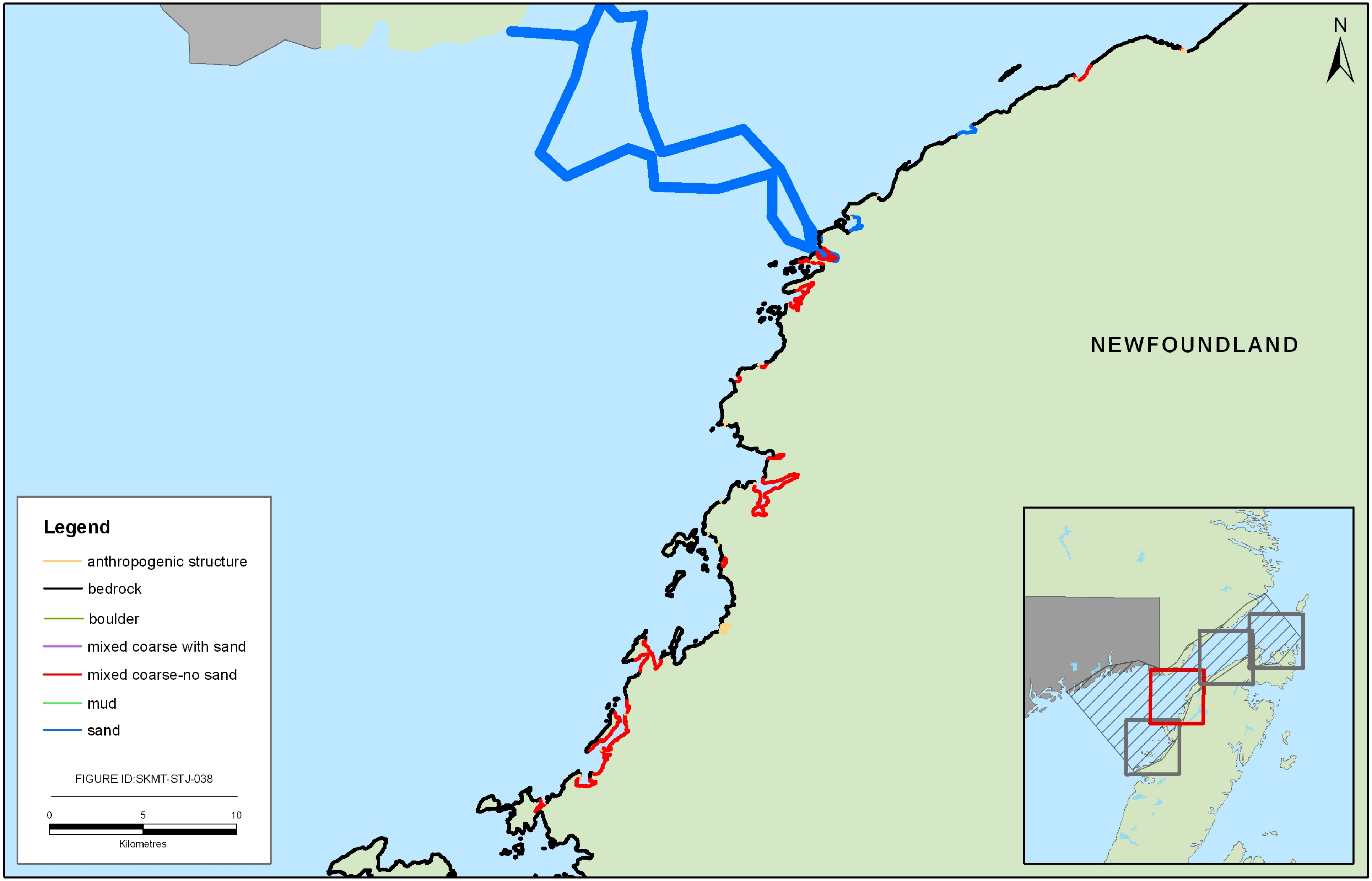

FIGURE C-3

Shoreline Classification Index (Map 2)

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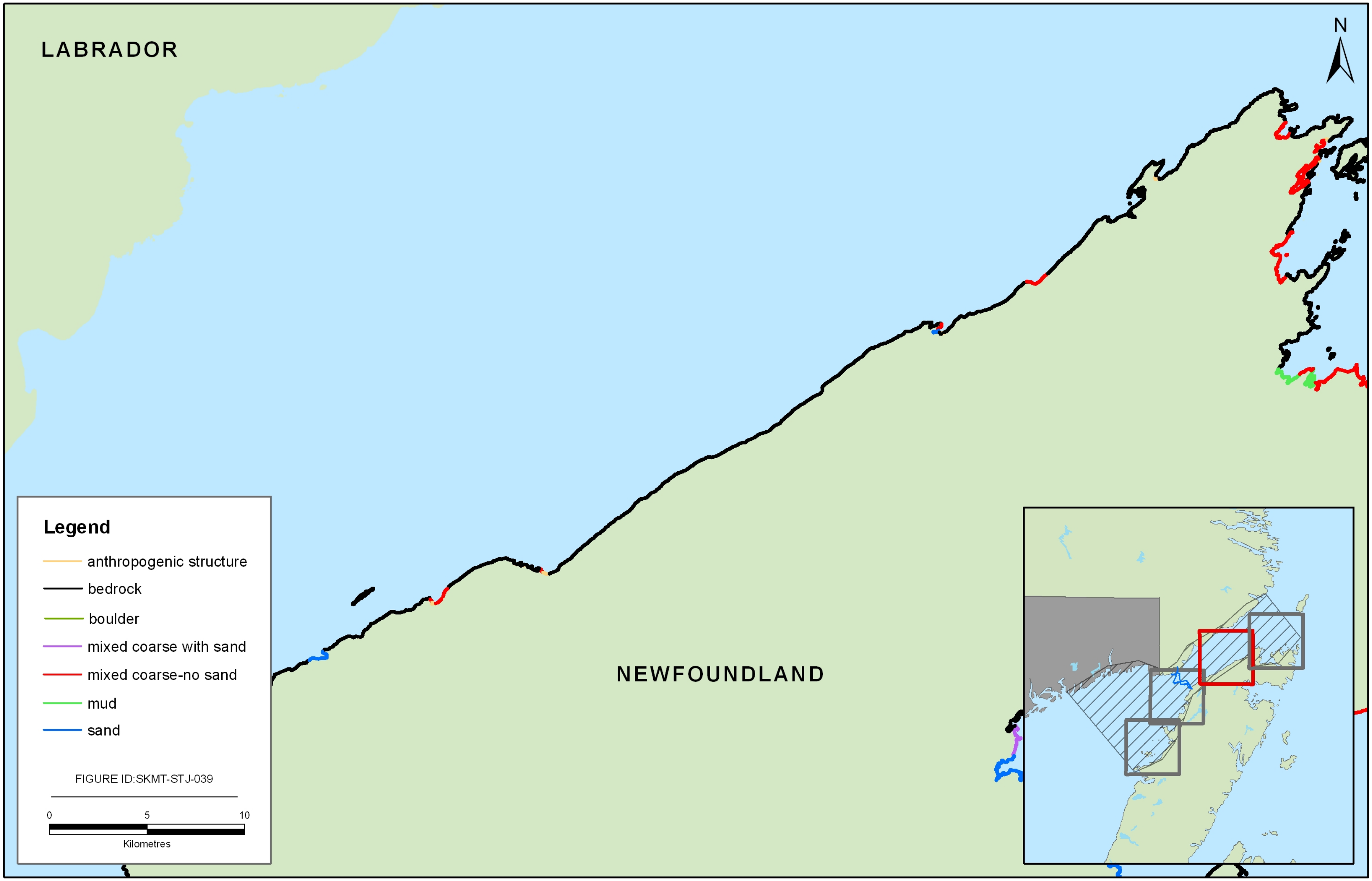

FIGURE C-4

Shoreline Classification (Map 3)

