LABRADOR – ISLAND TRANSMISSION LINK ENVIRONMENTAL ASSESSMENT

Marine Environment:
Marine Mammals, Sea Turtles and Seabirds Component Study - Revised

December 2012

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LOWER CHURCHILL PROJECT

LABRADOR – ISLAND TRANSMISSION LINK ENVIRONMENTAL ASSESSMENT
Environmental Component Studies: Introduction and Overview

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

The Project was registered under the Newfoundland and Labrador *Environmental Protection Act* (*NLEPA*) and the *Canadian Environmental Assessment Act* (*CEAA*) in January 2009 (with subsequent amendments and updates), in order to initiate the provincial and federal environmental assessment (EA) processes. Following public and governmental review of that submission, an Environmental Impact Statement (EIS) was required for the Project. The EIS is being developed by Nalcor Energy, in accordance with the requirements of both *NLEPA* and *CEAA* and the *EIS Guidelines and Scoping Document* issued by the provincial and federal governments.

In support of the Project's EIS, Nalcor Energy has undertaken a series of environmental studies to collect and/or compile information on the existing biophysical and socioeconomic environments and to identify and assess potential Project-environment interactions. This environmental study program has included field surveys, associated mapping and analysis, environmental modeling, and the compilation and analysis of existing and available information and datasets on key environmental components. This report comprises one of these supporting environmental studies.

A general guide to these Environmental Component Studies, some of which are comprised of multiple associated reports, is provided on the opposite page.

The information reported herein will be incorporated into the Project's EIS, along with any additional available information, to describe the existing (baseline) environmental conditions and/or for use in the assessment and evaluation of the Project's potential environmental effects and in the identification and development of mitigation.

This study focuses on the relevant aspects of the proposed Project – including the proposed and alternative HVdc transmission corridors, marine cable crossings, and/or other Project components and activities – as known and defined at the time that the EA process was initiated and/or when the study commenced. Project planning and design are ongoing, and as is the case for any proposed development, the Project description has and will continue to evolve as engineering and EA work continue. The EIS itself will describe and assess the specific Project components and activities for which EA approval is being sought, and will also identify and evaluate other, alternative means of carrying out the Project that are technically and economically feasible as is required by EA legislation.

The EIS and these Component Studies will be subject to review by governments, Aboriginal and stakeholder groups and the public as part of the EA process.

Nalcor Energy – Lower Churchill Project

LABRADOR-ISLAND TRANSMISSION LINK: ENVIRONMENTAL COMPONENT STUDIES (CSs)

Component Study	Reports	
1) Vegetation CS	Report 1a Ecological Land Classification	Report 1b Wetlands Inventory & Classification
	Report 1c Regionally Uncommon Plants Model	Report 1d Timber Resources
	Report 1e Vegetation Supplementary Report	
2) Avifauna CS		
3) Caribou & Other Large Mammals CS	Report 3a Caribou & Their Predators	Report 3b Moose & Black Bear
4) Furbearers & Small Mammals CS		
5) Marine Environment: Fish & Fish Habitat, Water Resources CS	Report 5a Marine Fish: Information Review	Report 5b Marine Flora, Fauna & Habitat Survey
	Report 5c Marine Habitats (Geophysical) Survey	Report 5d Water, Sediment & Benthic Surveys
	Report 5e Marine Surveys: Electrode Sites	Report 5f Marine Surveys: Supplementary
6) Freshwater Environment: Fish & Fish Habitat, Water Resources CS		
7) Marine Environment: Marine Mammals, Sea Turtles & Seabirds CS	Report 7a Marine Mammals, Sea Turtles & Seabirds: Information Review	Report 7b Marine Mammal & Seabird Surveys
	Report 7c Ambient Noise & Marine Mammal Surveys	
8) Species of Special Conservation Concern CS		
9) Marine Environment & Effects Modelling CS	Report 9a Strait of Belle Isle: Oceanographic Environment & Sediment Modelling	Report 9b Strait of Belle Isle: Marine Sound Modelling - Cable Construction
	Report 9c Electrodes: Environmental Modelling	
10) Historic & Heritage Resources CS		
11) Socioeconomic Environment: Communities, Land & Resource Use, Tourism & Recreation CS	Report 11a Communities, Land & Resource Use, Tourism & Recreation	Report 11b Current Levels of Accessibility Along the Transmission Corridor
12) Socioeconomic Environment: Aboriginal Communities & Land Use CS		
13) Socioeconomic Environment: Marine Fisheries in the Strait of Belle Isle CS		
14) Viewscapes CS		

Environmental Component Study Required Under the EIS Guidelines: Comprising Reports (Shaded cells above)	
Avifauna: 2, 7a, 7b	Furbearers: 4
Caribou (and Predators): 3a	Timber Resources: 1d
Water (Quality and Quantity): 5a, 5d, 5e, 5f, 6	Marine and Freshwater Fish and Fish Habitat: 5, 6, 7, 13
Species at Risk: 8	Historic Resources: 10
Viewscapes: 14	Socioeconomics: 11, 12, 13
Environmental study reports submitted as additional background information: 1a, 1b, 1c, 1e, 3b, 9	

Labrador – Island Transmission Link

Marine Environment:
Marine Mammals, Sea Turtles and Seabirds
Component Study - Revised

Preface

The *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study* (June 2011) was submitted as part of the Environmental Assessment (EA) of the proposed Labrador-Island Transmission Link (the Project).

Following review of the *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study* by the Environmental Assessment Committee (EAC), Aboriginal groups and the public, as required by the *Environmental Protection Act*, Nalcor Energy (Nalcor) was advised that the *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study* required additional work.

Nalcor has prepared a revised version of the *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study*, which includes grey highlighting of all new text that was added to address the comments received from public, Aboriginal, and governmental review.

This *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study – Revised* (December 2012) has been prepared and submitted as part of the Environmental Assessment (EA) of the proposed Labrador-Island Transmission Link.

It is comprised of three (3) associated study reports:

1) **Marine Mammals, Sea Turtles and Seabirds in the Strait of Belle Isle: Supplementary Information Review and Compilation - Revised** (December 2012): A summary of existing and available information on these components of the marine environment in the Strait of Belle Isle, intended to supplement the additional data collected through the surveys outlined below.

2) **Marine Mammals and Seabirds in the Strait of Belle Isle** (November 2000): Aerial and boat-based marine mammal and seabird surveys in the Strait of Belle Isle, as well as a detailed review of the relevant literature.

3) **Strait of Belle Isle: Ambient Noise and Marine Mammal Survey** (June 2011): A 2010 marine acoustic survey of ambient noise and marine mammal vocalizations at three locations within and near the identified Strait of Belle Isle cable crossing corridors.

The original Project concept for the proposed Strait of Belle Isle cables saw the preliminary identification of potential cable landing sites at Forteau Point, Labrador and Mistaken Cove, Newfoundland (with alternatives at L'Anse Amour and Yankee Point in Labrador and on the Island, respectively).

From there, multiple cables would be placed in two marine corridors across the Strait, as illustrated in the map provided.

Since that time, Nalcor has continued with its Project planning and engineering work, and in doing so, has proceeded to evaluate other possible design options and alternatives.

The Proponent is continuing to focus on Forteau Point as the likely Labrador cable landing site. On the Newfoundland side of the Strait of Belle Isle, Shoal Cove has also been identified as a possible site.

If these cable landing site options were to be finalized, on-land horizontal directional drilling technology may be used to install the cables from these locations, out to and under the Strait for up to several kilometers. From there, the cables would be placed on the seabed and protected with rock berms.

With this option, the cables would be placed within one marine corridor (rather than two) across the Strait. This corridor option is essentially an amalgamation of the two marine cable corridors described earlier - utilizing portions of each corridor along with a new short segment in to Shoal Cove, as illustrated in the map.

Given the nature and regional study areas of the reports that comprise this Component Study, the information and results included in it are applicable to either of the above described marine cable corridor options in the Strait of Belle Isle.

The environmental information presented in this *Marine Environment: Marine Mammals, Sea Turtles and Seabirds Component Study – Revised* (December 2012) will be incorporated and used in the Project's Environmental Impact Statement (EIS), which will provide a summary description of the existing environment and an environmental effects assessment for the proposed Project.

Labrador – Island Transmission Link

Marine Mammals, Sea Turtles and Seabirds in the Strait of Belle Isle: Supplementary Information Review and Compilation (Revised)

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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 Mammals, Sea Turtles and Seabirds: Supplementary Information Review and Compilation* has been completed with the objective to gather, summarize and present existing and available information on marine mammals, sea turtles and seabirds in the Strait of Belle Isle. This study complements information gathered during Project-related surveys of marine mammals and seabirds in the Strait of Belle Isle, and the literature review which accompanied this survey (JWEL 2000), as well as other associated studies by Nalcor Energy.

The Study Area was regional in nature, comprising 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). Additional organizations consulted included Environment Canada, the Bedford Institute of Oceanography, Woods Hole Oceanography Centre, Atlantic Canada Conservation Data Centre, Duke University, North Atlantic Right Whale Consortium, and the University of Rhode Island. An annotated bibliography including relevant papers, reports, data sources and personal communications is included as an appendix to this report.

Information on marine mammals, including whales (cetaceans) and seals (pinnipeds) in the Study Area was identified, compiled and reviewed. Recent information collected on marine mammals since 2000 is largely anecdotal in nature; however some systematic land-based, aerial and shipboard surveys do exist. Both anecdotal records and scientific studies and surveys were reviewed, and included information from the DFO historical sightings database, the Trans North Atlantic Sightings Survey, as well as from the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations database, and the Community Coastal Resource Inventory database. A review of information on sea turtles in the Study Area revealed that only a few records of sea turtle sightings exist in the Gulf of St. Lawrence, which likely indicates that sea turtles do not frequent this area.

A review of seabirds in the Study Area included information on migration patterns, nesting and important bird areas and nesting areas of seabirds, shorebirds and marine waterfowl. The information contained in the Eastern Canadian Seabirds At Sea database and the historical equivalent Programme Intégré de Reserches sur les Oiseaux Pelagiques database (both maintained by the Canadian Wildlife Service) were examined in order to determine timescale trends in relative seabird abundance within the Study Area, including seasonal and decadal comparisons of vessel survey effort, distributions and relative abundances of species and species groups.

Species listed under the *Species At Risk Act* and/or the provincial *Endangered Species Act*, and those that have been designated by the Committee on the Status of Endangered Wildlife in Canada, are identified and discussed as species of special conservation concern.

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 INTRODUCTION

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.

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 EA of the Project, this Marine Mammals, Sea Turtles and Seabirds Study has been completed with the objective to gather, summarize and present existing and available information on these marine wildlife in the Strait of Belle Isle area. This information is intended to supplement that collected through marine surveys conducted in the Strait of Belle Isle by Nalcor Energy and reported elsewhere.

1.1 Project Overview

The proposed 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 in Central Labrador, on the lower Churchill River adjacent to the Lower Churchill Hydroelectric Generation Project;
- an HVdc transmission line extending 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 approximately 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. From there, 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 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.

Engineering analyses are ongoing to assess these and other potential approaches and techniques for the 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 EA of the Project will also identify and evaluate alternative means of carrying out the Project that are technically and economically feasible. In conjunction and concurrent with the EA 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 mammals, sea turtles and seabirds 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 EIS for the proposed Project. The study further supplements the information gathered in the 1998 marine mammal and seabird surveys within the Strait of Belle Isle (and reported separately by JWEL 2000) and other studies by Nalcor Energy.

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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 mammals, sea turtles and seabirds 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 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 and elsewhere.

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, thereby encompassing an area of approximately 10,000 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.

The marine habitat features which are most influential for the distribution of marine mammals, sea turtles and seabirds are described in the ensuing sections. Further details on the marine habitat of the Strait of Belle Isle Study Area, are provided in other reports prepared for Nalcor Energy and reported elsewhere (e.g., AMEC Earth and Environmental 2010; Sikumiut 2010).

2.1.1 **Physical 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 a 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 productivity (Savenkoff et al. 2007). High nutrient levels from the Labrador shelf waters enter through the Strait of Belle Isle, as well as tidal mixing and upwelling in the region bring nutrients to the surface (Savenkoff et al. 2007). 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), that attract large concentrations of seabirds, including Northern Gannets that do not breed in the area but forage in the productive waters during the spring and summer (Huettman and Diamond 2000, McKinnon et al. 2009). It also provides a productive feeding environment for large cetaceans (Savenkoff et al. 2007).

The freshwater outflow from the St. Lawrence River into the estuary is a dominant feature in the oceanography of the Gulf of St. Lawrence, including the Strait. This outflow 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.

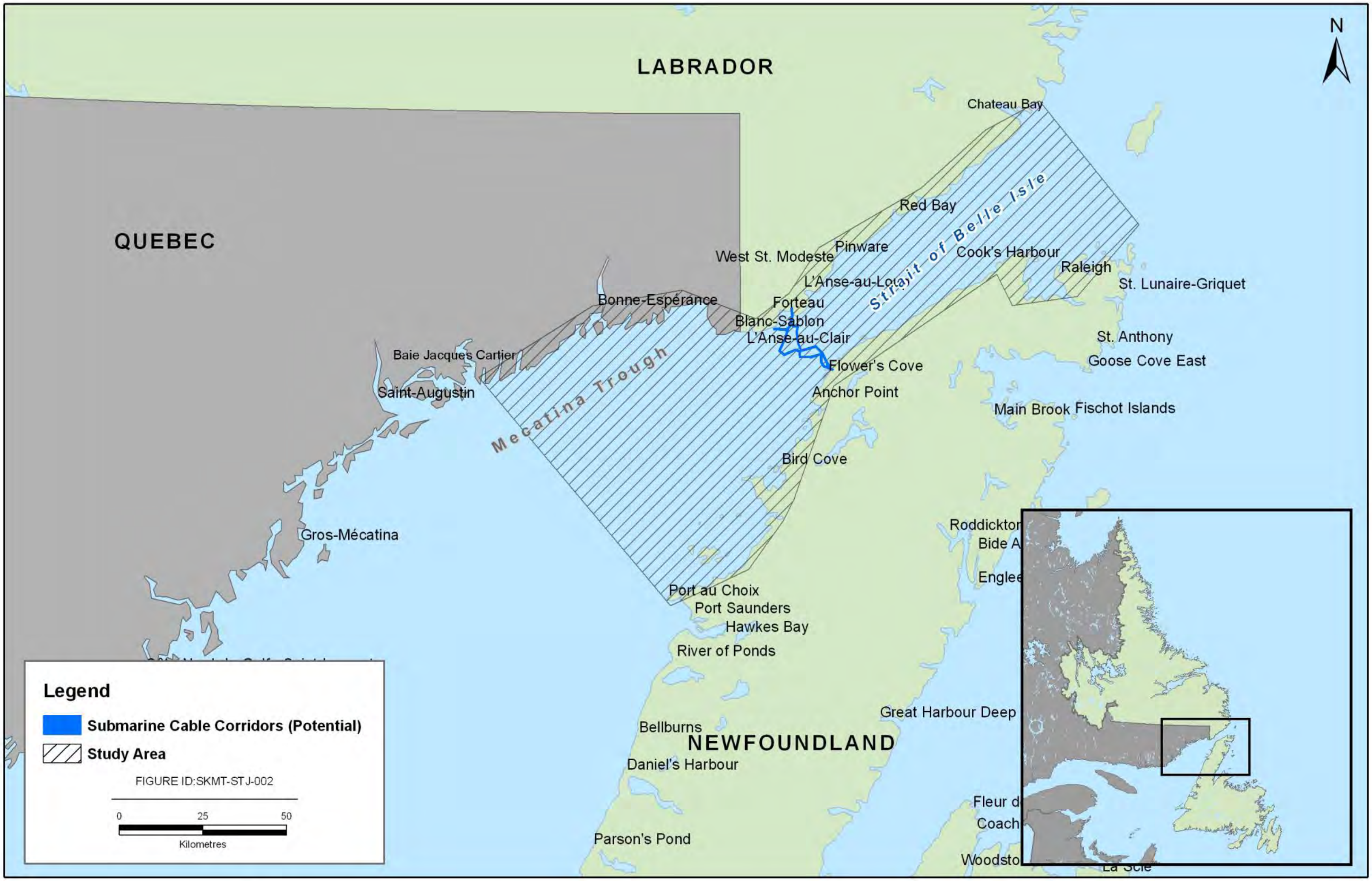

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FIGURE 2.1

Strait of Belle Isle Study Area

The tidal pulse from the Atlantic Ocean enters the Gulf 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).

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 reaches 50 to 60 m below the surface with average temperatures reaching between 10 and 11˚C, and average salinities between 30.6 and 32 practical salinity units (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 (BIO 2010).

2.1.2 **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 metre 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).

2.1.3 **Coastal Zone**

Shoreline habitats at the various potential landing sites for the proposed submarine cable crossing (Forteau Point, L'Anse Amour, Mistaken Cove and Yankee Point) were characterized by AMEC Earth and Environmental (2010). 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. The intertidal zone at the Mistaken Cove site consisted of largely exposed bedrock and sand/gravel beaches. The backshore consisted of two distinct vegetation types: (i) grasses and (ii) trees and tuckamore. The Yankee Point intertidal zone was divided into two distinct areas, having (i) bedrock with gravel/pebbles or (ii) gravel. The backshore at Yankee Point consisted of areas with grass and patches of tuckamore located immediately behind the survey area.

The shorelines of discrete reaches of coastline in the Strait of Belle Isle 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.

2.2 Methods

The study team has identified, acquired, compiled, reviewed and presented available and existing information on marine mammals, sea turtles and seabirds, shorebirds and waterfowl in the Strait of Belle Isle. The study initially involved conducting a thorough inventory of available information related to the Strait of Belle Isle. The following section presents the approach used in the review and synthesis of relevant information, key sources of information and data, agencies, organizations and persons contacted to acquire the information/data.

2.2.1 Information Sources

It was initially determined that a major source of relevant information was Fisheries and Oceans Canada (DFO). Efforts were concentrated on obtaining more recent and relevant information on the Study Area, to supplement a literature review for the same area completed in JWEL (2000). The Strait of Belle Isle Study Area included geographical areas that are the responsibility of two DFO Regions: Newfoundland and Labrador; and Quebec.

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

- EC/CWS ECSAS/PIROP Seabirds-at-Sea database. Dartmouth, Nova Scotia.
- CWS Red Knot occurrences database. St. John's, Newfoundland.
- CWS Seabird breeding population database. St. John's, Newfoundland.
- Gilliland, S. 1995. Aerial surveys for Common Eider and Harlequin Ducks on the coast of Labrador, 1994. CWS Report.
- Gilliland, S. 2000. Temporal and spatial patterns in abundance and distribution of Common Eiders along the coast of Labrdor. CWS Report.
- Gilliland, S. 2003. Common Eider colony summary tables. CWS, St. John's.
- Gilliland, S., G.J. Robertson, and G, Goodyear. 2008. Distribution and abundance of Harlequin Ducks breeding in northern Newfoundland. 2008. Waterbirds 1 (Special Publication 2):104-109.
- Selno J., B Mctavish, and J. Wells. 1996. Point Amour, Labrador Spring Eider Count and Seawatch April 19-May 24, 1996. Report prepared for CWS. St. John’s.
- DFO Oceans, Habitat Management, and Species at Risk Branch – Newfoundland and Labrador Region;
- DFO Science Branch - Newfoundland and Labrador Region and Quebec Region;
- DFO Science Advisory Reports of the Canadian Science Advisory Secretariat (CSAS) regarding the Large Ocean Management Areas (e.g., GOSLIM);
- DFO Canadian Science Advisory Secretariat (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);

- DFO Canadian Technical Report Series of the Journal of Fisheries and Aquatic Sciences;
- DFO Marine Environmental Data Service (MEDS) including the Integrated Science Data Management (ISDM) Databases;
- DFO Atlantic Zone Monitoring Program Database (AZMP);
- DFO Community-based Coastal Resource Inventory (CCRI) Database;
- DFO Gulf of St. Lawrence Integrated Management (GOSLIM) Ecosystem Overview Report (EOR) and associated databases; and
- DFO Libraries and WAVES Database (database of holdings of DFO libraries).

In addition to the above information sources, the study team has also communicated with a variety of CWS and DFO Staff to determine the availability of, and acquire access to, additional relevant information and data. A detailed listing of Personal Communications are provided in Section 5.0, and in general, the following responsible personnel within EC/CWS and DFO were contacted:

- Scientists and species experts - Newfoundland and Labrador Region, Atlantic Canada Region and Quebec Region;
- Section Heads with Science Branch - Newfoundland and Labrador Region;
- Area Habitat Biologist (Western Newfoundland - Newfoundland and Labrador Region);
- Oceans Biologist/GOSLIM Coordinator (Western Newfoundland - Newfoundland and Labrador Region);
- Species at Risk Coordinators - 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.

As indicated above, the study team also communicated with scientists at Environment Canada to acquire access to additional relevant information and data on seabirds, waterfowl and shorebirds in and near the Study Area. The various information/data sources that were examined through communications with EC and through available databases, included:

Government of Newfoundland and Labrador:

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

Universities, Institutions, and other Organizations:

- Memorial University of Newfoundland (MUN), including the Marine Institute and the Oceans Sciences Centre;
- Bedford Institute of Oceanography;
- Woods Hole Oceanographic Centre;
- University of Rhode Island;
- Duke University – Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP);
- North Atlantic Right Whale Consortium;
- Atlantic Canada Conservation Data Centre (ACCDC); and
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status reports.

In addition to identifying and exploring 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. This included the following sources and databases:

- Aquatic Sciences and Fisheries Abstracts (ASFA);
- GEOSCAN;
- Newfoundland and Labrador Archives; and
- Google Scholar.
- Important Bird Areas (www.ibacanada.ca)

Other information sources that were examined but subsequently determined to have limited or no relevant information 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 (C-NLOPB) Strategic Environmental Assessment (SEA) of the Labrador Shelf Offshore Area – Mostly offshore but some 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 includes relevant papers, reports, data sources and personal communications. Information sources that are relevant to the Study Area are included in the annotated bibliography, but were not necessarily used and cited directly in the report. Information sources used in the report to provide general information about species biology were not included in the annotated bibliography, since the annotated bibliography provides only relevant information on the Study Area.

2.3 Study Team

The study team was led by Larry LeDrew, Project Manager, with senior advice provided by Leroy Metcalfe and Dr. Thomas Smith. Suzanne Thompson conducted the literature review and participated in report preparation for marine mammals and sea turtles, and Dr. Bill Montevecchi, Chantelle Burke, Emily Connelly and Paul Regular conducted the literature review, ran spatial and temporal analyses, created maps and prepared the report for seabirds, shorebirds and marine waterfowl, and Grant Vivian prepared the other maps and figures (Table 2.1). Appendix B provides a more detailed biography of team members.

Table 2.1 Study Team Roles and Responsibilities

Name	Role	Responsibilities
Larry LeDrew, M. Sc.	Project Manager	Project management, client liaison, report review
Leroy Metcalfe, B.Sc.	Advisor	Report review
Thomas Smith Ph.D	Senior Advisor	Senior review
Bill Montevecchi, Ph.D	Researcher	Report preparation
Chantelle Burke, M.Sc.	Researcher	Report preparation
Paul Regular, B.Sc.	Researcher	Report preparation
Emily Connelly, B.Sc.	Researcher	Report preparation
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

This section provides 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 marine mammals, sea turtles and seabirds which are present in the Study Area is provided.

3.1 Major Information Sources

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 2006, 2007; Savenkoff et al. 2007).

During the establishment of GOSLIM, a zonal workshop was undertaken in 2006 (DFO 2006) 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.

Owing to the partitioning of marine taxa between federal regulatory departments, marine birds were not included in this DFO exercise, though they are clearly a key thematic layer for ecological and biological assessment of the Strait of Belle Isle. 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).

On the basis of available information, it is also very clear that the Strait of Belle Isle is an important area for marine birds. Information on marine mammals including whales and seals in the Gulf of St. Lawrence was reviewed in Lesage et al. (2007) in support of this initiative, and includes a detailed summary of information and a comprehensive literature review for the Gulf of St. Lawrence, including the Strait of Belle Isle. This report was used extensively in identifying information sources for marine mammals, as well as relevant details regarding the Study Area. The other thematic layers referenced above, are described in Sikumiut (2010).

Information on seabirds in the Study Area was compiled primarily by Dr. Bill Montevecchi, a regional expert in seabird ecology. Other sources include sightings and information from Canadian Wildlife Service (CWS), including the Eastern Canadian Seabirds At Sea (ECSAS) database, and the historical equivalent Programme intégré de recherches sur les oiseaux pélagiques (PIROP), CWS databases and grey literature on migration patterns and important habitat and nesting sites (CWS unpublished data).

3.2 Marine Mammals

In the ensuing sections, recent information sources for marine mammals in the Strait of Belle Isle are discussed in detail, and selected species are examined. This includes information regarding cetaceans (whales) both baleen whales (Mysticeti) and toothed whales (Odontoceti), and pinnipeds (seals). Species of special conservation concern are discussed in further detail in Section 3.5.

Information collected on marine mammals in the Strait of Belle Isle since the publication of JWEL (2000) has been relatively anecdotal in nature; however some systematic land-based, aerial and shipboard survey data does exist (Lawson et al. 2007; Lesage et al. 2007; Lawson and Gosselin 2009; Stenson et al. 2010; Hammill and Stenson 2010). Both anecdotal records and scientific studies and surveys are discussed.

3.2.1 Scientific Studies and Systematic Surveys

Marine mammals, including whales and seals, have been observed using the Strait of Belle Isle area for migratory, feeding and reproduction purposes. Due to the high cost of dedicated surveys, the frequency and geographical coverage are often limited for a particular area of interest. It should also be noted that caution should be used when interpreting information collected from surveys since many of these rely on "at surface" sightings (Lesage et al. 2007). This type of information can be biased toward species with higher detectabilities (i.e., larger species, and those with aggregative behaviour, or spend more time at the surface). Seasonal changes in the area can affect sightings of mammals due to seasonal migrations, and therefore interpretation of information collected from surveys conducted in the area depend on season, especially for seal species (Sjare, 2010, pers. comm.).

DFO conducted a large-scale aerial survey of marine megafauna in the northwest Atlantic during the summer of 2007 as part of the Trans North Atlantic Sightings Survey (TNASS), which extends from northeastern United States to the United Kingdom (Lawson and Gosselin 2009). This was the first systematic effort to provide coverage for much of the Canadian seaboard, and the first in more than two decades to survey the continental shelf along the Labrador and Newfoundland coasts for marine mammals, sea turtles and other species (Lawson and Gosselin 2009). The TNASS study objectives included an effort to estimate the abundance and distribution of marine megafauna in Atlantic Canadian waters. Where sufficient data existed, abundance and distribution was estimated for species of marine mammals (11 whale species) and the leatherback turtle.

During the TNASS survey, eight species of marine mammals were identified in the Strait of Belle Isle Study Area: beluga (*Delphinapterus leucas*); blue whale (*Balaenoptera musculus*); fin whale (*Balaenoptera physalus*); harbour porpoise (*Phocoena phocoena*); humpback whale (*Megaptera novaeangliae*); minke whale (*Balaenoptera acutorostrata*); Atlantic white-beaked dolphin (*Lagenorhynchus albirostris*); and white-sided dolphin (*Lagenorhynchus acutus*). Groupings of humpback whales were sighted more often in the Study Area than other species, while higher numbers of individual white-beaked dolphins were sighted during the survey in the Strait of Belle Isle than other species in the area, and had higher numbers in that area than other areas surveyed.

As discussed previously, during the identification and characterization of EBSAs for the GOSLIM, Lesage et al. (2007) identified important areas for marine mammals. Data were compiled from three aerial surveys: one in each of 1995 and 1996, as previously reported in Kingsley and Reeves (1998), and one in 2002. As well, data from telemetry studies in the Gulf of St. Lawrence for grey seals (*Halicoerus grypus*) and hooded seals (*Cystophora cristata*) for home range analysis were used (Lesage et al. 2007). For the area of the Strait of Belle Isle, including the Mecatina Plateau, at least 14 species of marine mammals were identified: grey seal; harbour seal (*Phoca vitulina)*; hooded seal; harp seal (*Pagophilus groenlandicus*); minke whale; blue whale; fin whale; humpback whale; killer whale; harbour porpoise; Atlantic white-sided dolphin; white-beaked dolphin; short-beaked common dolphin (*Delphinus delphis*); and long-finned pilot whale (*Globicephala melas*). With the exception of hooded seal, all of these species occur within the Strait of Belle Isle and the Mecatina Plateau with some regularity between May to December. Harp seals, hooded seals, and possibly fin whales occur regularly between December and May (Lesage et al. 2007). This data compilation study identified the Strait of Belle Isle as having a feeding function for diverse and high biomasses of megafauna; migration function during spring and fall and a reproduction function during winter for seals. Unique bathymetric characteristics result in persistent zooplankton aggregation in the Study Area (Sourisseau et al. 2006), resulting in the area supporting high biomasses of diverse megafauna (especially humpback whales) during certain periods of the year.

Richard Sears of the Mingan Island Cetacean Study (MICS), a not-for-profit organization, occasionally conducts surveys of marine mammals from St. Augustine to Blanc Sablon (Sears, 2010, pers. comm.). Data collected by Mr. Sears contains mostly boat-based surveys, although he has conducted coastal surveys in the Gulf of St. Lawrence in the 1980s (Sears and Williamson 1982). The last survey was conducted in 2006. Although an abundance of data have been collected, very few publications have been prepared (Sears, 2010, pers. comm.). Mr. Sears does have a photographic catalogue of certain species (e.g., blue whale). Details about Mr. Sears and the MICS can be found online (MICS 2010).

3.2.2 Anecdotal Information

Information sources for marine mammals in the Strait of Belle Isle are for the most part anecdotal in nature, and depend on sightings from fishers, tourists, as well as records of entrapments in fishing gear and strandings. The existing historical databases were previously reviewed in JWEL (2000), which did not include the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) and associated datasets. This is a spatially referenced online database for marine mammal, seabird and sea turtle data from around the world (OBIS-SEAMAP 2010). This database contains sightings data from various sources and data providers in the Strait of Belle Isle and was used to map species distributions/sightings in the Strait of Belle Isle region. Several datasets include sightings in the Strait of Belle Isle Study Area:

- The University of Rhode Island, Bureau of Land Management, Cetacean and Turtle Assessment Program (CETAP) includes opportunistic sightings of whales, dolphins and sea turtles, and population surveys conducted from 1978 to 1982;
- The Allied Humpback Whale Catalog by the College of the Atlantic, Allied Whale includes sightings of humpback whales between 1976 and 2003; and
- Years of the North Atlantic Humpback Whale (YoNAH) Encounter, which is a collaboration led by Peter Stevick, University of Southern Maine, includes humpback whale sightings, plus photos, genetic sampling and behaviour data from 1992 to 1993.

Data were also provided by Dr. Jack Lawson at DFO (DFO 2010b). Dr. Lawson maintains a sightings database of marine mammals, and includes mostly anecdotal sightings of marine mammals, with most data gathered from platforms of opportunity that were vessel-based. The quality of the data is unknown, and depends on factors such as the observer experience, sighting effort, platform limitations, and sea state. These factors and the inherent problem of cetacean negative or positive reactions to the approach of such vessels have not been factored into the data. True species density or areal abundance cannot be estimated, since sighting effort has not been quantified in most cases. For completeness, these data represent an amalgamation of sightings from a variety of years and seasons. Hence they may obscure temporal or areal patterns in distribution (e.g., the number of pilot whales sighted in nearshore Newfoundland appears to have declined since the 1980s, even though the total number sighted in the overall database suggest they are relatively common). These data are undergoing a continuing process of error-checking. Sighting data are continually being received and entered, so the present dataset is incomplete, although new data will represent a small portion of the total (Lawson, 2010, pers. comm.). For these reasons, the sightings database is mapped for illustration purposes only, to give an indication of the sightings of various species in the Study Area.

Another source of information for this study has been the DFO led CCRI. There are three inventories for the Study Area including:

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

These data 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. These inventories were compiled in partnership between government agencies (primarily DFO, Environment Canada, Newfoundland and Labrador Department of Fisheries and Aquaculture) and local development associations. A review of the CCRI information determined that it was of considerable relevance to the study, including a collection of marine mammal sightings. It is important to highlight that much of the data contained in these inventories are local ecological knowledge based, collected through interviews, and therefore are considered anecdotal in nature.

Sightings of marine mammals in this database included whales, seals, walruses (*Odobenus rosmarus*) and polar bears (*Ursus martimus*). Due to the inconsistencies in species identifications, whales were placed in one category, while seals were placed in a separate category. Sightings information is presented in Figure 3.1. The database included two sightings of polar bears, one walrus sighting, and one sea turtle sighting in the Strait of Belle Isle Study Area.