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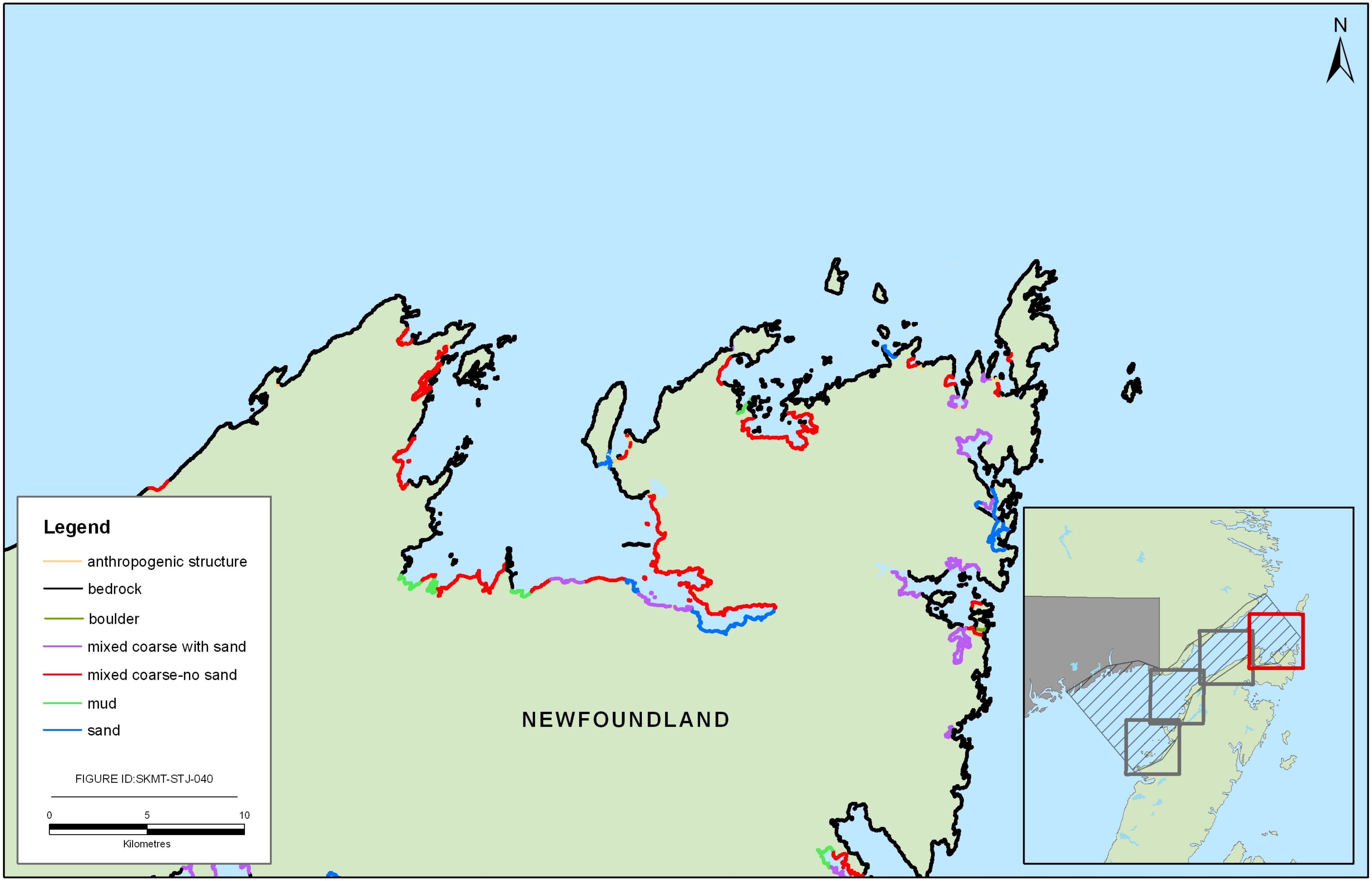

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FIGURE C-5

Shoreline Classification (Map 4)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

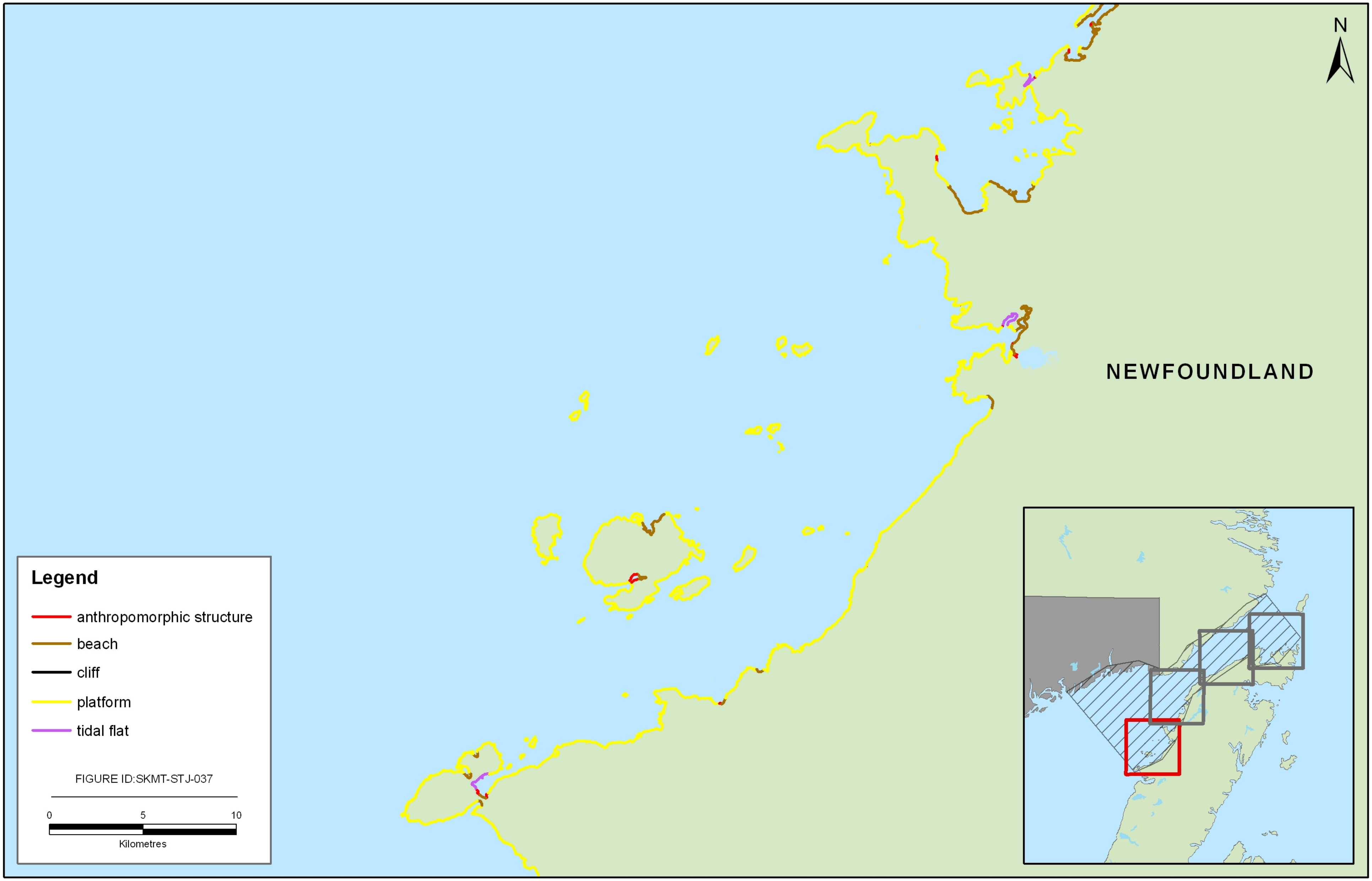

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FIGURE C-6

Lower Intertidal Zone Form (Map 1)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

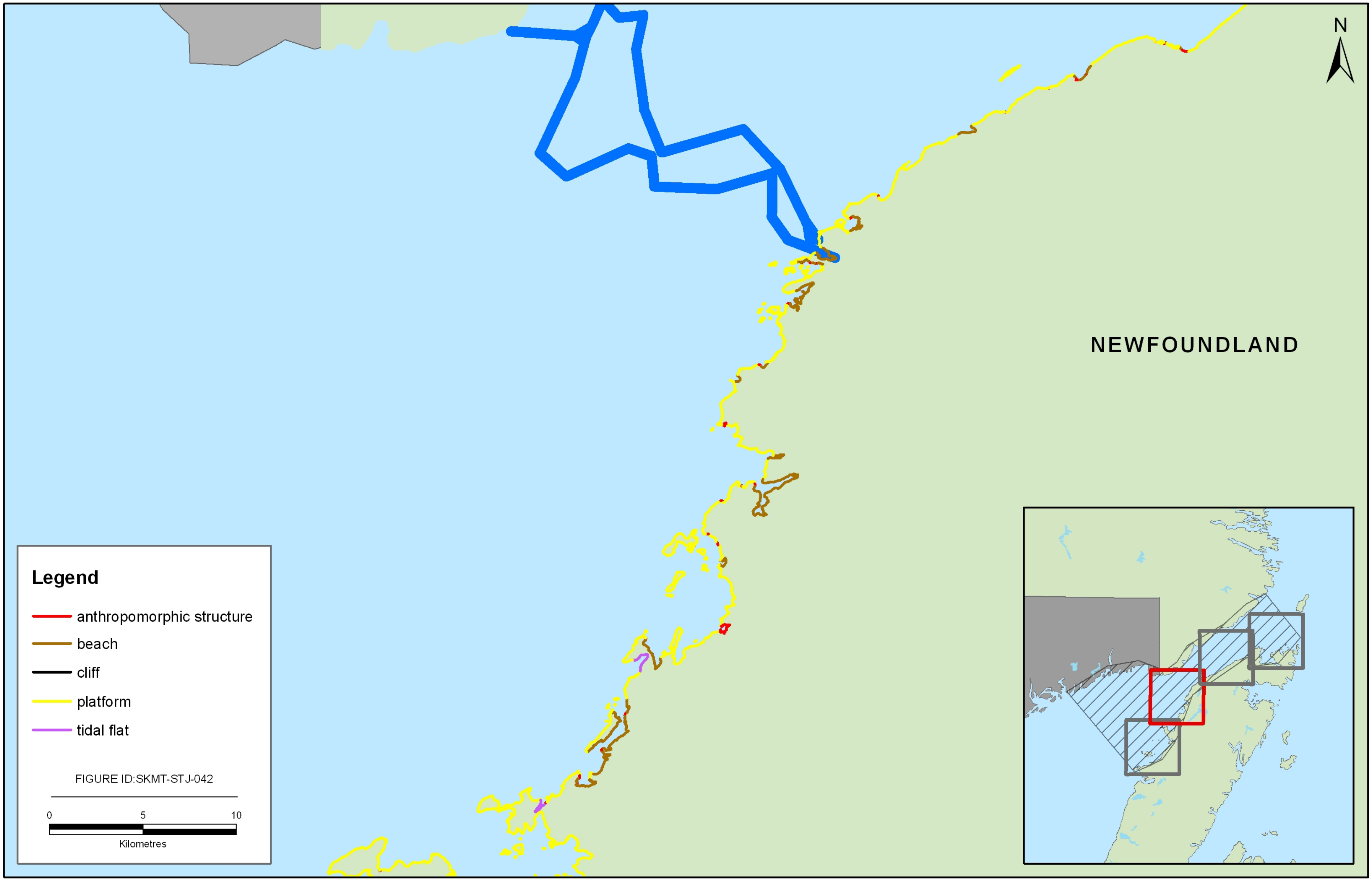

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FIGURE C-7

Lower Intertidal Zone Form (Map 2)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