3.2.3 **Whales (Cetaceans)**

Both baleen and toothed whales have been known to occur in the Study Area. As previously noted, the Strait of Belle Isle has been identified as an important area for marine mammals in the Gulf of St. Lawrence (DFO 2006, 2007; Lesage et al. 2007). Lawson and Gosselin (2009) provide the most recent estimates of the distribution and abundance of several marine mammals in Atlantic Canada, including in the Gulf of St. Lawrence. Several of these species are considered under the *Species At Risk Act* (*SARA*) or by COSEWIC, and are therefore discussed in further detail in Section 3.5. Historically bowhead whales (*Balaena mysticetus*) were also captured by Basque whalers in the Strait of Belle Isle, however, there are no modern reports of these animals in this area (Barkham 1984; Rastogi et al. 2004). North Atlantic right whale (*Eubalaena glacialis*) were also thought to be captured in this area, although recent genetic studies suggest that this is likely not true (Rastogi et al. 2004).

3.2.3.1 **Baleen Whales (Mysticetes)**

Baleen whales identified as frequently using the Strait of Belle Isle include: humpback whale; blue whale; fin whale (*Balaenoptera physalus*); and minke whale. Sei whale (*Balaenoptera borealis*) have also been identified in historical data, although these sightings are rare. Historical sightings of baleen whales in relation to the Study Area are presented in Figure 3.2, as taken from the OBIS-SEAMAP database, and data provided by DFO (2010b).

Humpback Whale

Humpback whales sightings in the Strait of Belle Isle are quite common, as cited by several studies (Lesage et al. 2007; Lawson and Gosselin 2009). They are regular visitors in the Gulf of St. Lawrence during the ice-free period (Lesage et al. 2007) and are known to breed and overwinter in southern climes. In the Gulf of St. Lawrence, humpback whale sightings appear to be in concentrations in the northern Gulf sectors including the Strait of Belle Isle/Mecatina Plateau (Lesage et al. 2007). Winter occurrence in the Gulf of St. Lawrence has been largely undocumented, and only anecdotal reports suggest that they are present at least through to mid to late January, with most sighted off Gaspé (Lesage et al. 2007). It is not known how large the population is in the Gulf of St. Lawrence, however, there are an estimated 2,500 individuals in Canada (Conestoga-Rovers & Associates 2008). The humpback whale is listed under Schedule 3 of the *SARA* as 'Special Concern', and is therefore not officially protected.

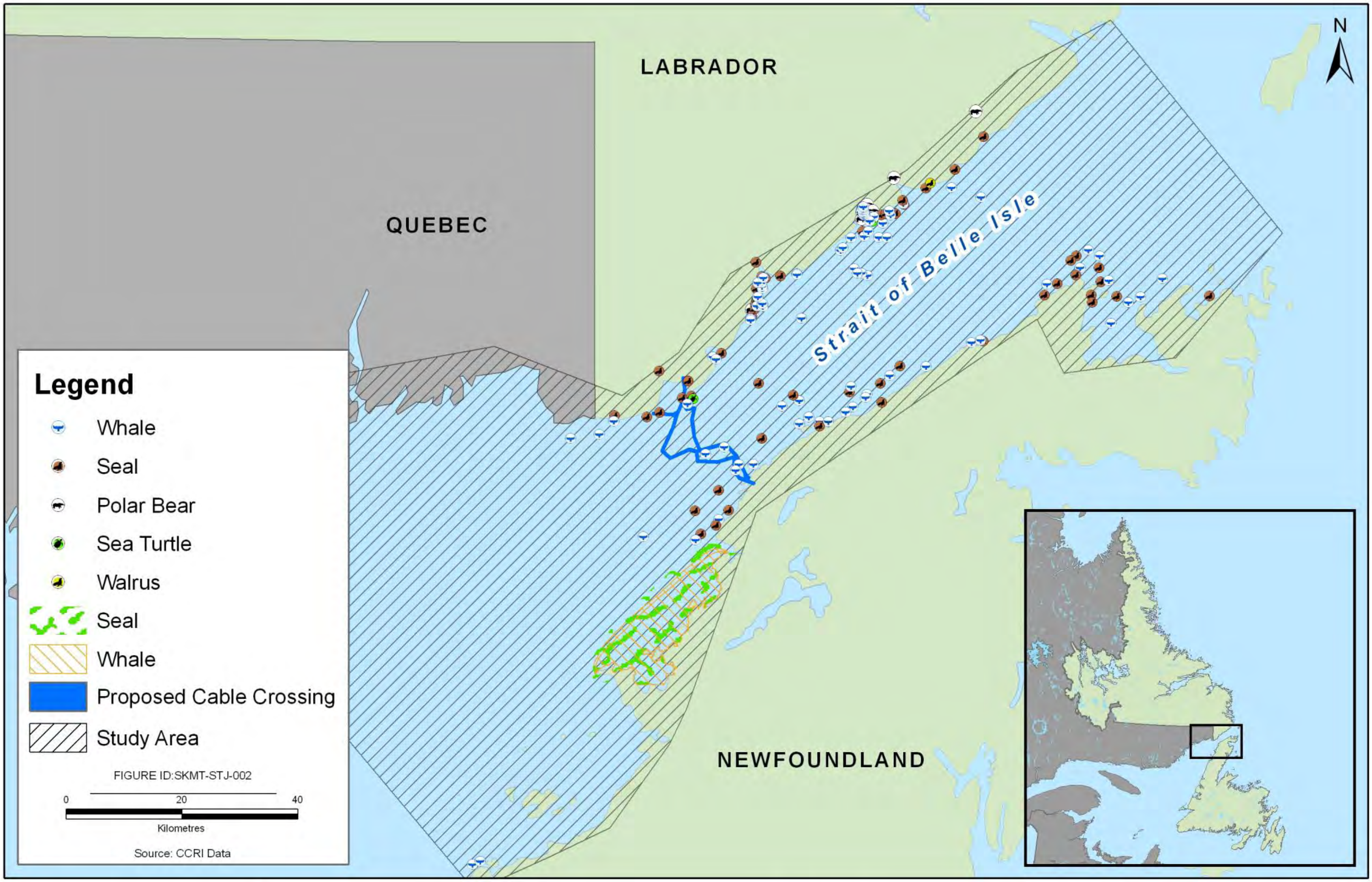

FIGURE 3.1

Anecdotal Sightings of Marine Mammals and Sea Turtles

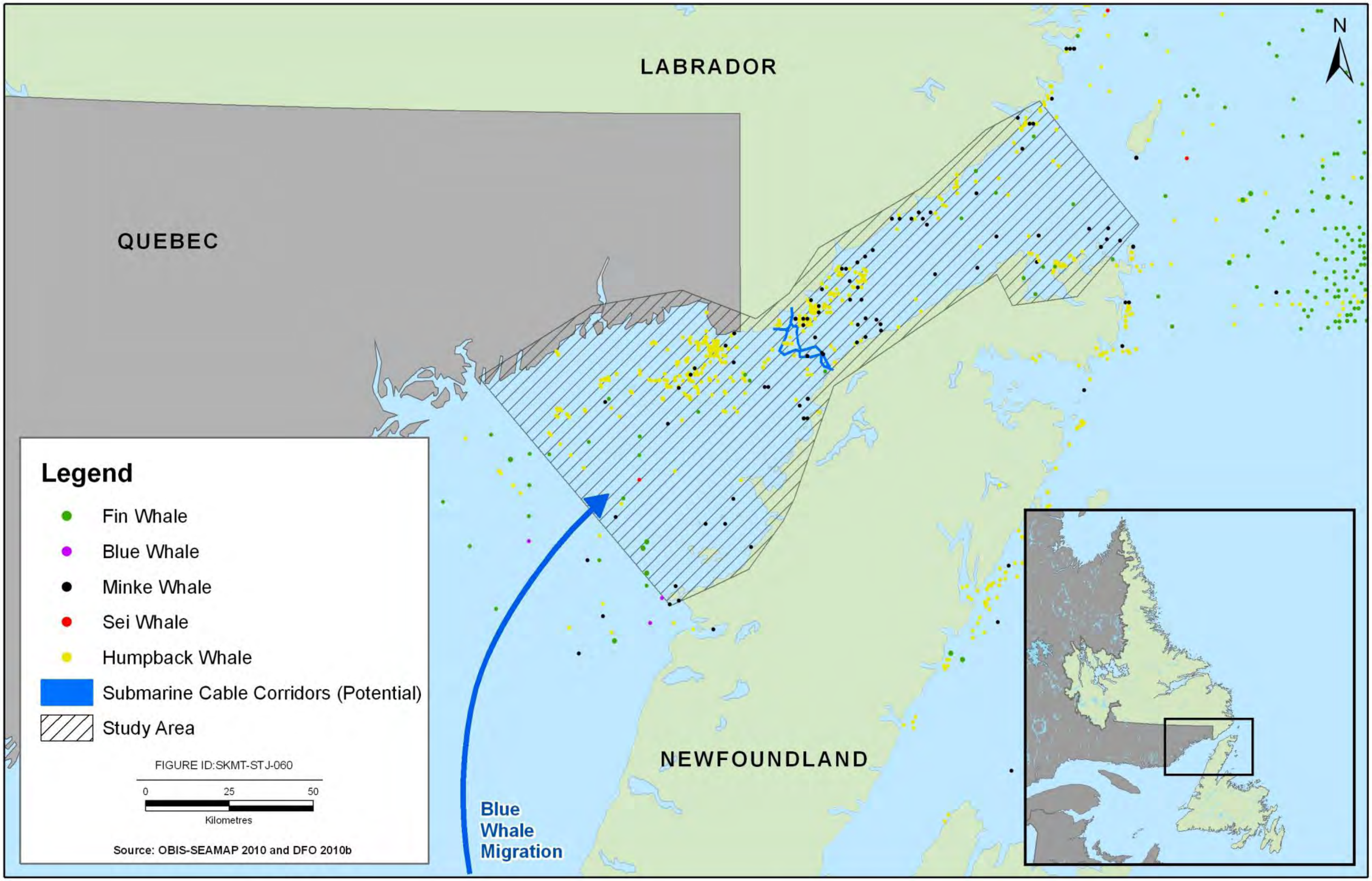

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FIGURE 3.2

Historical Baleen Whale Sightings

Blue Whale

In spring, summer and fall, the blue whale population in Canada is distributed along the north shore of the Gulf of St. Lawrence, from the St. Lawrence River estuary to the Strait of Belle Isle, and off eastern Nova Scotia. In the winter they are concentrated off the south coast of Newfoundland. They are also known to summer in the Davis Strait (Waring et al. 1999). Distributional data for blue whales in the Gulf of St. Lawrence are scarce; however they have been detected historically in the Strait of Belle Isle area (Lesage et al. 2007). There are an estimated 50 to 105 individuals in the Gulf of St. Lawrence each year (Conestoga-Rovers & Associates 2008). Only six blue whales were detected in the Gulf during the TNASS surveys conducted in the summer of 2007 (Lawson et al. 2007). Although only infrequently sighted, blue whales have been also spotted near Blanc Sablon during the spring (Sears, 2010, pers. comm.). Blue whales are considered 'Endangered' under the *SARA* (Schedule 1).

Fin Whale

Fin whales regularly visit the Gulf of St. Lawrence, and historical records indicate their presence between Pointe-des-Monts and Sept-Îles to the west of Anticosti, and in the Jacques-Cartier Strait, associated with thermal fronts (Lesage et al. 2007). Estimates of population are not certain, however the population in the Gulf of St. Lawrence is in the low 100s (Conestoga-Rovers & Associates 2008). Studies described in Lesage et al. (2007) observed fin whales exclusively in the northern and northeastern Gulf of St. Lawrence, although this distribution may be due to low survey effort, both spatially and temporally (Lesage et al. 2007). In the Gulf of St. Lawrence, only six fin whales were detected during the TNASS surveys conducted in the summer of 2007 (Lawson and Gosselin 2009). Fin whales are also known to occur in the St. Lawrence Estuary during the ice-free period, until at least January (Lesage et al. 2007). They are also known to be present in the northern Gulf during the ice-covered period (Lesage et al. 2007). This is substantiated by ice-entrapment reports in historical literature (Sergeant et al. 1970). Fin whales are listed as 'Special Concern' under *SARA* (Schedule 1) and are therefore officially protected.

Minke Whale

Like humpback whales, minke whales are also very commonly sighted in the Strait of Belle Isle (Lesage et al. 2007). Unlike most rorqual species, they do not prefer thermal fronts, but are found on sandy bottom substrates (Lesage et al. 2007). There is no reliable estimate of population in the Gulf of St. Lawrence, although it is thought to be 1000 plus individuals (Conestoga-Rovers & Associates 2008). Minkes have not been assessed by COSEWIC, however their populations appear to be much healthier than those of other baleen whale species (Conestoga-Rovers & Associates 2008).

3.2.3.2 **Toothed Whales (Odontocetes)**

Toothed whales which have been sighted in the Strait of Belle Isle Study Area include; killer whale; long-finned pilot whale; harbour porpoise; Atlantic white-sided dolphin; white-beaked dolphin; and short-beaked dolphin. Historical sightings of toothed whales in relation to the Study Area are presented in Figure 3.3, according to the OBIS-SEAMAP database and data provided by DFO (2010b).

Killer Whale

Killer whales have been sighted in Atlantic Canada, although relatively little is known about this species. Their nomadic way of life makes them difficult to observe and study, and therefore anecdotal information is the largest source of information about this species in the Gulf of St. Lawrence (Whales Online 2010). In the Gulf of St. Lawrence, they are mostly sighted in the Mingan Island area and the Strait of Belle Isle (Lawson et al. 2007; Lesage et al. 2007). They have been sighted in the Study Area ambushing prey such as Atlantic salmon (Sears, 2010, pers. comm.).

Opportunistic sightings data from 1864 to 2007 and a multi-year photographic catalogue of killer whales in Atlantic Canada were examined to determine the status of killer whales by Lawson et al. (2007). Most of the sightings took place between June to September, within the last seven years. These data were used to compile groups of killer whales frequenting waters in Newfoundland and Labrador. No estimates of population in the Northwest Atlantic have been made, however a photographic catalogue of at least 64 individuals found off Newfoundland and Labrador exists (Lawson et al. 2007). The results from this research suggested that the waters off St. Anthony and the Strait of Belle Isle may be important for these whales.

Long-finned Pilot Whale

Long-finned pilot whales have been sighted in the Strait of Belle Isle (Figure 3.3). There is possibly only a few thousand individuals present in the Gulf of St. Lawrence, and there does not appear to be a north to south seasonal migration, although some seasonally migrate between inshore and offshore areas (Conestoga-Rovers & Associates 2008).

Harbour Porpoise

Harbour porpoise have been long observed in the Strait of Belle Isle region (Lesage et al. 2007). Recently there have been particularly high catches of harbour porpoises as by-catch in fishing gear in the Strait of Belle Isle (Lawson et al. 2004; Lesage et al. 2006). This is often evidence of regular occurrence of this species. However, there has not been any evidence of harbour porpoise occurring in the Gulf of St. Lawrence during the winter months (Lesage et al. 2007). The population of harbour porpoises in the Gulf of St. Lawrence is estimated to be somewhere between 36,000 and 125,000, and their migration is not well understood (Conestoga-Rovers & Associates 2008).

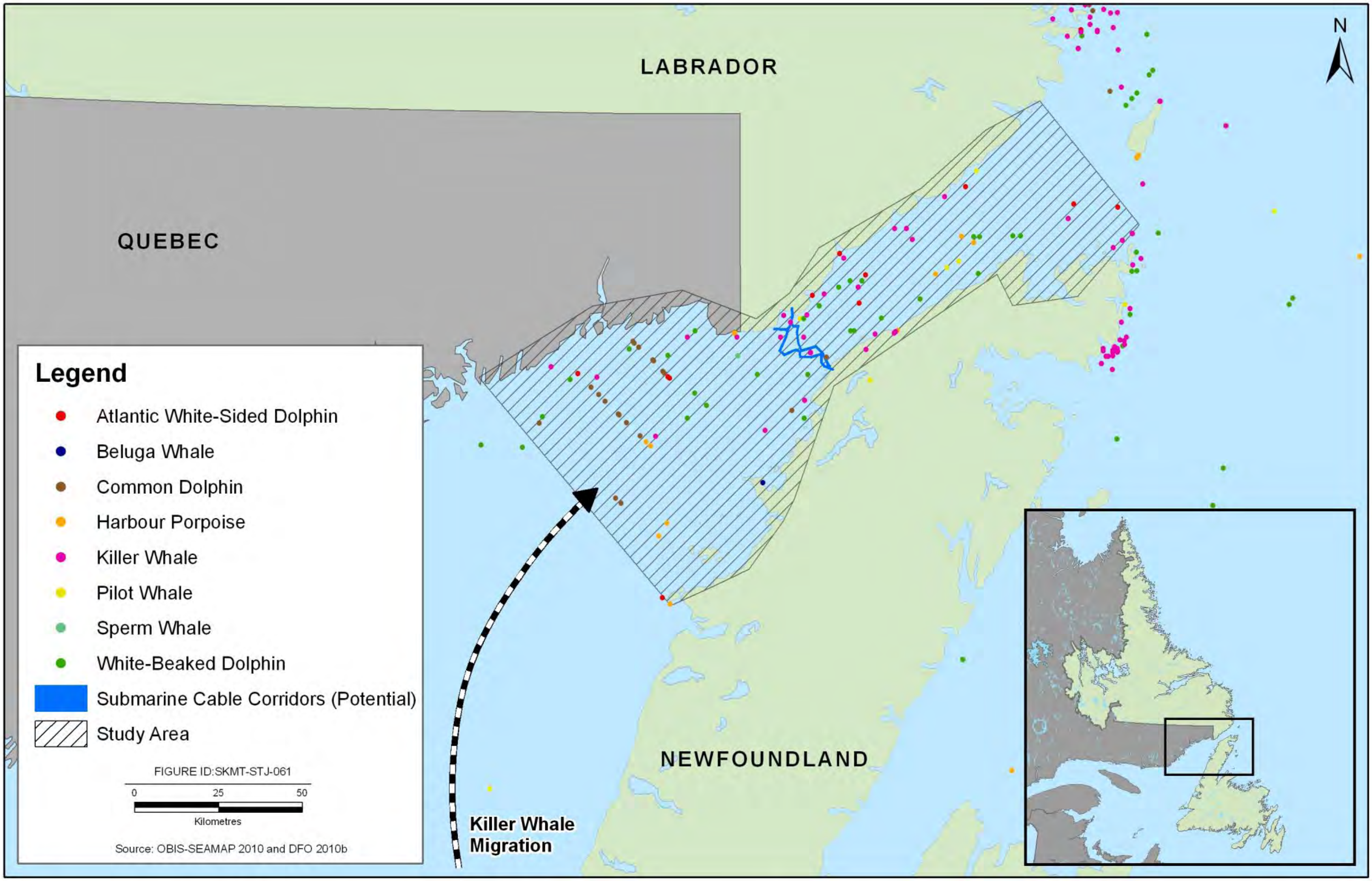

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FIGURE 3.3

Historical Toothed Whale Sightings

Dolphin Species

Three species of dolphins have been sighted in the Strait of Belle Isle Study Area: Atlantic white-sided dolphin; white-beaked dolphin; and short-beaked dolphin. All three are often present in the summer months, where they can be found feeding.

During aerial surveys conducted in 1995, 1996 and 2002, Atlantic white-sided dolphin were generally found in deeper waters in the Gulf of St. Lawrence. They were, however, also found in the shallower waters of the Strait of Belle Isle (Lesage et al. 2007). No reliable estimates of populations exist, although there appears to be 500 to 12,000 individuals in the Gulf of St. Lawrence (Conestoga-Rovers & Associates 2008). They are sporadically found in the Gulf of St. Lawrence, however their migration routes within the area are unknown.

White-beaked dolphin were almost exclusively found in the northeastern Gulf of St. Lawrence, including the Strait of Belle Isle, during aerial surveys conducted during the summers of 1995, 1996 and 2002 (Lesage et al. 2007). According to studies conducted in 1995 and 1996, the population of white-beaked dolphins is approximately 2,500 in the Gulf of St. Lawrence.

The first documented sightings in the Strait of Belle Isle area of short-beaked dolphin were from data compiled and discussed by Lesage et al. (2007). This also applies to the Gulf of St. Lawrence as a whole, where a total of 243 individuals were sighted (Lesage et al. 2007). Their migration routes in the Gulf of St. Lawrence are therefore unknown.

Other Species

Beluga whales have also been sighted in the Strait of Belle Isle area (e.g., one sighting in the region in 2007 surveys reported in Lawson and Gosselin (2009). Beluga whales are commonly a cold water / Arctic species, however have historically been recorded in the St. Lawrence Estuary, particularly at the mouth of the Saguenay River which has the oceanographic characteristics of an arctic fjord. Although populations have declined (Hammill et al. 2007), beluga whales were the second most commonly sighted cetacean in the Gulf and Scotian Shelf strata during the TNASS Surveys conducted in the summer of 2007 (Lawson and Gosselin 2009). One sperm whale (*Physeter macrocephalus*) was also sighted in the Strait of Belle Isle Study Area in 1993 (DFO 2010b; Figure 3.3).

3.2.4 Pinnipeds (Seals)

Surveys for pinnipeds (seals) usually take place when a high abundance of different species can be expected to be observed in a specific area (Robillard et al. 2005). Recent surveys conducted in the Gulf of St. Lawrence captured seals in areas further south than they might have been normally expected during that specific time of year (Sjare, 2010, pers. comm.). Species of seals that use the Strait of Belle Isle area include: harp seal; grey seal; harbour seal; and hooded seal. Bearded seals (*Rignathus barbatus*) have also been spotted breeding as far south as Belle Isle, north of the Study Area, and even further south according to anecdotal information (Sjare, 2010, pers. comm.). In general, the Strait of Belle Isle Study Area is used for both migratory purposes and for whelping areas for these species of seals.

Harp Seal

Being the most abundant seal in the Gulf of St. Lawrence, harp seals have an estimated total population of 5.8 million, with approximately one third of that population within the Gulf of St. Lawrence (Lesage et al. 2007). They are known to occur in the Gulf of St. Lawrence between January through April and May, where they are normally hunted (Lesage et al. 2007). Along with hooded seals, they are known to be present in the Strait of Belle Isle between December and May (Stenson et al. 2003).

As part of ongoing resource status assessments, aerial surveys for harp seals are commonly conducted in the Gulf of St. Lawrence, including the Strait of Belle Isle, with recent results of pup production estimates reported in Stenson et al. (2002; 2003; 2005; and 2010). The last harp seal aerial survey within the Study Area was conducted in 2008, with results reported on abundance in Hammill and Stenson (2010), and on pup production in Stenson et al. (2010). Harp seals are known to use the pack ice within the Strait of Belle Isle for whelping (Sjare, 2010, pers. comm.). After the conclusion of whelping, the pups that do not continue with the ice down through the Gulf leaving via the Cabot Strait may migrate through the Strait of Belle Isle in June (Lesage et al. 2007). Knowledge of harp seal distribution and behaviour outside of the ice-free season is mostly through by-catch in various fisheries. The lumpfish fishery, which occurs between April to July, has captured harp seals in the Gulf of St. Lawrence (Sjare et al. 2005), thus substantiating the idea that harp seals may remain in the region during the summer season. Figure 3.4, which was reproduced from DFO (2010a), demonstrates the range, migratory patterns and important whelping areas for harp seals in the Gulf of St. Lawrence.

FIGURE 3.4

Migratory Patterns and Whelping Concentrations of harp Seals

Grey Seal

Grey seals inhabit continental shelf waters including the Gulf of St. Lawrence and estuary. They are found there seasonally for moulting, feeding and breeding purposes (Conestoga-Rovers & Associates 2008). Grey seals normally enter the estuary of the Gulf in April and May to moult (Lesage et al. 2007). Studies from 1994 to 2001 in the Gulf of St. Lawrence and estuary investigated the distribution and abundance of grey seals (Robillard et al. 2005). These studies also observed haul out habitat for grey seals in the Gulf of St. Lawrence, which included mostly exposed reefs, as well as isolated rocks, sand banks, and reefs connected to land. Pinnipeds usually haul out of the water to areas of ice or land, between periods of foraging for different reasons, including breeding or predator avoidance. Grey seals were also observed on rocky ledges on shore near steep cliffs (Robillard et al. 2005).

Grey seals represent the second most abundant seal species in the Gulf of St. Lawrence, with an estimated 52,000 individuals entering the Gulf to reproduce in 2004, or approximately 20 percent of the total population of the Northwest Atlantic based on pup counts in whelping areas (Hammill and Gosselin 2005; Trzcinski et al. 2006; Bowen et al. 2007). Grey seals have been noted hauling out in sites in the Strait of Belle Isle, and are therefore known to occur there at least during the ice-free period between May to December (Lesage et al. 2007).

Hooded Seal

Hooded seals are said to be a single population in the Atlantic Ocean, and are highly migratory, solitary individuals. For this reason, they may be difficult to detect, although they have been observed in the Strait of Belle Isle during post-breeding migration (Bajzak et al. 2009). Females leave the whelping patch once the pups are weaned, usually in March, move to the northern slope of the Laurentian channel and remain there until early May, at which point they begin their migration to Greenland (Bajzak et al. 2009). Males may also migrate to Greenland this way, but they leave the whelping area at the end of March when breeding ceases and, move to the northern slope of the Laurentian channel for four weeks before beginning their migration (Lesage et al. 2007).

Like harp seals, hooded seals have been known to use the pack ice in the Strait of Belle Isle region (Sjare, 2010, pers. comm.), and may be present in the Study Area between December and May (Stenson et al. 2003). Bajzak et al. (2009) noted that results from tagging studies in the Gulf of St. Lawrence indicated that all of the 23 tagged hooded seals (11 females, 12 males) migrated toward Greenland, most through the Cabot Strait (eight females, nine males), whereas the others migrated through the Strait of Belle Isle (three females, three males). Figure 3.5, adapted from Bajzak et al. (2009), demonstrates three distinctive and typical migratory tracks for postbreeding hooded seals, through the Gulf of St. Lawrence to Greenland including the Strait of Belle Isle, and the Cabot Strait. Hooded seals spend their summers in the Arctic (Lesage et al. 2007).

FIGURE 3.5

Details of Three Distinctive (Typical) Migratory Routes from the Gulf of St. Lawrence to Greenland for Postbreeding Hooded Seals

Harbour Seal

Harbour seals use the coastal environment and are relatively sedentary throughout most of the year. Atlantic Canada estimates of harbour seals are largely undocumented, and it is considered the least abundant of seal species, having approximately 10,000 to 15,000 individuals, with approximately 4,000 to 5,000 in the Gulf of St. Lawrence (Lesage et al. 2007). Recent information on harbour seal distribution and abundance is scarce, and is lacking for the Quebec Lower North Shore and Western Newfoundland, although older data suggested that this area is used during ice-free period (Robillard et al. 2005; Lesage et al. 2007). Studies in 1994 to 2001 in the Gulf of St. Lawrence and estuary looked at distribution and abundance of harbour seals (Robillard et al. 2005). These studies also observed haul out habitat for harbour seals in the Gulf of St. Lawrence, which included mostly isolated rock substrates, as well as exposed reefs, sand banks, and reefs connected to land. Harbour seals were also observed on rocky ledges on shore near steep cliffs (Robillard et al. 2005). These surveys were conducted throughout the Gulf of St. Lawrence, estuary and the Saguenay River, however little information was collected in the Study Area.

3.3 Sea Turtles

The few records of sea turtle sightings in the Gulf of St. Lawrence indicates that sea turtles are not common in the Study Area (O'Boyle 2001). Two species of sea turtle that could potentially occur in the Strait of Belle Isle are the leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). These are found in the waters off Newfoundland during the summer and fall (Goff and Lien 1988; Marquez 1990; Witzell 1999). The loggerhead turtle is more common off the Atlantic coast, but is found in higher numbers offshore (O'Boyle 2001). The Kemp's ridley turtle (*Lepidochelys kempii*) may also occur in eastern Canada, although little is known about their distribution (Conestoga-Rovers & Associates 2008).

Leatherback Turtle

Leatherbacks can be found in the tropical, temperate and boreal waters of the Atlantic, Pacific and Indian Oceans. The northern most recorded latitude of a leatherback is 71°N and the southernmost is approximately 27°S (Atlantic Leatherback Turtle Recovery Team 2006). These animals appear to mainly use northern waters to forage during the summer and fall, before undertaking a southward migration (Atlantic Leatherback Turtle Recovery Team 2006). This northern distribution encompasses Canadian waters, having a broad seasonal distribution that includes slope waters east of the Fundian Channel, Georges Bank, south coast of Newfoundland, Sydney Bight and the southern Gulf of St. Lawrence (DFO 2004). Few records for the Gulf of St. Lawrence exist, including the Strait of Belle Isle, although one tagged animal entered the Gulf in 2000 (O'Boyle 2001). Leatherback turtles have also been reported off the coast of Labrador (Threlfall 1978). Shoop and Kenney (1992) state that the availability of appropriate food and suitable nesting beaches are probably the two more important factors affecting distribution and abundance of leatherback turtles. Leatherback turtles are listed as 'Endangered' under Schedule 1 of *SARA*, which gives them legal protection and mandatory recovery requirements (Atlantic Leatherback Turtle Recovery Team 2006).

The overall range of leatherback turtles in Atlantic Canada is presented in Figure 3.6. The shaded areas in the figure depict the different concentrations of observations originally compiled and presented by the Atlantic Leatherback Turtle Recovery Team (2006), and presents data from Goff and Lien (1988), from Witzell (1999) and from James (2000).

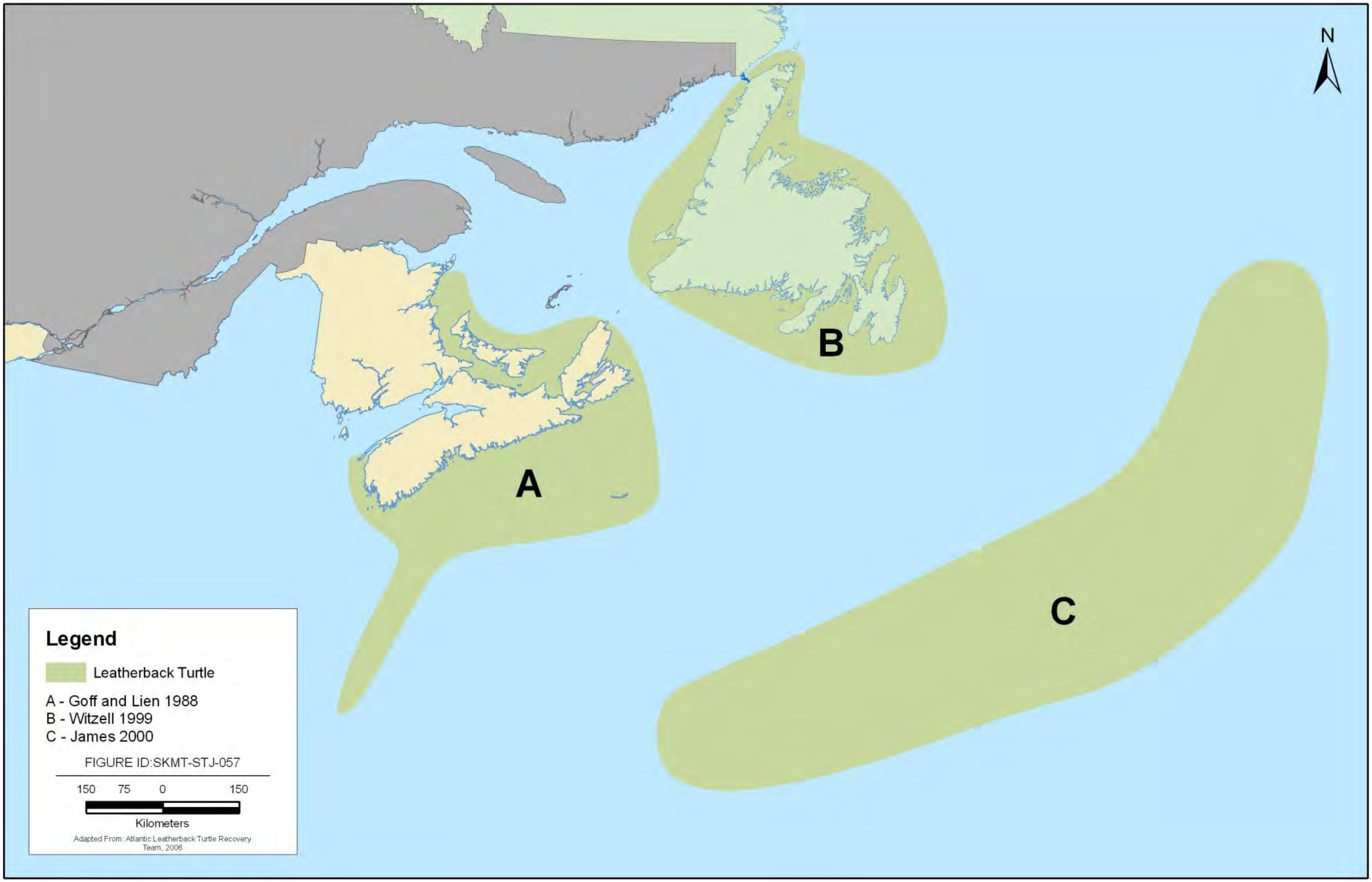

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FIGURE 3.6

Distribution of Leatherback Turtle in Atlantic Canada

Leatherback turtles have been occasionally spotted in the Gulf of St. Lawrence. During the collection of data for the 2007 TNASS study, sea turtles were one of the targeted species (Lawson and Gosselin 2009).