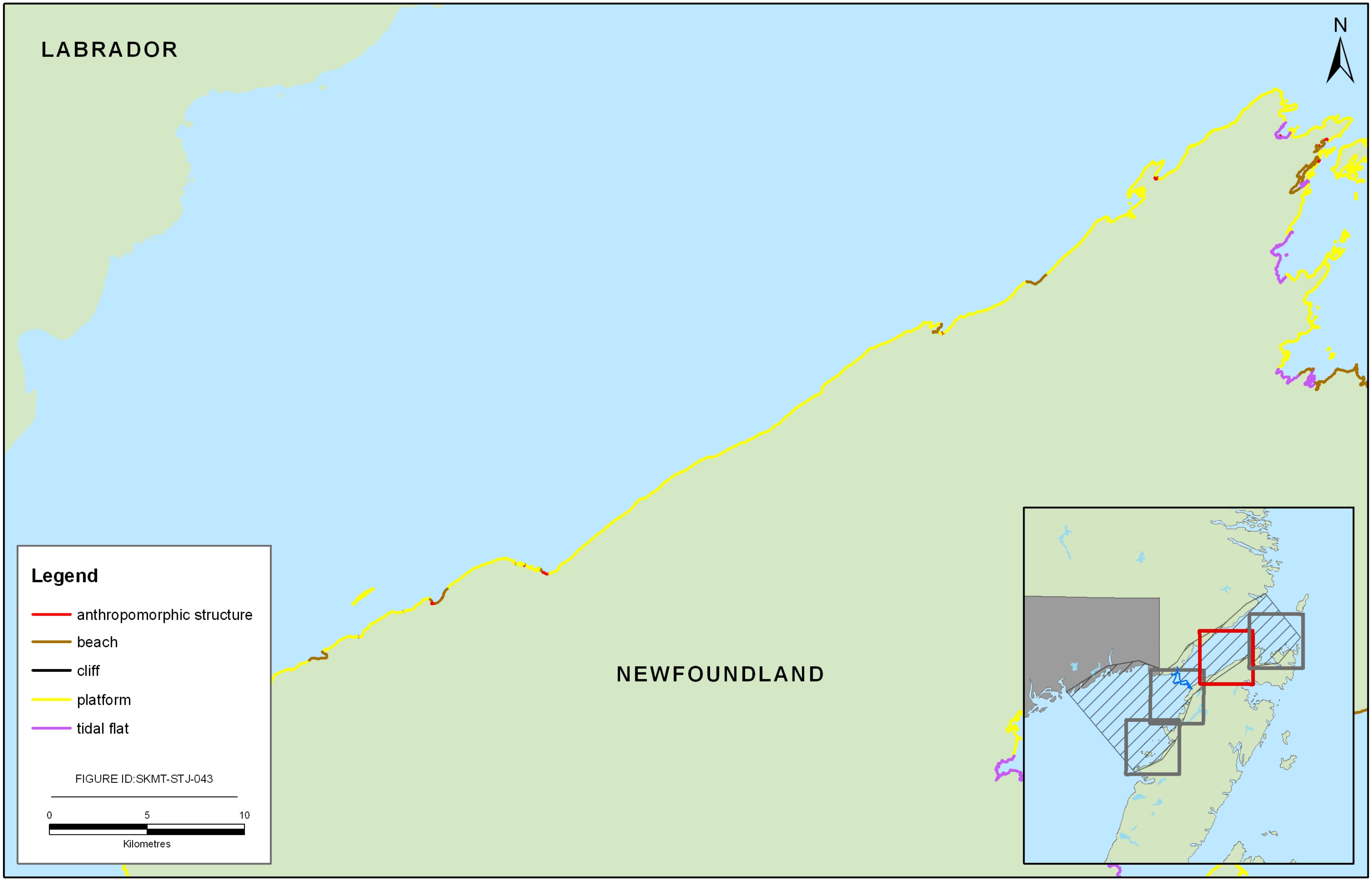

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FIGURE C-8

Lower Intertidal Zone Form (Map 3)

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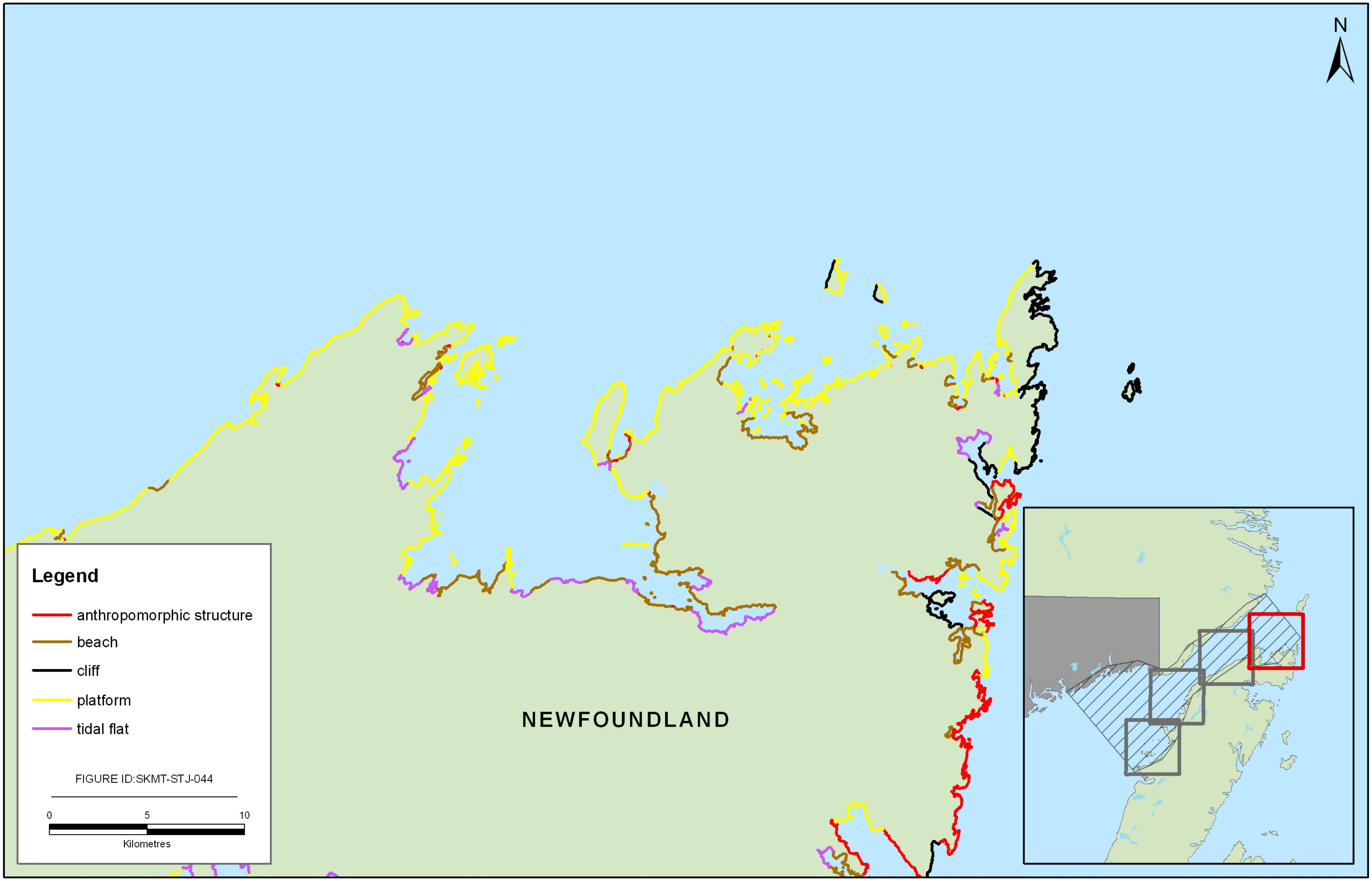

FIGURE C-9

Lower Intertidal Zone Form (Map 4)