The status of the leatherback turtle population in the Atlantic Ocean is difficult to assess because of their widespread distribution and limited accessibility (i.e., minimal on-land use by females during nesting only). Because only nesting females are accessible, counts of females or their nests provide the best, and currently the only, index of leatherback turtle population size (DFO 2004).

Loggerhead Turtle

The distribution of the loggerhead turtle is constrained by temperature and the species is not generally observed in waters below 15˚C (O'Boyle 2001). Loggerhead turtles are present in Atlantic Canada waters during the summer season and may stay later in the season than leatherback turtles (O'Boyle 2001). Loggerhead turtles have been designated by COSEWIC as 'Endangered", however they are not listed under *SARA*. It appears that loggerhead populations are stable or declining slowly in the North Atlantic. Although available trend data are insufficient to make a clear determination, populations are thought to be much reduced from historical levels (Brazner et al. 2006 in O'Boyle 2006). It has been suggested that foraging in Atlantic Canada occurs in the areas of the Georges Banks and Grand Banks, due to high catches in the Canadian Pelagic Longline Fishery since 1999 (Brazner et al. 2006 in O'Boyle 2006). Although they may possibly occur in the general vicinity of the Strait of Belle Isle, their presence is likely rare within the Study Area.

3.4 Seabirds

The following section, overviews information on marine birds in the Strait of Belle Isle, relating to vessel survey effort, avian distributions, species occurrences and abundances across seasons and decades and important aspects of migration patterns, nesting, molting and wintering grounds that highlight the ecological significance of the study area. Species of special conservation concern are discussed in detail in Section 3.5.

More than 30 species of seabirds and marine ducks breed, moult, and over-winter in the Strait of Belle Isle, and large numbers of birds migrate through the Strait during spring and fall (Tables 3.1 and 3.2). To take the first evidence from human activity in the area, remains of more than 28 species of birds have been uncovered at the Maritime Archaic site in Port au Choix, Newfoundland (Tuck 1976). The most common of these are the now extinct Great Auks (*Penguinis impennis*), gulls, Red-breasted Mergansers (*Mergus serrator*), swans, loons, geese, Bald Eagles (*Haliaeetus leucocephalus*), murres and cormorants. The Great Auks were migrating from colonies on the Bird Rocks of the Isles de Madeleine and from Funk Island on the northeast coast of Newfoundland. Gannets, murres and other seabirds from these colonies currently move through the Strait. Marine birds that move through and use the Strait of Belle Isle throughout the year (although most commonly during fall, spring and summer) are presented in Tables 3.1 and 3.2.

There are a number of important breeding colonies within the Strait of Belle Isle, along the coasts of Labrador, Quebec and the island of Newfoundland as well as on islands along both coasts. During summer, warm water flows out of the Gulf of St. Lawrence on the Newfoundland (southern) side of the Strait. This warm water mass interfaces and contrasts sharply with the cold inflowing Labrador Current on the Labrador (northern) side of the Strait (Farquarson and Bailey 1966, cf. Garrett and Petrie 1981). The interface between the water masses appears to be a productive site for pelagic seabirds (LeGrow 1999). Consistent with breeding colony distributions (below), it is expected that during summer diving species (auks, marine ducks) will be more abundant in the cold northern waters of the Strait and that surface-feeding gulls and terns will dominate in the warmer southern waters on the Newfoundland side of the Strait. Concentrations of pelagic seabirds are expected in the interface between the water masses in the mid-Strait region.

An estimated 20% of the eastern North American population of Harlequin Duck, a Species of Special Concern under SARA, overwinters on Newfoundland's Northern Peninsula (Gilliland et al. 2008) and the Endangered Ivory Gulls (*Pagophila eburnea*) occur in winter and spring in association with Arctic pack ice and especially with whelping harp seals (*Phoca groenlandica*). The region is also an important molting ground for Common Eiders and Harlequin Ducks (Gilliland 1995).

Table 3.1 Marine Birds that Commonly Use the Strait of Belle Isle (Rees 1963; Brown 1986)

Common Name	Scientific Name
Common Loon	*Gavia immer*
Northern Fulmar	*Fulmarus glacialis*
Great Shearwater	*Puffinus gravis*
Sooty Shearwater	*Puffinus griseus*
Leach's Storm-Petrel	*Oceanodroma leucorhoa*
Northern Gannet	*Morus bassanus*
Double-crested Cormorant	*Phalacrocorax auritus*
Great Cormorant	*Phalacrocorax carbo*
Phalaropes	*Phalaropus spp*.
Jaegers	*Stercorarius spp.*
Ring-billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*
Iceland Gull	*Larus glaucoides*
Glaucous Gull	*Larus hyperboreus*
Great Black-backed Gull	*Larus marinus*
Black-legged Kittiwake	*Rissa tridactyla*
Caspian Tern	*Sterna caspia*
Common Tern	*Sterna hirundo*
Arctic Tern	*Sterna paradisaea*
Dovekie	*Alle alle*
Common Murre	*Uria aalge*
Thick-billed Murre	*Uria lomvia*
Razorbill	*Alca torda*
Atlantic Puffin	*Fratercula arctica*
Black Guillemot	*Cepphus grille*

Table 3.2 Marine Ducks that Use the Strait of Belle Isle (LeGrow 1999)

Common Name	Scientific Name
Common Eider	*Somateria mollissima*
Harlequin Duck	*Histrionicus histrionicus*
Long-tailed Duck	*Clangula hyemalis*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Common Goldeneye	*Bucephala clangula*
Barrow's Goldeneye	*Bucephala islandica*
Red-breasted Merganser	*Mergus serrator*

Due to the ecological importance of the Strait of Belle Isle and surrounding area to several species of marine birds and ducks (Common Eider, Harlequin Duck, Black Guillemot, Black-legged Kittiwake and auks), specific sites have been identified as IBAs for the purpose of highlighting their conservation status (Figure 3.7). Table 3.3 lists the designated IBA sites that fall within the study site as well as the species of marine birds that have triggered the IBA designation and their defining ecological significance. Major movements of seabirds and Common Eiders have been observed from Point Amour during spring migration including an estimated 2 % of the world's population of Black Guillemots (S. Gilliland, pers. comm.; LeGrow 1999), driving its designation as an IBA (Russell and Fifield, 2001). The Baie de Brador on the northeast shore of the Gulf of St. Lawrence, in the Strait of Belle Isle is an important breeding area for auks (Atlantic Puffin and Razorbill), including Quebec's largest Atlantic Puffin colony (BIOMQ 1999). St. Peter's Bay located on the southeast coast of Labrador is an IBA that lies outside the study area but its significance as a molting area for Common Eiders and Harlequin Ducks (Russell and Fifield, 2001) warrants mention given that birds using the site likely migrate through the study area during spring and fall.

Table 3.3 Designated Important Bird Areas (IBAs) in the study area

Site	Species	Ecological Significance
St. Peter's Bay, Labrador	Common Eider, Harlequin Duck	Molting ground, nesting area[1]
Point Amour, Labrador	Common Eider, Auks, Black Guillemot	Migratory corridor[1]
Baie de Brador, Quebec	Atlantic Puffin, Razorbill	Breeding habitat[2]

[1]Russell and Fifield, 2001;
[2]www.ibacanada.com

In addition to IBA sites, the Hare Bay Islands Ecological Reserve located on the eastern Northern Peninsula of Newfoundland provides critical breeding habitat for Common Eiders and a number of seabird species including common and Arctic terns and double-crested cormorant, as well as Ring-billed, Herring, and Great Black-backed Gulls.

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FIGURE 3.7

Important Bird Areas

3.4.1 Marine Bird Migrations

Large numbers of seabirds and waterfowl migrate through the Strait of Belle Isle, and many are known to congregate on rounded headlands (e.g., Point Amour and Forteau Point) as they move along the coast (Russell and Fifield 2001). Great Auks migrated from colonies on the Bird Rocks of the Isles de Madeleine and from Funk Island on the northeast coast of Newfoundland used the Strait of Belle Isle.

Major movements of loons, seabirds and marine ducks have been observed from Point Amour during spring migration (S. Gilliland, pers. comm.; LeGrow 1999), driving its designation as an Important Bird Area (IBA; Russell and Fifield, 2001). Observations from a land-based survey in 1996 (19-24 May) documented a significant number of eider ducks (>60,000) and auks (>40,000) moving through the Strait during spring migration (Table 3.4). In addition, recorded large numbers of Black Guillemots represent approximately 2 % of the world's estimated population (Selno et al. 1996, Russell and Fifield, 2001). Peak movement of eiders and auks occurred during 10-14 and 22-23 May respectively (Figure 3.8). Fall migration of Common Eiders and auks through the Strait of Belle Isle is more protracted than in spring and can continue into December (S. Gilliland, pers. comm.), there are no systematic observations available during fall migration which represents a significant gap in baseline data needed to fully assess the significance of the Strait of Belle Isle to migratory seabirds and waterfowl.

Table 3.4 Numbers of the Most Abundant Bird Species during Spring Migration in the Strait of Belle Isle

Species	Total number	Source
Common Eider	62,275	Selno et al. 1996 Russell and Fifield, 2001
Auk spp.	43,578	Selno et al. 1996 Russell and Fifield2001
Black Guillemot	5465	Selno et al. 1996 Russell and Fifield 2001

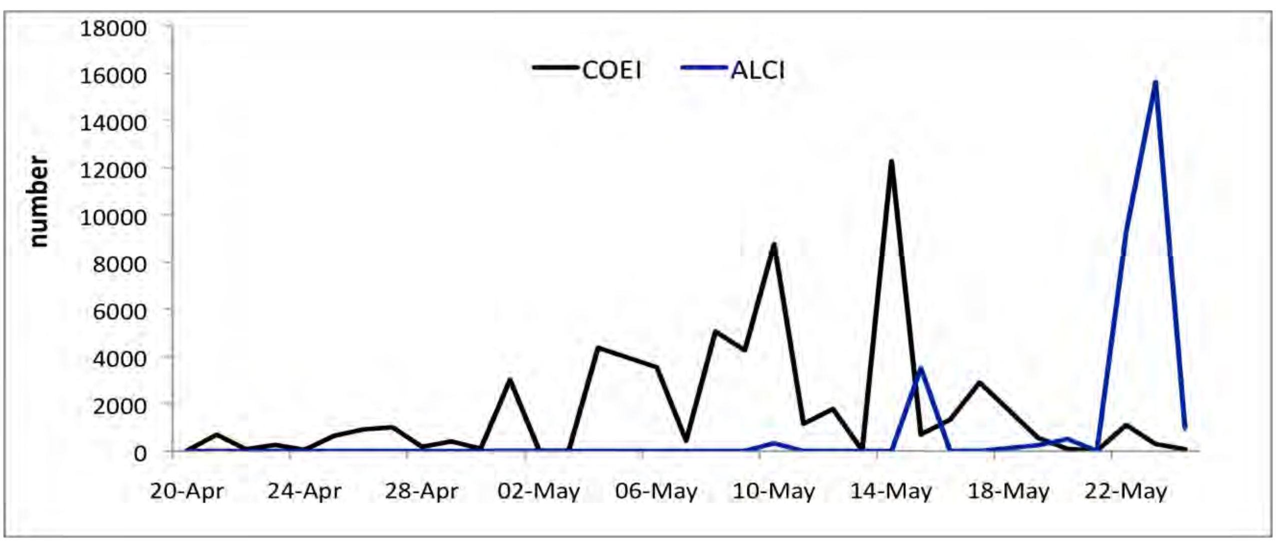


Figure 3.8 Peak Numbers of Common Eiders and Auks Observed at Point Amour during Spring Migration in 1996 (CWS unpub. data 1996)

3.4.2 Seabirds at Sea

Systematic counts of seabirds from vessels have been carried out in the waters of Eastern Canada since the 1960s (Rees 1963; Brown et al. 1975; Lock et al. 1994; LeGrow 1999; Gjerdrum et al. 2010, 2012). Almost all of this effort was standardized and organized by the CWS (Brown et al. 1975). The PIROP Program (Brown et al. 1975) was conducted from 1966-1992. A recent program was initiated by CWS in 2005 (ECSAS), which follows standardized methods outlined by Gjerdrum et al. 2012 and is referred to as the distance sampling method (Buckland et al. (2001). No survey data were available for the Strait of Belle Isle for the 1990s. Appendix C presents an analysis of all of the available PIROP and ECSAS pelagic data for the study area. The ACCDC in Sackville, New Brunswick has some records of birds in Newfoundland and Labrador and in the region of the Strait of Belle Isle, but this is mostly taken from CWS sources (Kiers, 2010, pers. comm.). Table 3.5 presents density estimates (birds per km^2) according to species groups in the Study Area during the summer for ECSAS surveys only (provided by the CWS).

Table 3.5 Density Estimates for Seabirds in the Strait of Belle Isle during Summer from ECSAS Database

Common Name	Density (birds per km^2)	± Standard Error
All Waterbirds	9.61	3.84
Northern Fulmar	0.41	0.28
Shearwaters	0.87	0.51
Northern Gannet	1.37	0.63
Large Gulls	1.45	0.94
Black-legged Kittiwakes	2.34	1.66
Dovekie	0.25	0.24
Murres	0.65	0.73
Other Auks	0.59	0.44

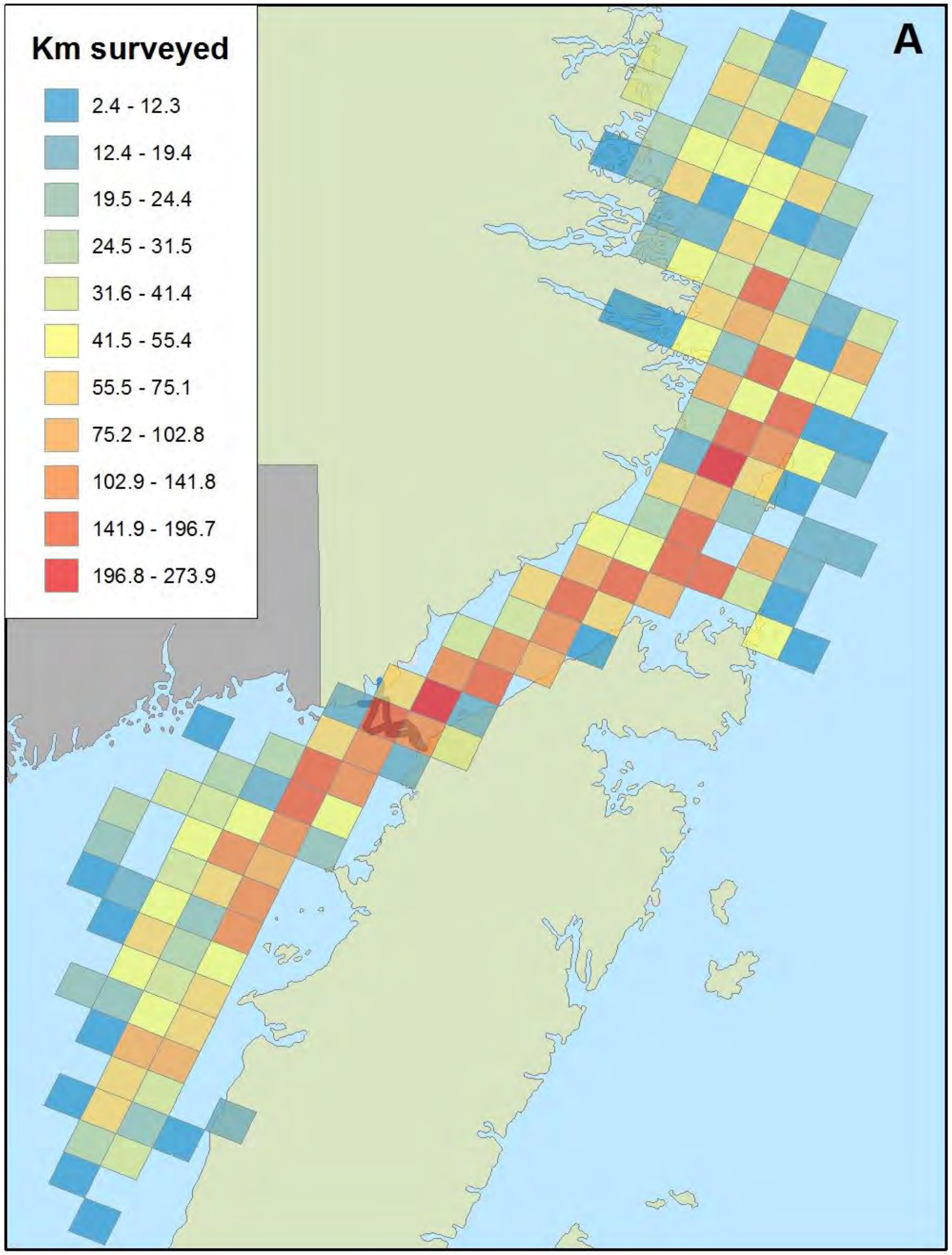
Both the ECSAS and PIROP databases were examined to determine marine bird occurrences and abundances (birds per linear kilometer), within the Study Area, and to make seasonal and decadal comparisons. PIROP survey data for the Study Area were available for 14 years spanning the period from 1969 to 1987. ECSAS data for the area were available for 5 years, from 2005 to 2009. The data are presented as linear densities (birds per linear km) to account for the differences in methodology used in the PIROP and ECSAS programs, where only the ECSAS surveys used the distance sampling methods needed to generate estimates of birds per km^2 corrected for detectability (as shown in Table 3.5). Therefore further analysis that uses PIROP and ECSAS are presented as linear densities (birds per linear km). Survey data were first mapped first to examine overall effort and effort according to seasons (based on the equinoxes and solstices) for the two survey methods (PIROP and ECSAS). Linear kilometers of survey effort were totaled for each 10 x 10 km grid cell and mapped using ArcGIS 10. Only surveys on the western side of the Northern Peninsula were included. Secondly, linear densities for all birds were mapped and this was controlled for effort by dividing the total counts for all surveyed birds in that 10 x 10 km grid cell by the total amount of survey effort within that area, for the appropriate time period.

Figure 3.9A shows survey effort in the Strait of Belle Isle for all surveys (PIROP and ECSAS) including the proposed location of the underground transmission cable and Figure 3.10 shows survey effort for PIROP and

ECSAS separately according to season. The greatest survey effort occurred during PIROP surveys (Figure 3.10), and overall survey effort was highest during the summer (Figure 3.10 A). The more limited ECSAS survey effort however has good coverage around the proposed cable area. Although for survey effort in the Strait of Belle Isle during summer PIROP surveys is generally high, there is very poor coverage during all other seasons (fall, winter and spring; Figure 3.10A). More survey effort during these periods is urgently needed to adequately assess the importance of this area to marine birds throughout the year, particularly during fall and spring migration.

Figure 3.9B shows the total linear densities of birds within the Strait of Belle Isle during all seasons (PIROP and ECSAS) in relation to the proposed cable site. Based on the PIROP summer surveys, which had the highest survey coverage, we see that the Strait of Belle Isle is a high use area for seabirds during this period. Information for other seasons is limited due to lack of adequate coverage, making analysis of important areas during these periods difficult to assess. ECSAS surveys show lower densities throughout the study area for the autumn surveys (Figure 3.10B), while the spring and summer surveys reveal moderate bird densities just south of the proposed cable area. The current survey coverage is very limited for the latter ECSAS time period, again highlighting the need of more extensive seasonal coverage.

Overall, a high diversity of seabird species make use of the areas over the proposed cable tracks: Atlantic Puffins, Arctic Terns, Black-legged Kittiwakes, Black Guillemots, Common Terns, Common Murres, Glaucous Gulls, Great Black-backed Gulls, Great Shearwaters, Great Skuas, Herring Gulls, Leach's Storm-Petrels, Northern Gannets, Northern Fulmars, Parasitic and Pomarine Jaegers, Razorbills, and Sooty Shearwaters. The species composition of birds using the area is described in greater detail in the following sections.



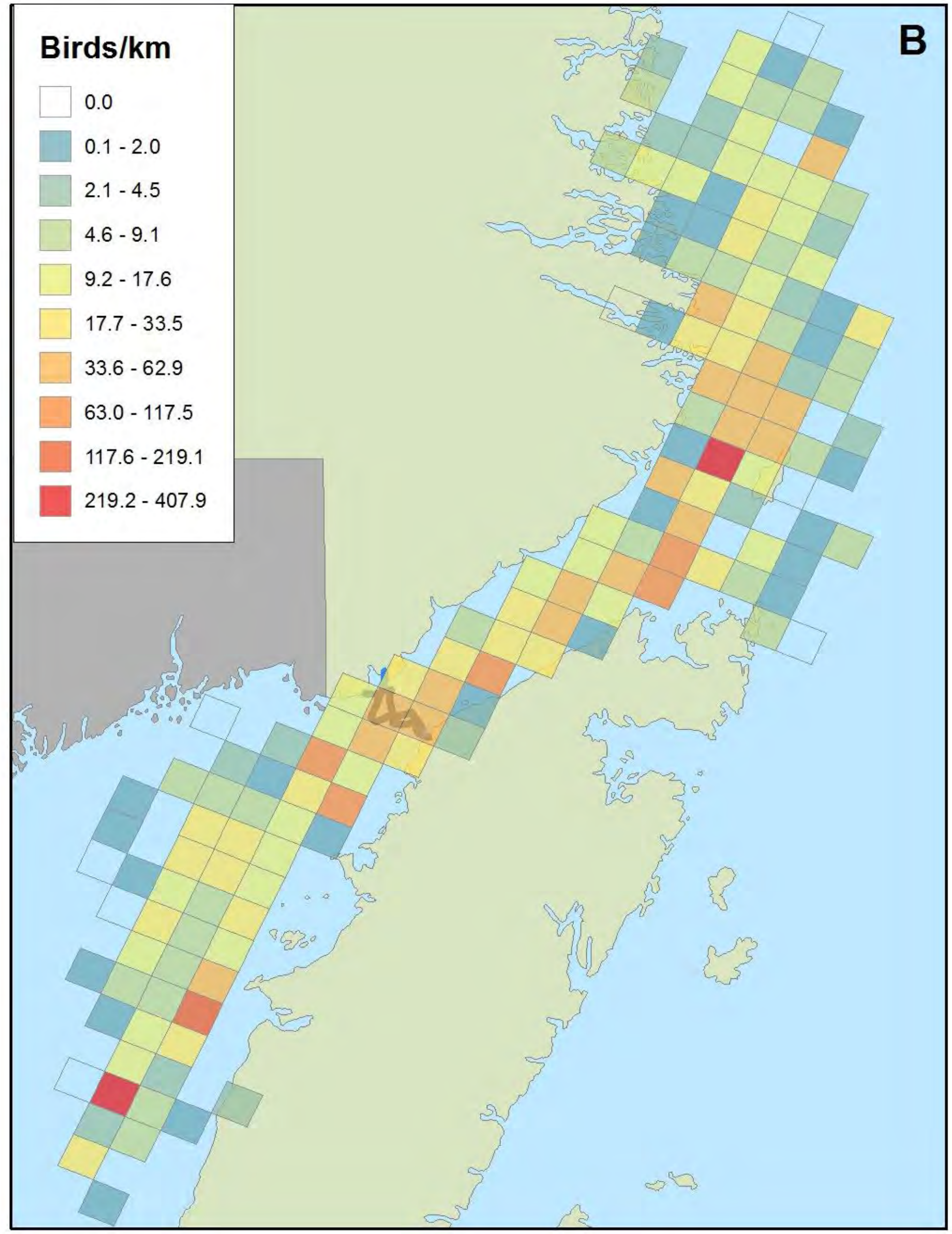


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FIGURE 3.9

Linear kilometers surveyed during all survey periods (A) and total birds surveyed controled for effort (B)

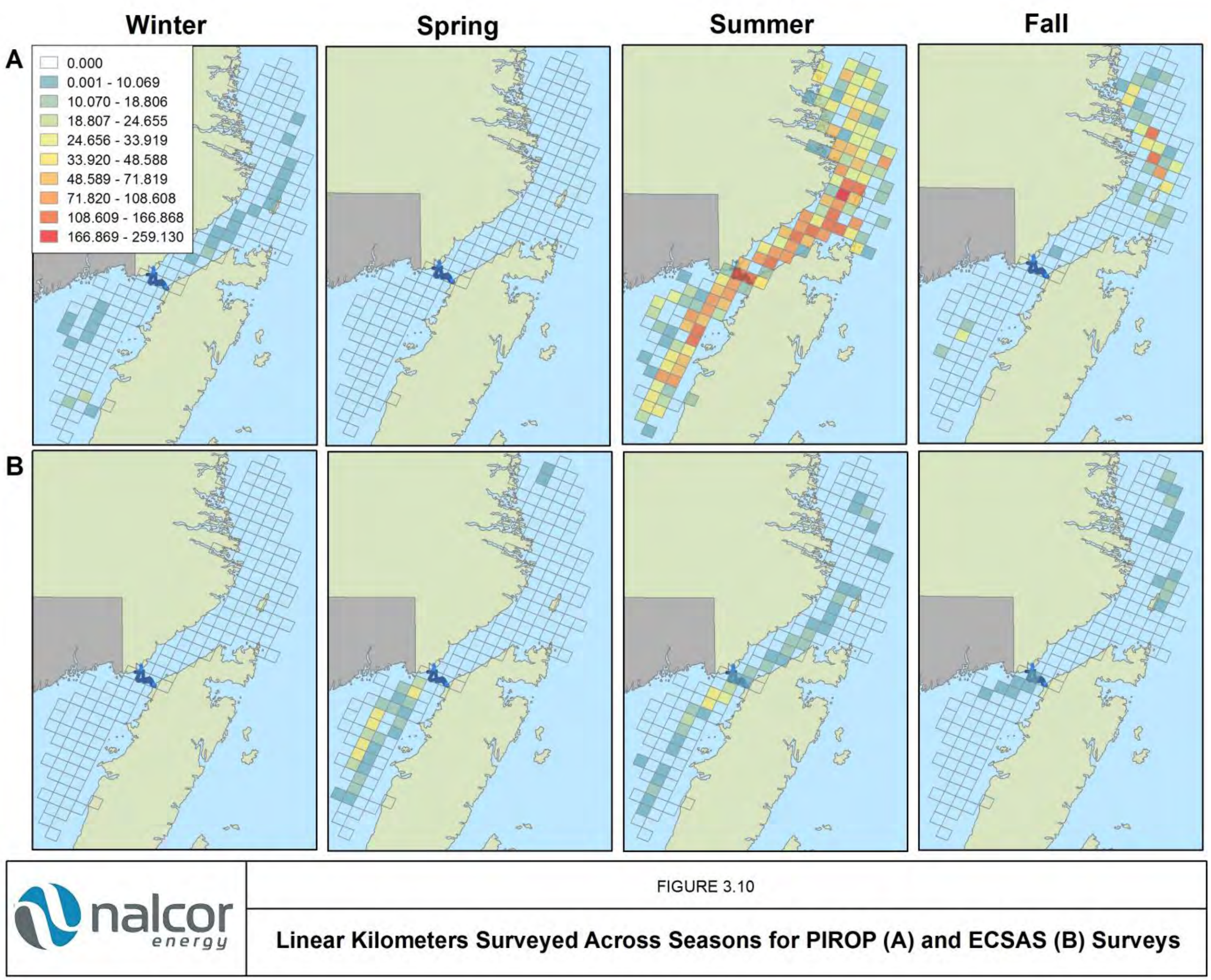


Figure 3.10 Linear kilometers surveyed across seasons for PIROP (A) and ECSAS (B) surveys

3.4.2.1 **Abundance and Occurrence**

This section describes species-specific patterns of abundance and occurrence in the study area during PIROP and ECSAS surveys expressed as percent relative abundance (% RA) and percent frequency of occurrence (% FO). Percent relative abundance was calculated by dividing species-specific totals by the total number of birds per linear km observed across surveys, and percent frequency of occurrence by dividing the number of surveys a species was recorded on (>1 bird) by the total number of surveys.

Twenty-six species of marine birds were recorded in the Study Area (Table 3.6). Great Shearwaters and Black-legged Kittiwakes were the most abundant species, accounting for 21.3 % RA and 18.4 % RA respectively, followed by Northern Fulmar (16.9% RA). Gulls, including Herring Gull and Great Black-backed Gull accounted for a high proportion (10.2% and 8.8% RA) of the total number of species observed. Northern Fulmar was the most frequently observed species (11% FO) followed by Black-legged Kittiwake and Great Shearwater (10.5 and 10 % FO, respectively). The correlation between the relative abundance and frequency of occurrence scores is quite robust ($r = 0.93$, $df = 32$, $P < 0.0001$).

Table 3.6 Percent Relative Abundance and Percent Frequency of Occurrence of All Seabird Species and Species Groups Observed During PIROP and ECSAS Surveys

Species	Relative Abundance (%)	Frequency Occurrence (%)
Great Shearwater	21.3	10
Black-legged Kittiwake	18.4	10.5
Northern Fulmar	16.9	11
Herring Gull	10.2	9.7
Great Black-backed Gull	8.8	7.8
Sooty Shearwater	7.5	7.8
Common Murre	2.7	3.7
Atlantic Puffin	1.8	4.1
Leach’s Storm-Petrel	1.7	1.8
Northern Gannet	1.4	3.9
Dovekie	0.6	1.6
Iceland Gull	0.5	1.2
Thayer’s Gull	0.5	0.2
Pomarine Jaeger	0.4	1.5
Razorbill	0.3	1
Red Phalarope	0.2	0.3
Glaucous Gull	0.2	0.7
Wilsons Storm-Petrel	0.2	0.6
Black Guillemot	0.1	0.7
Thick-billed Murre	0.1	0.6
Arctic Tern	0.1	0.6
Parasitic Jaeger	0.1	0.3

Common Tern	0.1	0.3
Great Skua	0	0.2
Manx Shearwater	0	0.1
Long-tailed Jaeger	0	0.2
Seabirds Not Identified to Species		
Murres	1.8	4.3
Phalaropes	1.5	0.6
Auks	1.1	2.2
Gulls	0.7	1
Shearwaters	0.5	0.9
Jaegers	0.3	1.4
Terns	0.2	0.8
Storm-Petrels	0.1	0.3

Table 3.7 summarizes the percent relative abundance (% RA) and percent frequency of occurrence (% FO) ranking scores for seabirds according to taxonomic groups (PIROP and ECSAS). Gulls (including six species) were the most abundant taxonomic group (39.1 % RA), followed by shearwaters (29.3 % RA), Northern Fulmar (16.9 % RA) and auks (six species; 8.6 % RA). Gulls were the most frequently observed group during surveys (31.1 % FO), were the least frequently observed species groups (all less than 5 % FO). Clearly, the Strait of Belle Isle is an important movement corridor for many species of marine birds, with many species using the Strait to move in and out of the Gulf of St. Lawrence.

Table 3.7 Ranking of Species Groups in All Decades According to Percent Relative Abundance (Expressed as Percentages) Using PIROP (1960s Through 1980s) and ECSAS (2000s) Methods

Species Group	Relative Abundance (%)	Frequency Occurrence (%)
Gulls	39.1	31.1
Shearwaters	29.3	18.9
Fulmar[1]	16.9	11
Auks	8.6	18.3
Storm-Petrels	1.9	2.7
Phalaropes	1.7	0.9
Gannet[2]	1.4	3.9
Jaegers	0.8	3.6
Terns	0.3	1.7

Note: [1] category contains only one species (Northern Fulmar)
[2] category contains only one species (Northern Gannet)

3.4.2.2 Decadal Trends

To account for the effects of unbalanced survey effort across decades, datasets were balanced by calculating the average of species-specific totals (birds/km) from 1,000 permutations of 10 randomly selected surveys within each decade. This analysis suggests declines in the overall abundance and diversity of seabirds during the 2000s. Gulls totally dominated in the 1960s and were the most abundant species group in all decades with the exception of the 2000s. Shearwaters exhibited a strong decline in the 2000s. Auks were the most abundant species groups during the 2000s, but their numbers were lower than during 1970s. The relative abundances of the different avian taxa recorded during the 1960s, 1970s, 1980s and 2000s are shown in Figure 3.11. With regard to some of these potential changes, it must be cautioned that the PIROP survey methods used during the pre-2000 decades included all birds regardless of distance from the vessel, whereas the more recent ECSAS survey methods count birds only within 300 m of the vessel. Hence, earlier PIROP counts could be inflated in comparison with the more current ones and might account for some apparent declines in abundance.