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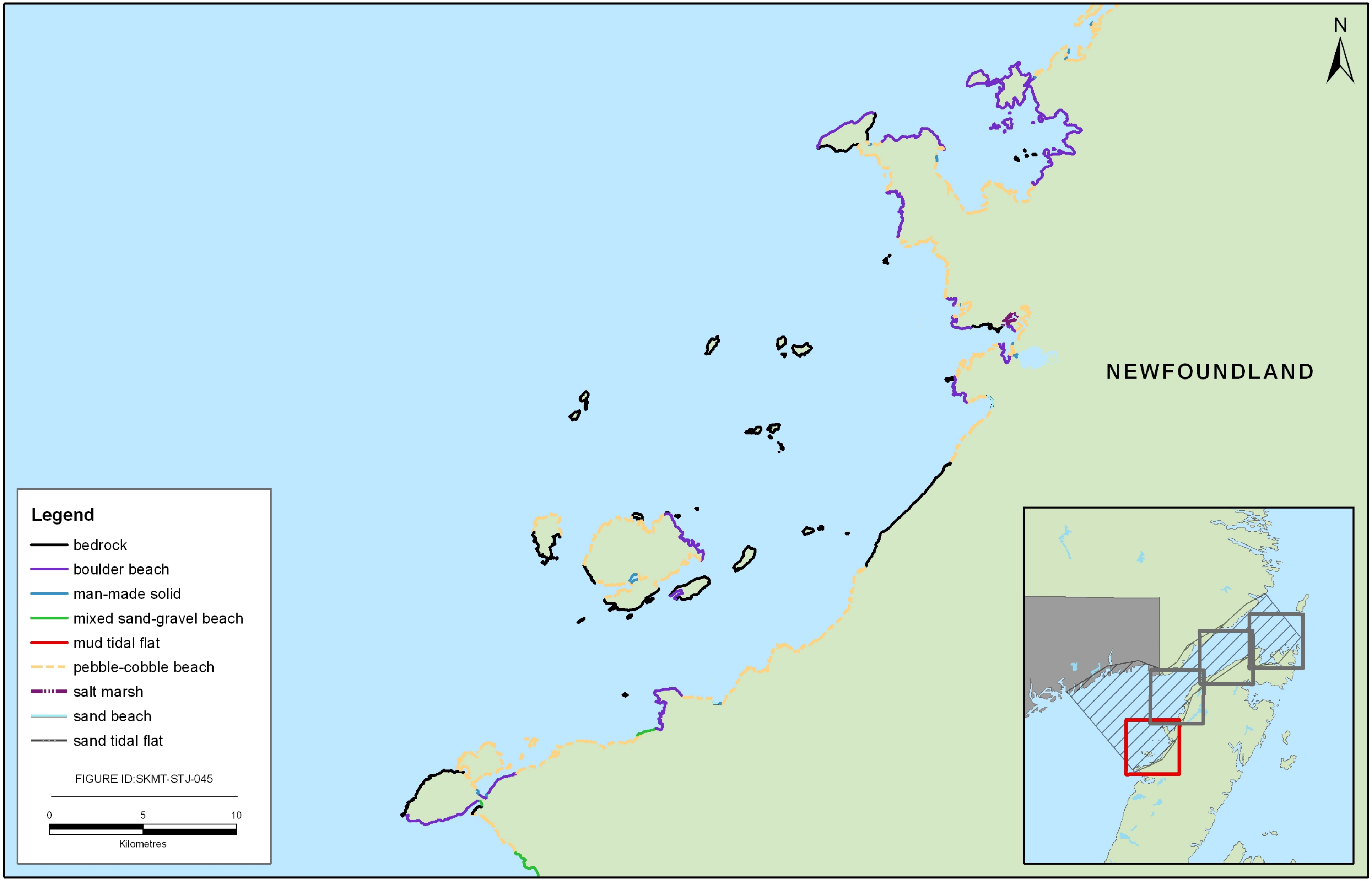

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FIGURE C-10

Shore Type (Map 1)

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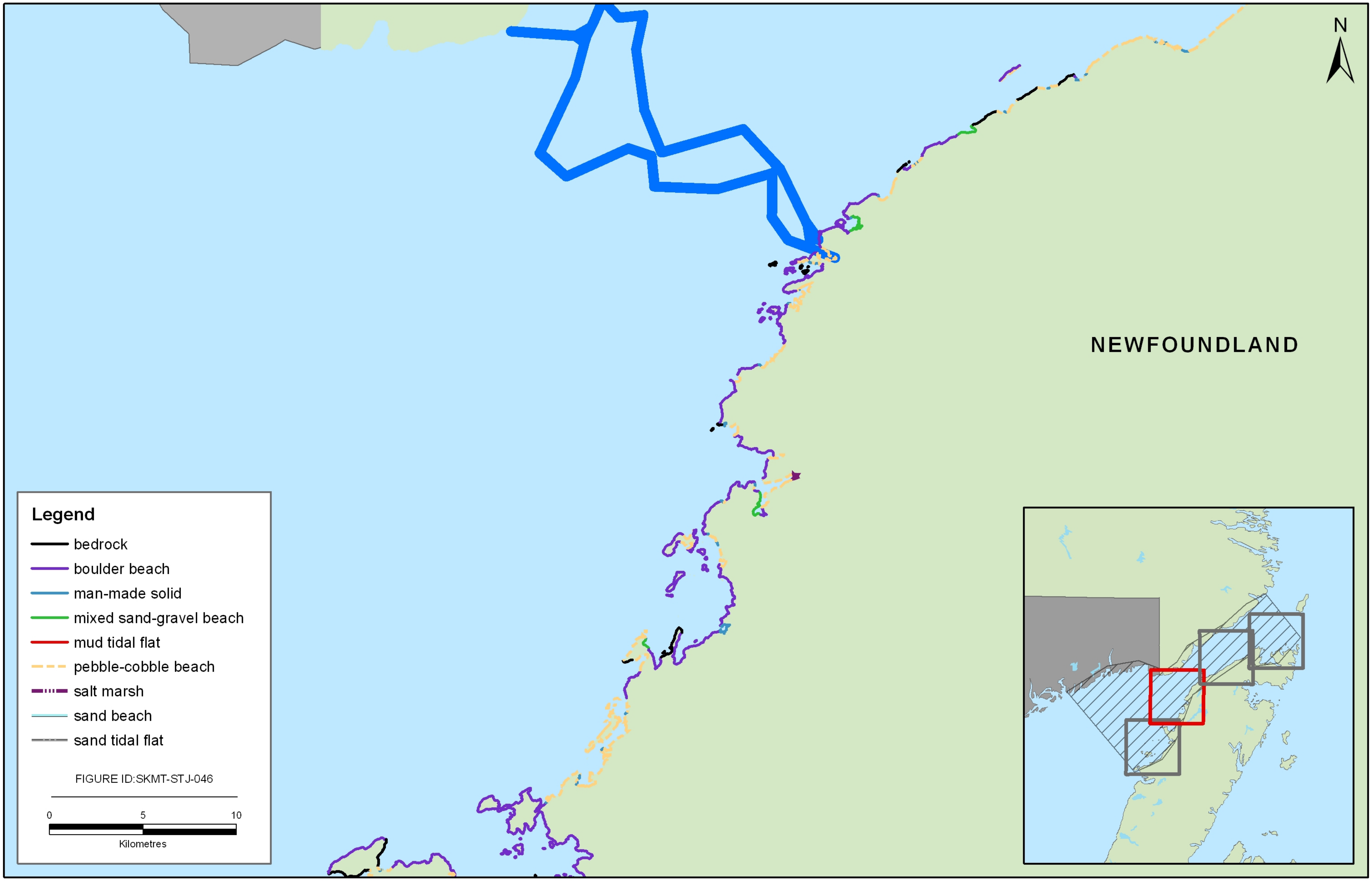

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FIGURE C-11

Shore Type (Map 2)

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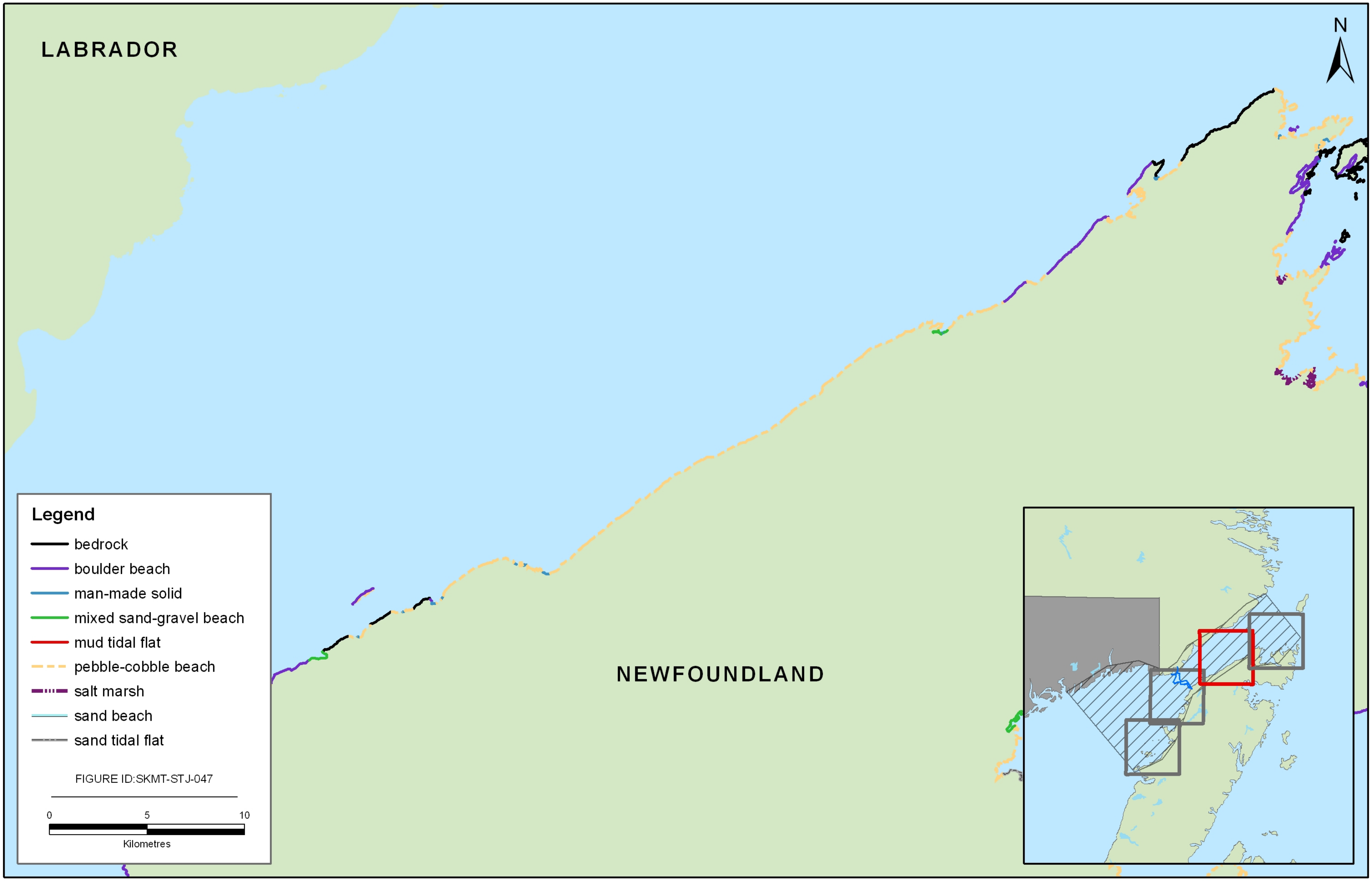