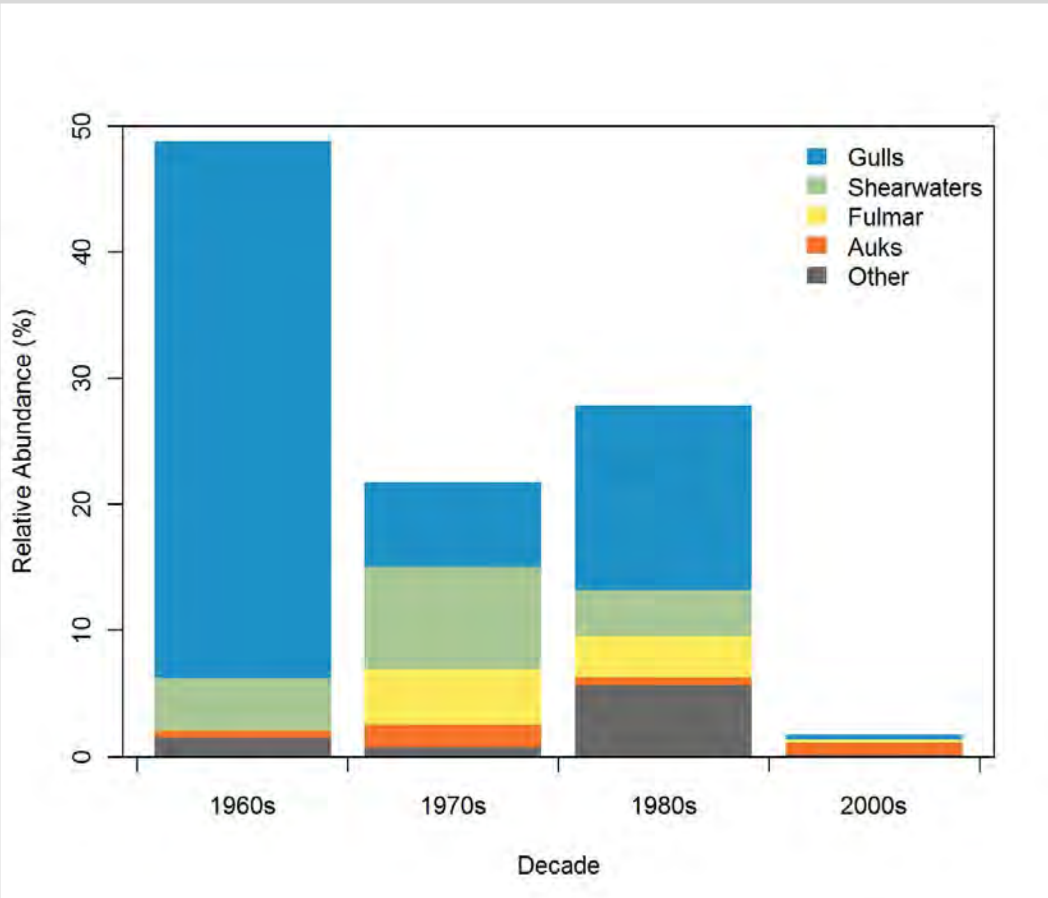


Figure 3.11 Relative number of seabirds counted on vessel surveys in the Strait of Belle Isle during the 1960s, 1970s, 1980s and 2000s.

Some findings of declines in the relative abundances of seabirds during the current decade are supported by concurrent evidence. Gjerdrum et al. (2010) found a striking southerly shift in the distribution of shearwaters and an offshore movement of gulls away from the Strait of Belle Isle in the current decade. It seems likely that at least some of this long-term decrease in seabird numbers and biodiversity in the Strait of Belle Isle is related to ocean climate change. Informative investigations could involve relating changes in the temperature and salinity of the southerly flowing Arctic water being moved into the Gulf of St. Lawrence through the northern waters of the Strait by the Labrador Current. As well, changes in the warmer water flowing out through the southern part of the Strait could influence marine productivity and the occurrences and distributions of prey species that in turn affect changing distributional patterns of top seabird predators. On top of this and owing to the closure of the commercial gillnet fishery and of the northern cod fishery in the early 1990s, there were much less fishery discards and offal available to scavenging seabirds like gulls and shearwaters. Hence, there are numerous and interactive potential reasons for changes in seabird occurrences and distribution. Considerably more research is needed to determine which and how different influences may be playing out in the Strait of Belle Isle.

3.4.2.3 **Seasonal Trends**

The monthly occurrences of the most abundant seabird groups are shown in Figure 3.12. As above for decadal trend assessments, comparisons were balanced by calculating the average of species-specific totals (birds/km) from 1,000 permutations of ten randomly selected surveys within each month. The majority of birds were recorded during the summer, composed primarily of gulls and non-resident shearwaters (Figure 3.13) which unlike other species observed during the summer are not associated with breeding colonies. Non-breeding Northern Fulmars are also relatively abundant during summer. Few birds were observed during winter and spring when the Strait of Belle Isle is usually ice-covered, preventing vessel traffic.

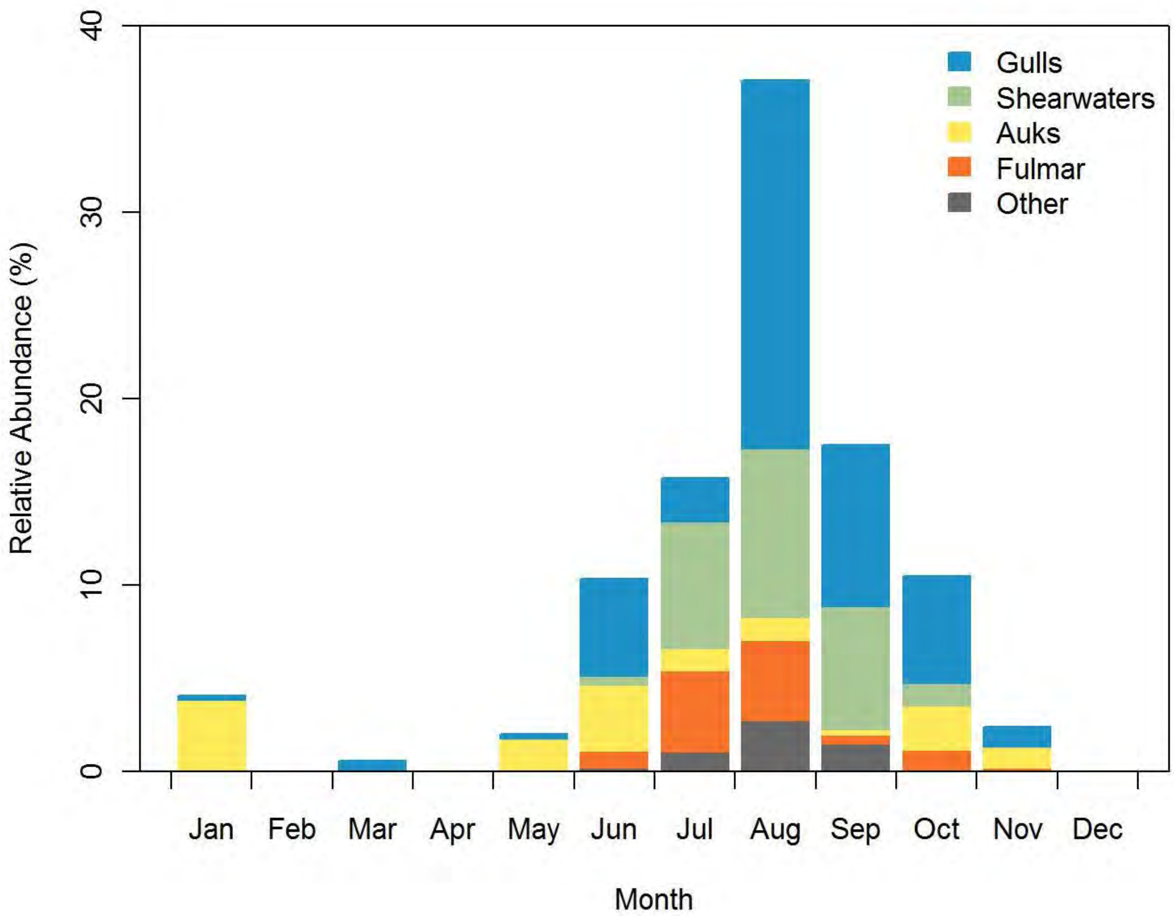


Figure 3.12 Monthly Relative Abundances (% RA) of the Most Abundant Species Groups Recorded during All PIROP and ECSAS Surveys Combined

It is evident from the monthly analysis of seabird data that the number and diversity of birds detected is a function of survey effort (see also LeGrow 1999). Figure 3.12 clarifies this relationship in a direct comparison of seabird occurrences and vessel survey effort. The conclusion is straight-forward, more surveys result in the detection of more birds and more species diversity. This stands true even if surveys are balanced by random selection as there will be more resampling in smaller samples. In other words, fewer surveys will observe fewer birds, and as such there is a higher probability that random samples will include surveys with fewer birds.

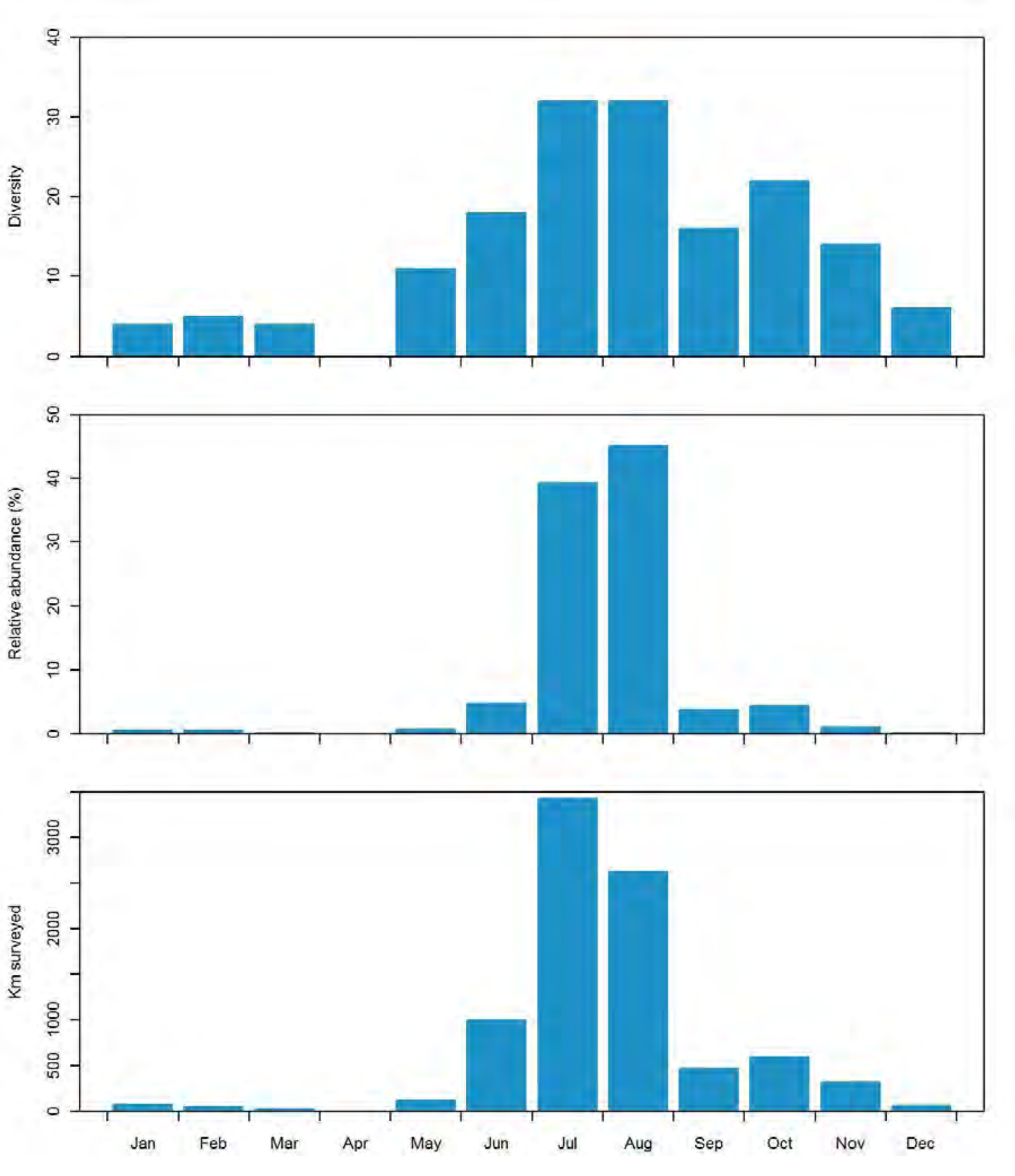


Figure 3.13 Monthly Diversity, Relative Abundance and Survey Effort Recorded during All PIROP and ECSAS Surveys Combined

3.4.3 Marine Bird Breeding Colonies

There are many important marine bird breeding colonies within the Strait of Belle Isle Study Area (Figure 3.14). The largest colonies distributed along the North Shore of the Gulf of St. Lawrence support globally and regionally significant populations of diving auks (Atlantic Puffin, Razorbill, Black Guillemot and Common Murre; Figure 3.14). Smaller colonies of terns (Common and Arctic Terns) and gulls (Herring and Great Black-backed Gulls) are distributed on the Newfoundland side of the Strait (Figure 3.14). Nesting sites of Common Eiders are widely distributed throughout the Study Area, including a colony on Herb Island where gulls and terns also nest very near the landing site for the transmission cable on the Newfoundland side (Canadian Wildlife Service unpublished data, 2010). Information on the Quebec colonies is taken primarily from CWS surveys conducted in 1993 (BIOMQ, 1999). Information on tern and eider nesting areas is based on CWS aerial (2006) and land-based point count surveys (CWS unpublished data, 2010).

Among the colonies located on the north shore of the Gulf of St. Lawrence, Les Îles Sainte-Marie colony is the largest and supports 14 species of breeding birds (Figure 3.14) including globally significant populations of Common Murres (25,308 in 1993) and Razorbills (3,342 in 1993), whose numbers at this site have increased from previous decades (BIOMQ 1999). Les Îles Sainte-Marie is also an important breeding site for Common Eiders (spp. *dresseri*), with 628 pairs documented in the last survey (1982) distributed over 13 small islands in the archipelago. Double-crested Cormorants (740 pairs in 1993) and Great Cormorants (mean of 47 pairs in 1982 and 1988) nest at Îles Sainte-Marie as well as smaller numbers of Black Guillemot, Red-throated Loon, Herring Gull, Great Black-backed Gull and Black-legged Kittiwake.

The Baie de Brador colony, composed of a number of small islands (Île Greenly and Île aux Perroquets) lies in close proximity to the proposed transmission-landing site on the Quebec shore (Figure 3.14). This colony supports 11,785 breeding pairs of Atlantic Puffins (last surveyed in 1993), or nearly 3 % of the North American population. The Razorbill also breeds in globally significant numbers at Baie de Brador, with 954 birds or approximately 1 % of the North American population (BIOMQ 1999). Numbers of Atlantic Puffins and Razorbills at this colony have declined from previous decades, due primarily to harvesting pressures (egg-collecting and poaching) and human disturbance during the breeding season (BIOMQ 1999).

Baie des Loups, in the northeastern part of the Gulf of St. Lawrence (Figure 3.13) also supports a variety of alcids (Atlantic Puffin, Razorbill, Common Murre and Black Guillemot), Common Eiders and gull species (Great Black-backed Gull and Herring Gull). Atlantic puffin is the most abundant breeding seabird (6917 in 1993) representing 1.5 % of the North American population (BIOMQ 1999). Razorbills are down significantly from 11,000 in 1965 to only 241 in the most recent survey in 1999 (BIOMQ 1999) and Common Murres have experienced a drastic decline from a maximum of 2,180 individuals in 1972 to only a few birds in 1993. The total number of breeding birds at Baie des Loups (16,629 in 1993) is down from a peak population of 27,000 individuals in 1965 (BIOMQ 1999). Common Eiders also breed at Baie des Loups with a relatively stable population that has varied between 400-800 pairs from 1930 to 1990s. Leach's Storm-petrels also breed here and may be recent immigrants to this colony; and the first breeding pairs (just over 100) were documented during the 1993 survey (BIOMQ, 1999).

Documented declines in alcid numbers at Baie de Brador and Baie des Loups (16,629 individuals in 1993, down from 27,000 in 1965; BIOMQ 1999) have been attributed to harvesting pressure (eggs and birds) and human disturbance. However, reductions in anthropogenic threats in recent decades due to stricter hunting regulations

(1992) and reductions in bycatch following the large-scale removal of gillnets during the groundfish moratorium, alcid populations are experiencing populations throughout their range in Newfoundland and Labrador (Robertson et al. 2004). In light of these recent trends, new surveys are warranted to reassess the population status of these important colonies and the significance of the region to global alcid populations.