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FIGURE C-12

Shore Type (Map 3)

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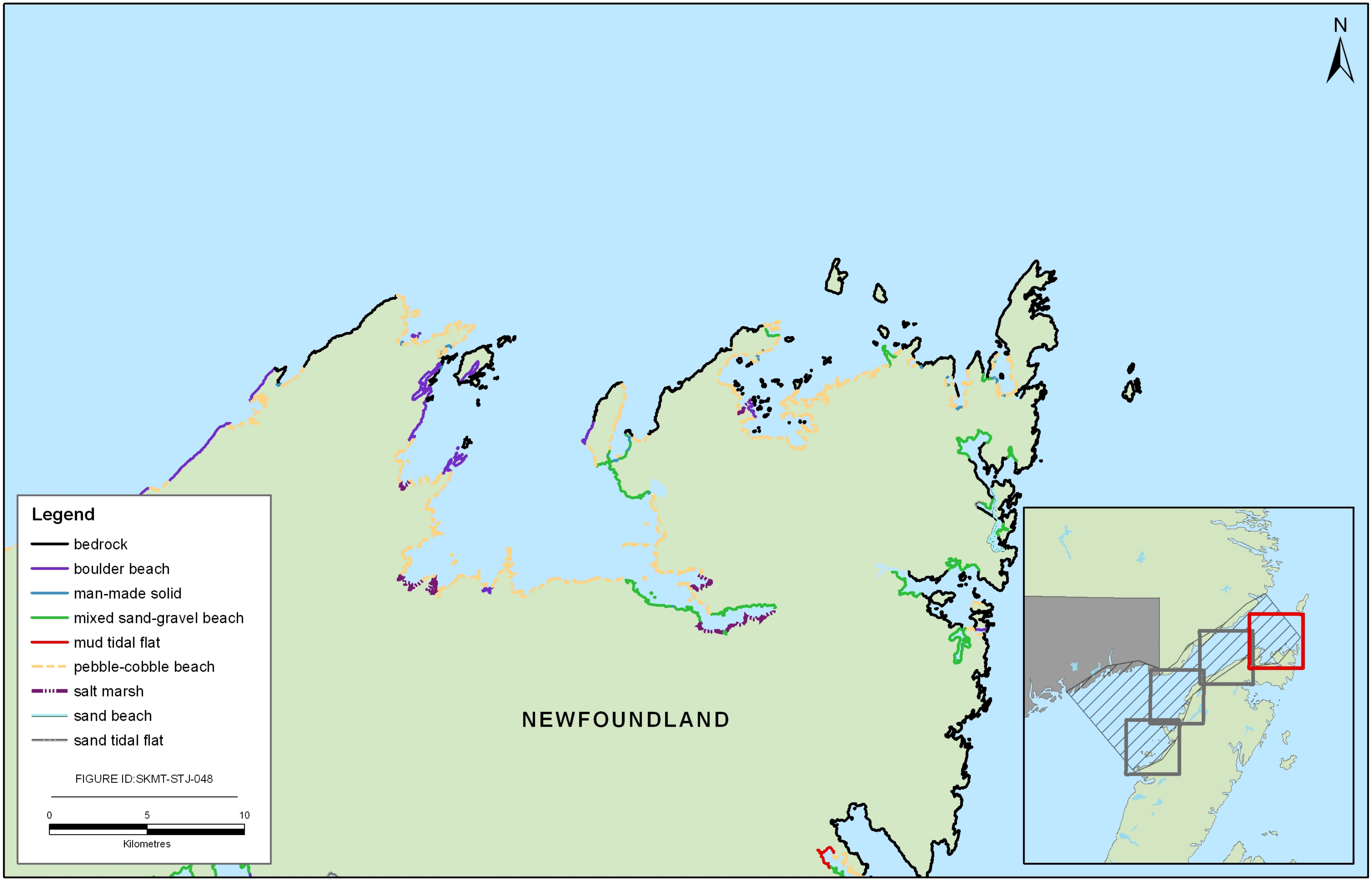

FIGURE C-13

Shore Type (Map 4)

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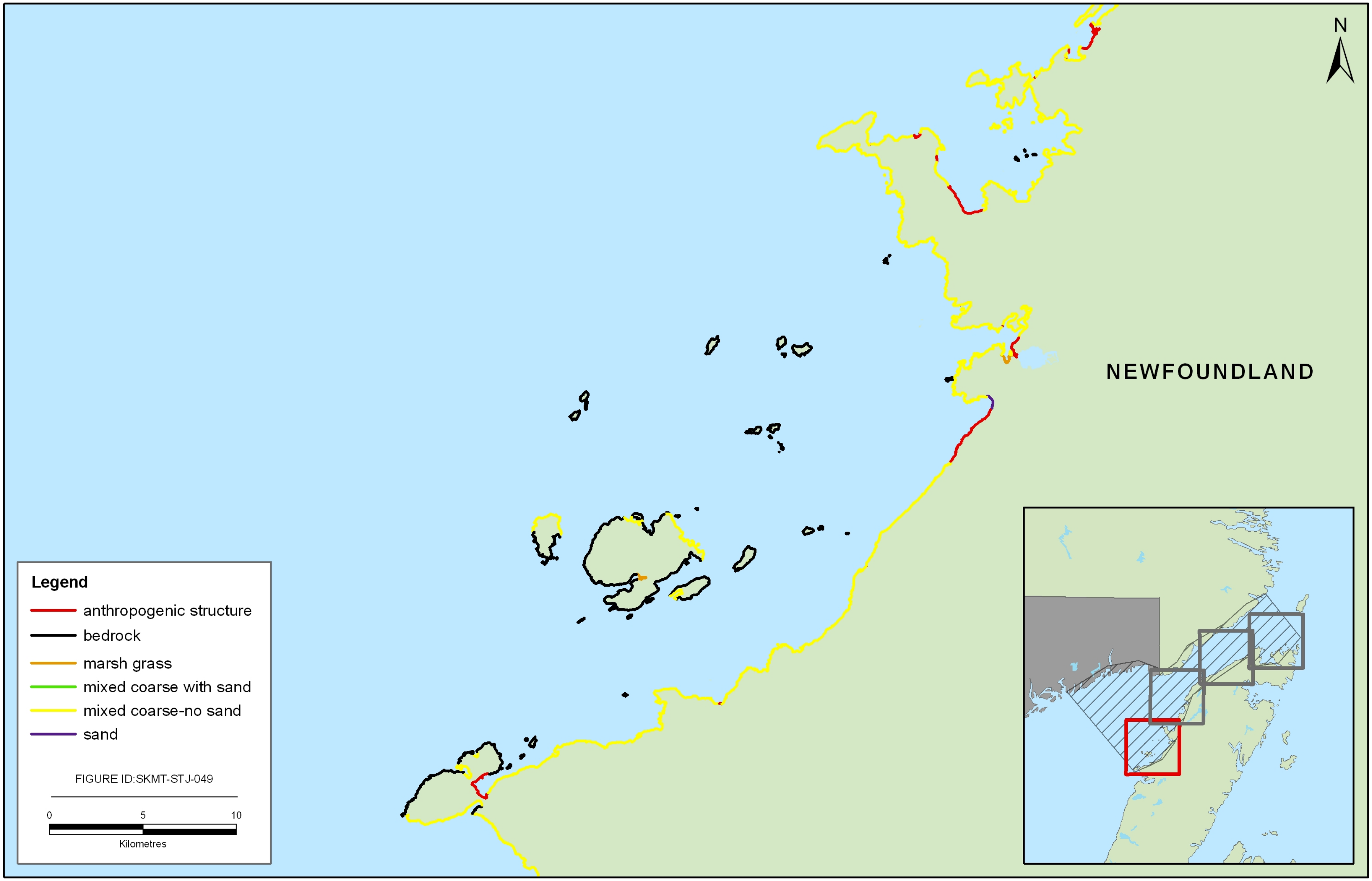

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FIGURE C-14

Backshore Material (Map 1)

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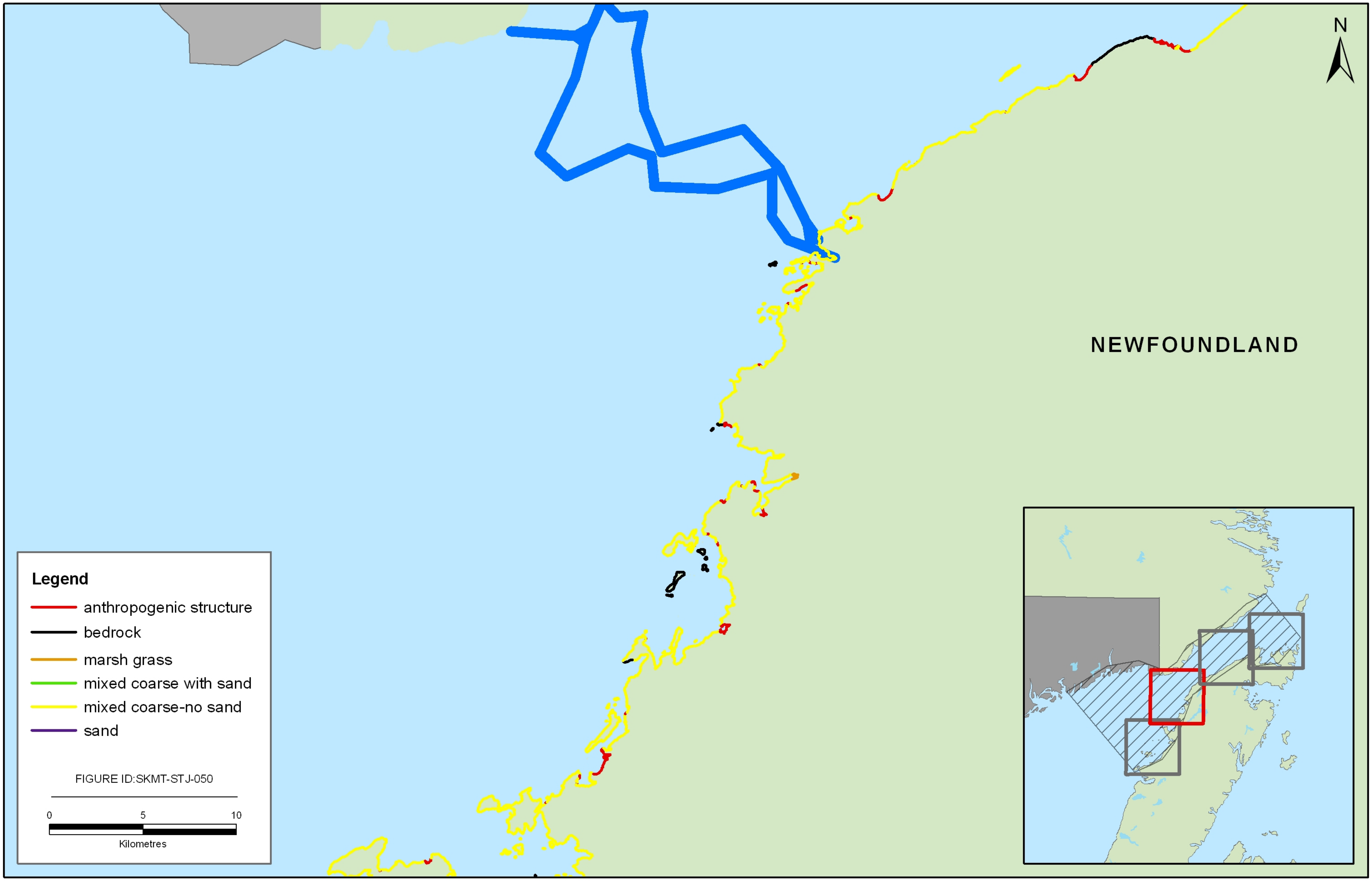

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FIGURE C-15

Backshore Material (Map 2)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

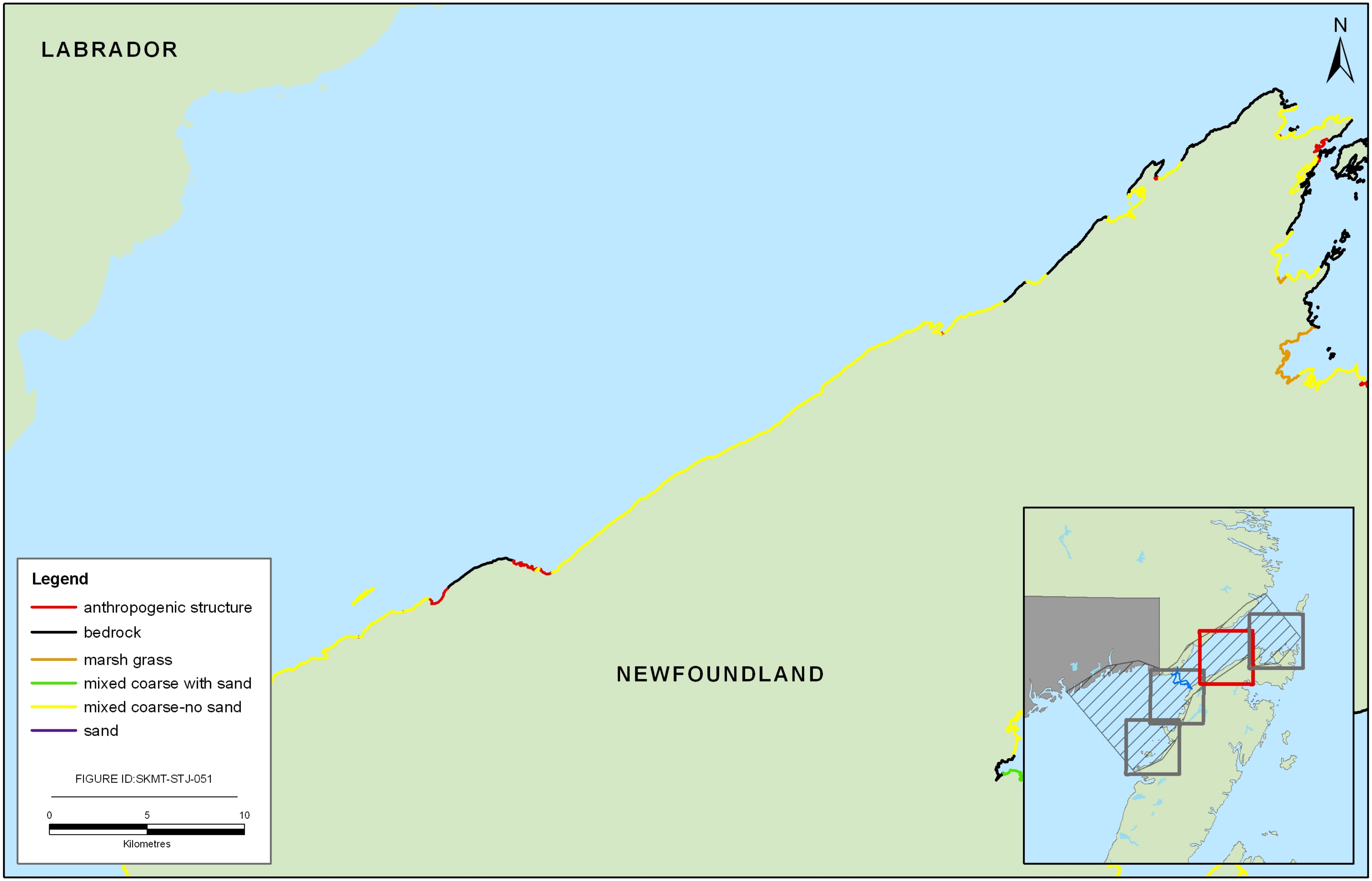

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FIGURE C-16

Backshore Material (Map 3)

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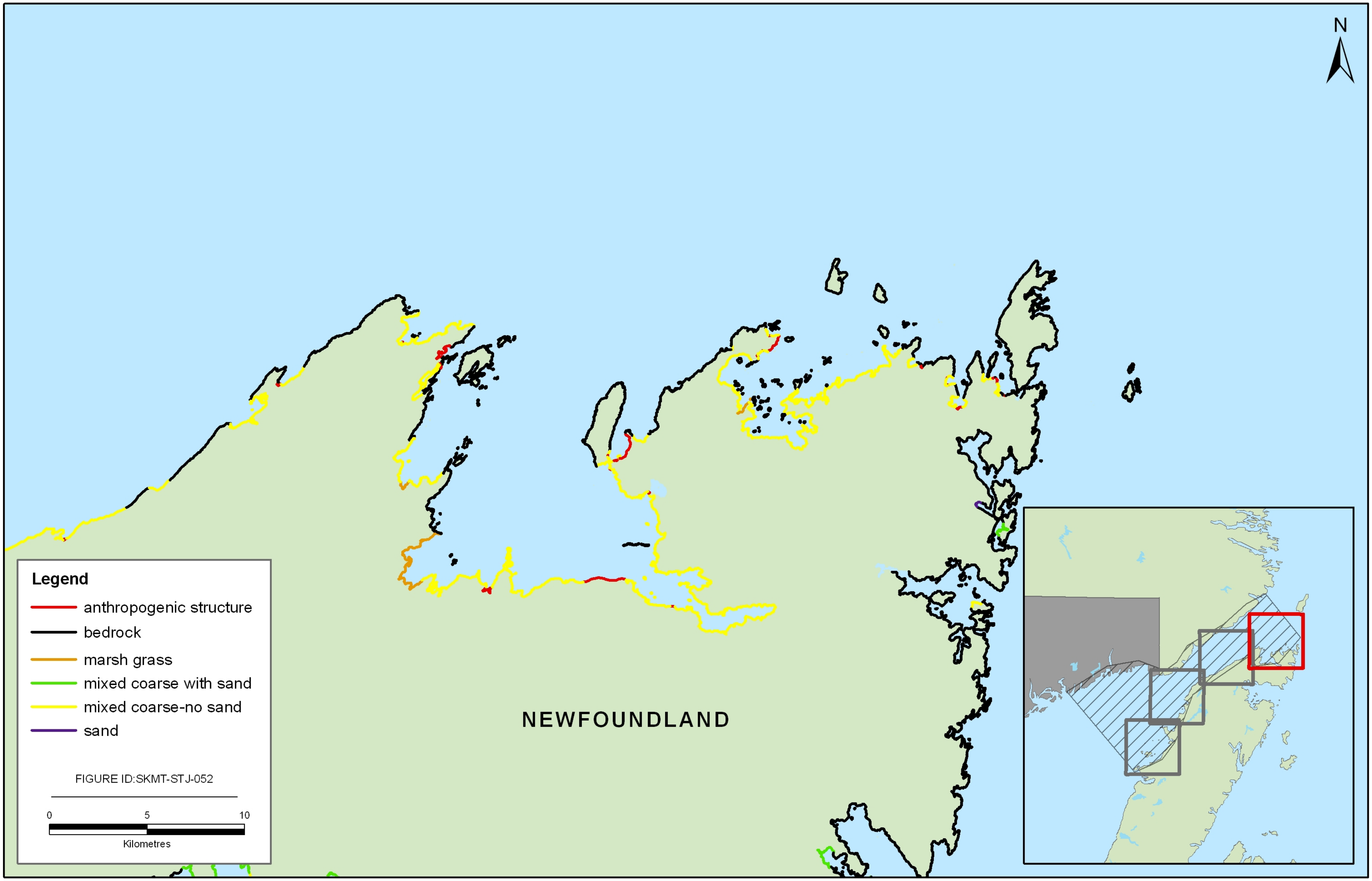

FIGURE C-17

Backshore Material (Map 4)

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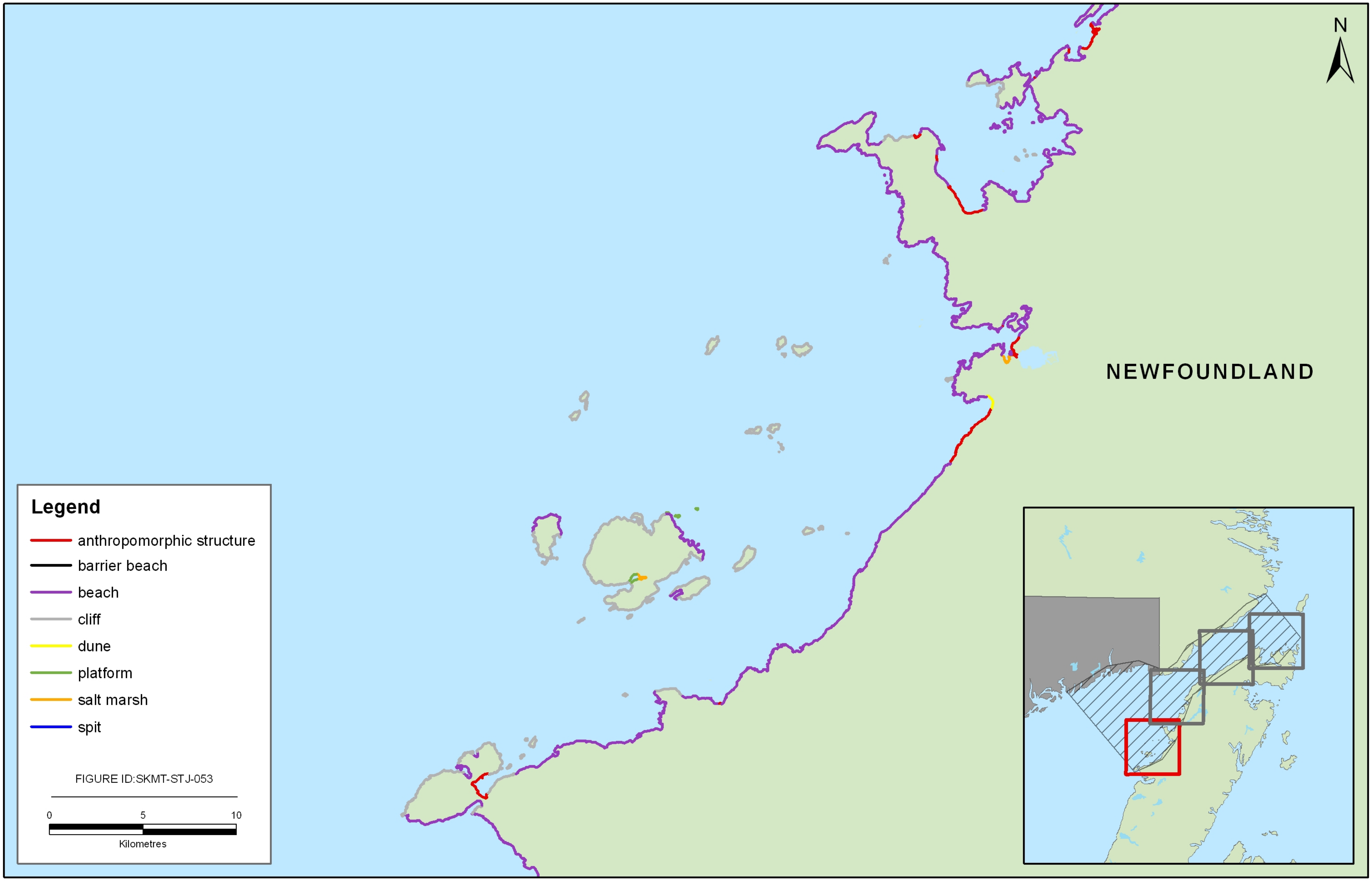

FIGURE C-18

Backshore Form (Map 1)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

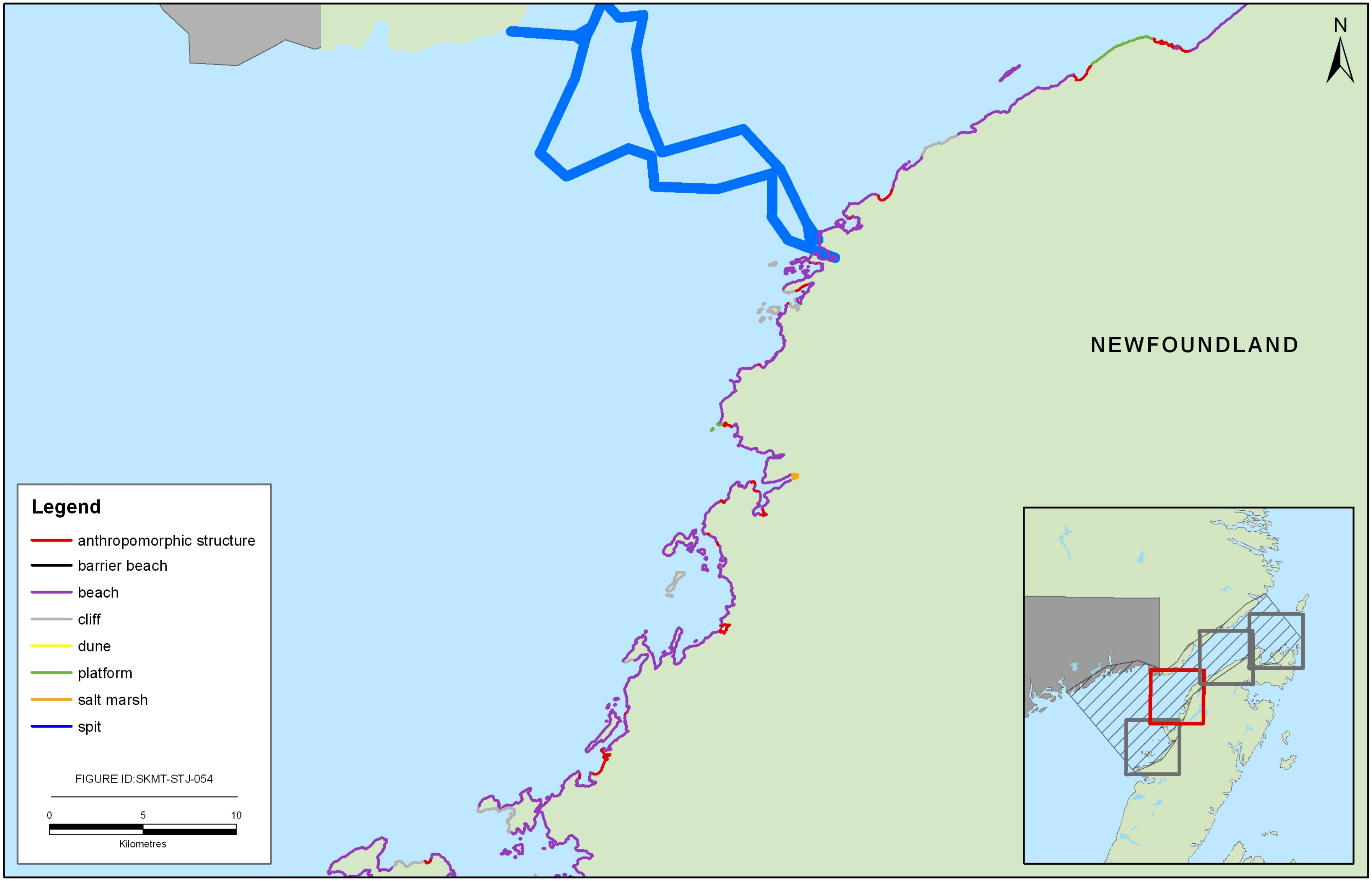

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FIGURE C-19

Backshore Form (Map 2)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada

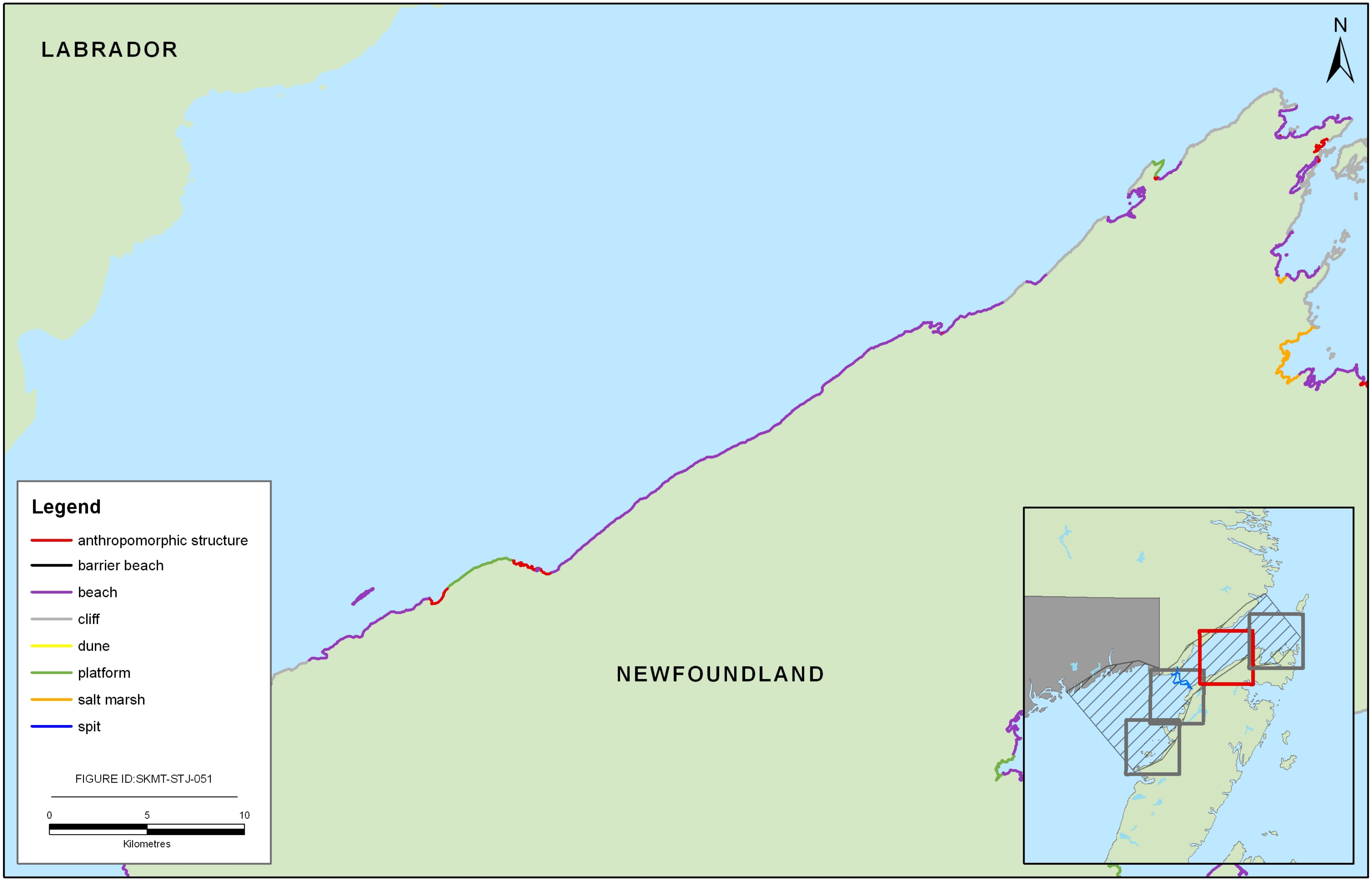

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FIGURE C-20

Backshore Form (Map 3)

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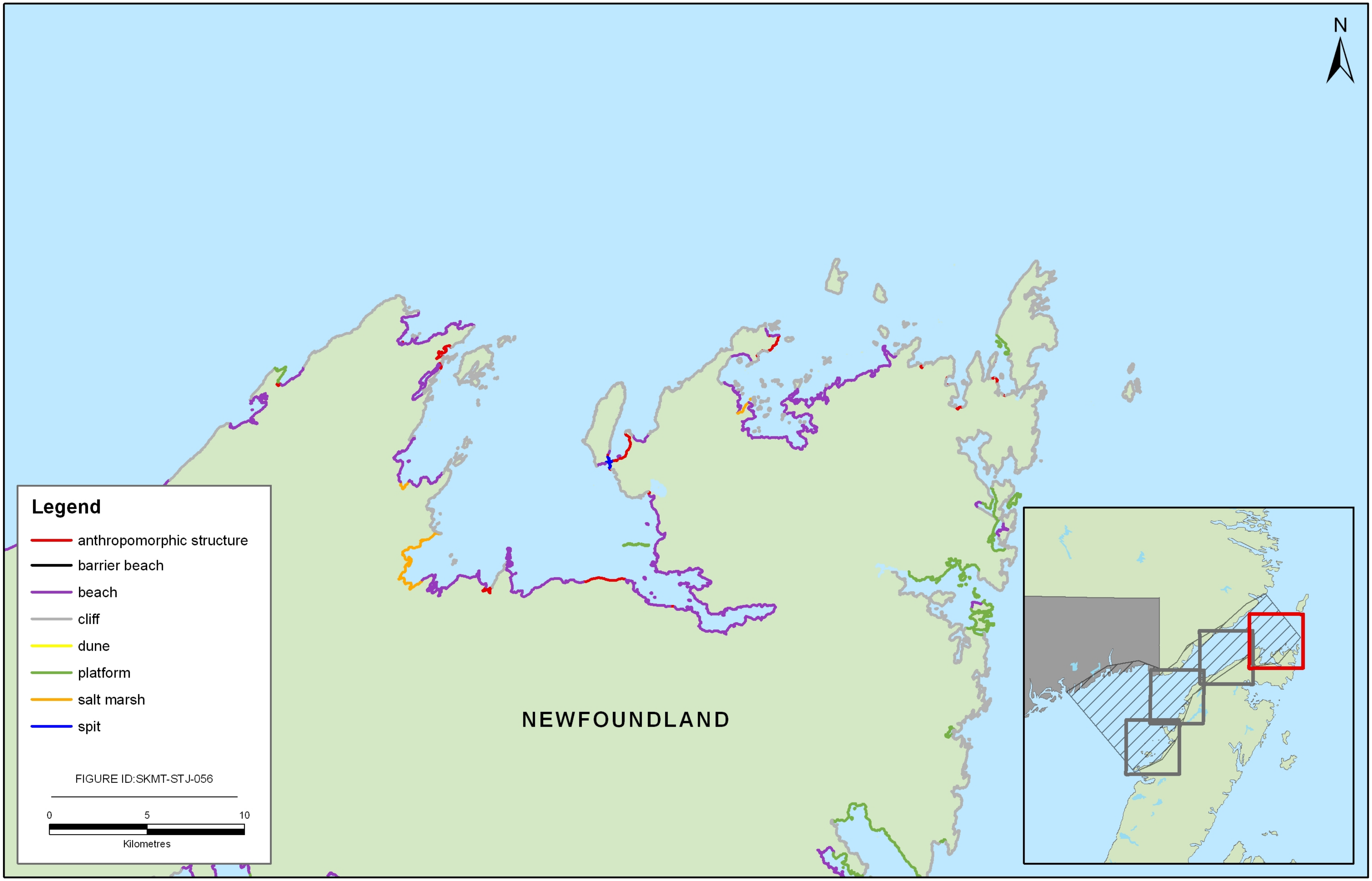

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FIGURE C-21

Backshore Form (Map 4)

This product has been produced by Sikumiut Environmental Management Ltd. based on data provided by Environment Canada