Globally significant numbers of Herring Gulls (3,107 pairs) breed at the Saint-Augustin Migratory Bird Sanctuary, a group of islands and rocks along the northeast section of the Gulf of St. Lawrence (IBA site) as well as smaller numbers of Ring-billed Gulls, Great Black-backed Gulls and Common Terns. There were 7,580 individuals documented at this colony during the last survey (1988). Common Eider numbers at Saint-Augustin have declined sharply to 12 individuals (1988) from 1500 adults in 1960. Red-throated Loons bred there (22 individuals in 1960) and there are a number of small tern colonies (Common and Arctic Terns) located on the Newfoundland side of the Strait of Belle Isle on the Northern Peninsula (Figure 3.14), the largest of which (375 pairs of Common and Arctic Terns) is located at Forresters Point on Current Island. An aerial survey conducted by CWS in 2006 provides the most recent information on the numbers and distributions of tern and eider colonies.

Common Eiders are the most abundant waterfowl species in the study area and there are important colonies distributed on small, low lying islands throughout the study area and surrounding coastal regions (Northern Peninsula, Newfoundland). The Refuge de Saint-Augustin and Refuge des Îles Sainte Marie, support more that 1000 breeding females (CWS unpublished data, 2010) and at least four other eider colonies are located on the eastern side of Newfoundland's Northern Peninsula. Bell Island, the southern-most of two islands generally referred to as the Grey Islands off the eastern side of the Northern Peninsula, supports the largest colony of nesting Common Eiders on insular Newfoundland. It is estimated that at least 1,000 pairs of the *dresseri* subspecies nest there, which represents just over 1% of the estimated population of this subspecies (CWS unpublished data, 2010).

3.4.4 **Shorebirds**

Numerous species of shorebirds occur at coastal headlands and beaches in the Strait of Belle Isle and along Newfoundland’s west coast with peak numbers during fall migration (August, September, October). Key feeding, roosting and stopover sites include Eddies Cove East, Eddies Cove in Gros Morne National Park, Shoal Cove West, Bear Cove, L’Anse au Loup, Pines Cove, Port Saunders and L’Anse aux Meadows (see Figure 3.15).

The Canadian Wildlife Service conducts surveys and collects records of shorebird occurrences in the province (CWS unpublished data, 2010). The most common shorebirds that stop in the Strait during fall migration are White-rumped Sandpipers (*Calidris fuscicollis*), Greater Yellowlegs (*Tringa melanoleuca*), Semi-palmated Sandpipers (*Calidris pusilla*), Ruddy Turnstones (*Arenaria interpres*), Semi-palmated Plovers (*Charadrius semipalmatus*) and Dunlin (*Calidris alpina*). Table 3.8 lists the most common shorebirds that occur in the region during autumn. Purple Sandpipers (*Calidris maritime*) and Whimbrels (*Numenius phaeopus*) also occur commonly in the study area. Observations of Red Knot (*Calidris canutus rufa*) that are listed as ‘Endangered’ by *SARA*, have been recorded in close proximity to the Study Areas (Figure 3.15) with peak numbers (52 individuals) recorded at Port aux Choix, Newfoundland during October 2007 (CWS unpublished data 2010). Smaller numbers of Red Knots (2-6 birds) have been observed at Eddies Cove East on nine different occasions, all during late summer/fall months (August to November) suggesting that this area may be used as a stopover site during migration.

Table 3.8 Most Common Shorebird Species that Stop in the Strait of Belle Isle during Fall Migration Listed in Order of Abundance Based on CWS Shorebird Survey Database (CWS Unpublished Data 2010)

Common Name	Scientific Name
White-rumped Sandpiper	*Calidris fuscicollis*
Greater Yellowlegs	*Tringa melanoleuca*
Semi-plamated Sandpiper	*Calidris pusilla*
Ruddy Turnstone	*Arenaria interpres*
Semi-palmated Plover	*Charadrius semipalmatus*
Dunlin	*Calidris alpine*
Sanderling	*Calidris alba*
Least Sandpiper	*Calidris minutilla*
Black-bellied Plover	*Pluvialis squatarola*
Lesser Yellowlegs	*Tringa flavipes*
Whrimbrel	*Numenius phaeopus*

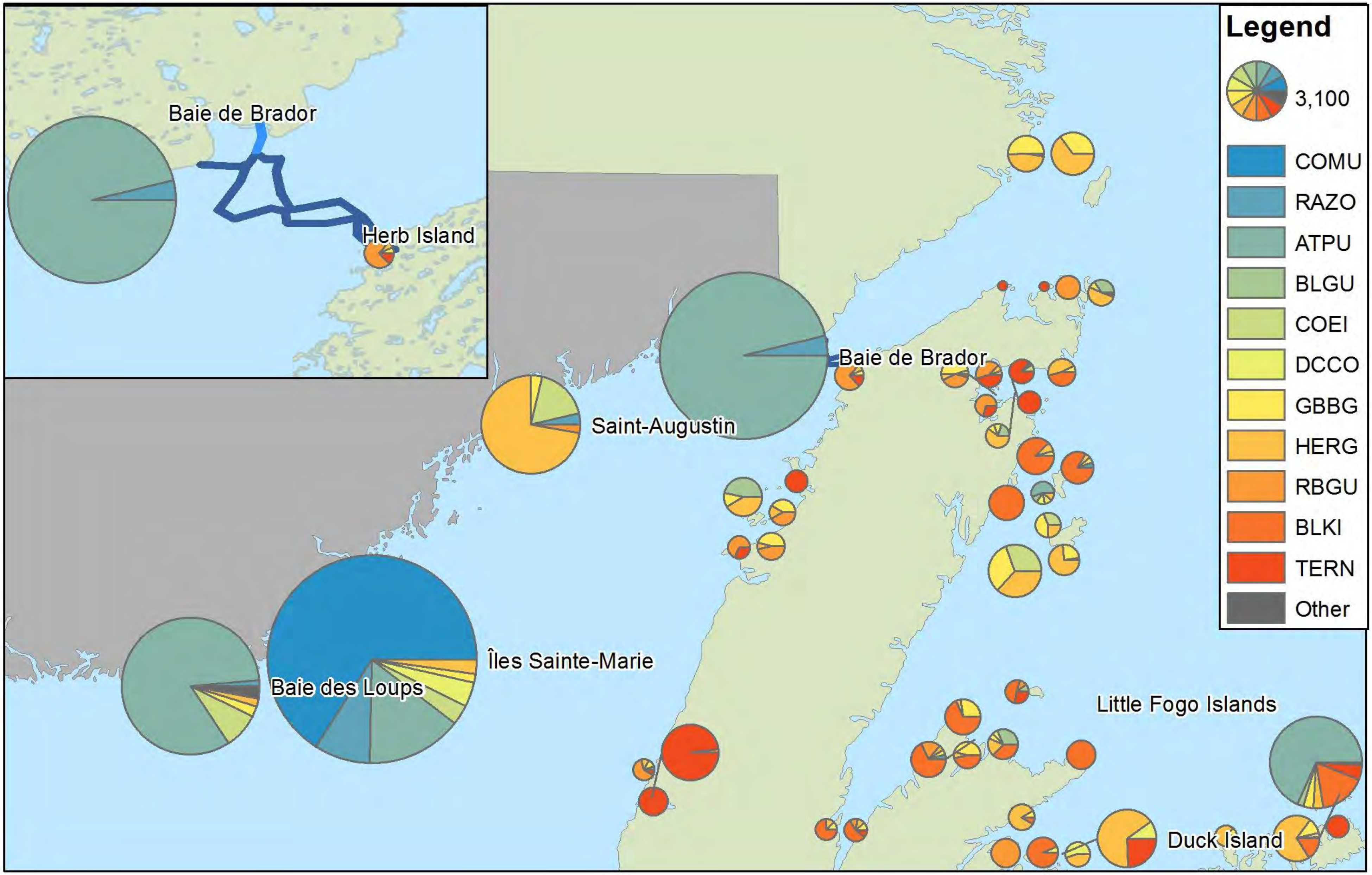
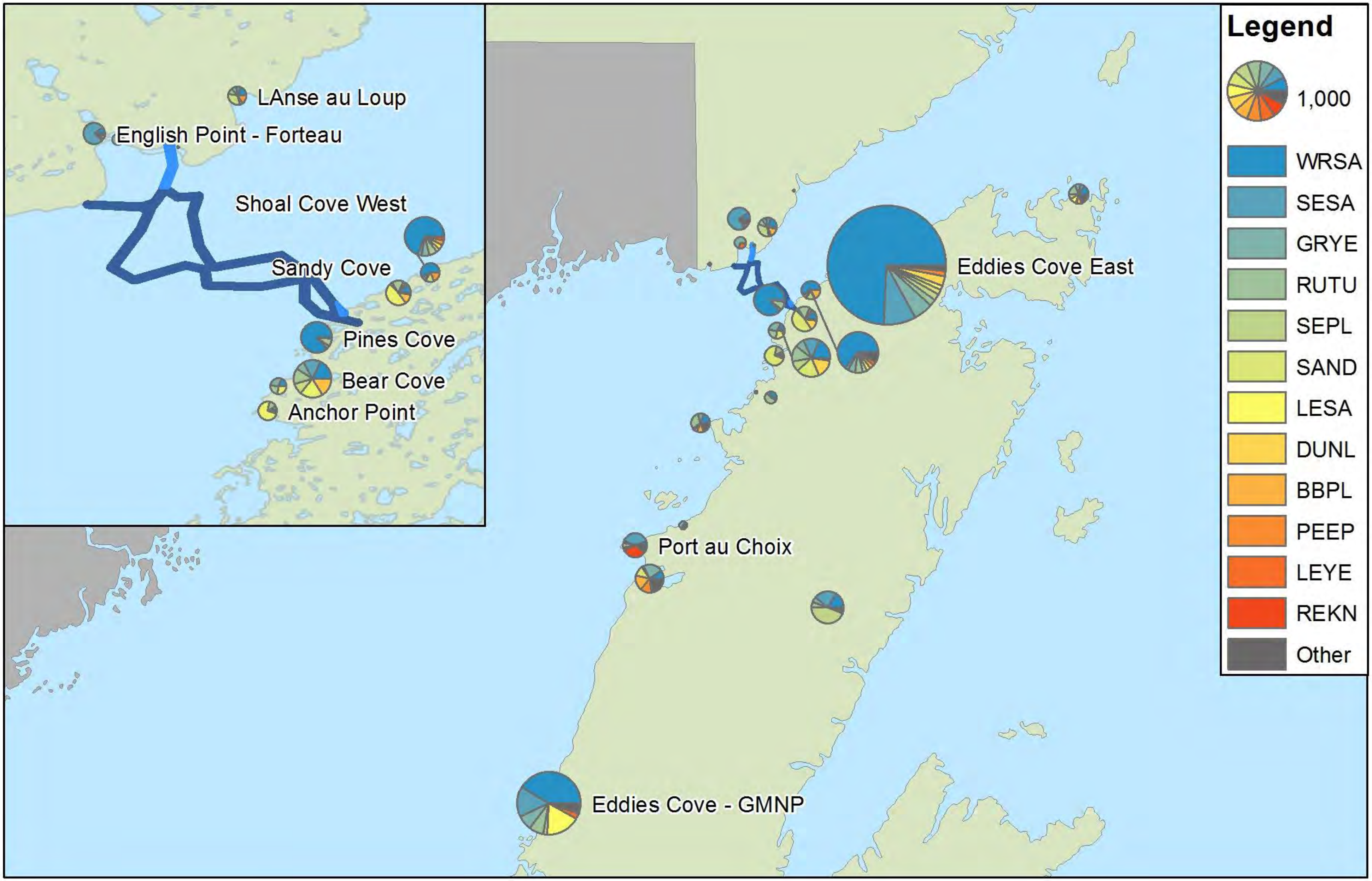


FIGURE 3.14

Breeding Sites with Greater Than 400 Individuals



nalcor energy	FIGURE3.15
	Shorebird Sites

3.5 Species of Special Conservation Concern

Several of the marine mammal and seabird species, and two sea turtle species that occur within the Strait of Belle Isle are designated as being of special conservation concern and are discussed in this section. Some of these species have either been designated under the federal *Species at Risk Act* (*SARA*) and/or the *Newfoundland and Labrador Endangered Species Act (NL ESA*). Of the species discussed in this report, only the seabirds are considered under both legislations, as marine mammals and sea turtles are considered under federal legislation only. Other species discussed in this section are marine mammal and sea turtle species assessed and designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

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*). Only 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' or 'Extirpated', while management plans are required for species designated as 'Special Concern'.

As *SARA* designation and COSEWIC designation are very different in terms of legal protection, the following sections have been sub-divided to reflect these differences. The section includes a discussion of *SARA* designated marine mammal and sea turtle species, followed by *SARA* and *NL ESA* designated seabird species. In addition, marine mammal and a sea turtle species designated by COSEWIC (including species that are on Schedule 2 and Schedule 3 of *SARA* and therefore not legally protected) that are known to occur in the Study Area are also discussed.

3.5.1 ***SARA* Designated Marine Mammal and Sea Turtle Species**

Marine mammal and sea turtle 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 3.9 and include the blue whale, fin whale and the leatherback turtle.

A discussion of these three species follows in Table 3.9 including reasons for their designations.

Table 3.9 Marine Mammals and Sea Turtles that are Listed Under the *Species At Risk Act (Schedule 1)*

Species	***SARA* Designation**
Blue whale (*Balaenoptera musculus*) Atlantic population	Endangered Schedule 1
Fin whale (*Balaenoptera physalus*) Atlantic Ocean population	Special Concern Schedule 1
Leatherback turtle (*Dermochelys coriacea*) Atlantic Ocean population	Endangered Schedule 1

Blue Whale

The blue whale, a large baleen whale, is listed under *SARA* as 'Endangered' and was last assessed by COSEWIC in May 2002 (COSEWIC 2010). Whaling reduced the original population. There are now fewer than 250 mature individuals, and strong indications of a low calving rate and a low recruitment rate to the studied population. Today, the biggest threats for this species come from ship strikes, disturbance from increasing whale watching activity, entanglement in fishing gear, and pollution. They may also be vulnerable to long-term changes in climate, which could affect the abundance of their prey (COSEWIC 2010).

Fin Whale

The fin whale, the second largest of baleen whales, is listed under *SARA* as 'Special Concern' and was last assessed by COSEWIC in May 2005 (COSEWIC 2010). During much of the 20th Century, the size of this population was reduced by whaling. Sightings remain relatively common off Atlantic Canada and they have not been hunted since 1971. There is some uncertainty regarding the current abundance and level of depletion relative to pre-whaling numbers. Threats to the fin whale include ship strikes and entanglement in fishing gear, although none are thought to seriously threaten the population (COSEWIC 2010).

Leatherback Turtle

The leatherback turtle is listed as 'Endangered' under Schedule 1 of *SARA,* and is protected under the Act. A Recovery Team has been formed to develop a recovery strategy (Atlantic Leatherback Turtle Recovery Team 2006). The species is undergoing a severe global decline (greater than 70 % in 15 years). In Canadian waters incidental capture in fishing gear is a major cause of mortality. A long lifespan, very high rates of egg and hatching mortality, and a late age of maturity makes this species unusually vulnerable to even a small increase in rates of mortality of adults and older juveniles (COSEWIC 2010).

3.5.2 ***SARA* and *NL ESA* Designated Seabird Species**

Seabird species of special conservation concern status that occur in the Strait of Belle Isle include Ivory Gull (*Pagophila eburnea*), Harlequin Duck (*Histrionicus histrionicus*), Barrow's Goldeneye (*Bucephala islandica*) and Red Knot (*Calidris canutus rufa*). There is also strong likelihood that the Endangered Piping Plover (*Charadrius melodus melodus*) ventures into the proposed corridor during its pre- and post-breeding movements. Any remnants of the Endangered Eskimo Curlew (*Numenius borealis*) population could also occur in the proposed corridor. Most of these species, with the exception of the Harlequin Duck and possibly the Red Knot, are considered uncommon or rare within the Study Area. These species are designated under the federal (*SARA*) and/or provincial (*NL ESA*) legislation (Table 3.10). Recovery strategies have been developed for both the Piping Plover (Environment Canada 2006) and the Eskimo Curlew (Environment Canada 2007); they are posted on the *SARA* Registry.

A discussion of these six species follows in Table 3.10 including their likely occurrence in the Study Area, and reasons for their designations.

Table 3.10 Coastal and Marine Bird Species that are Listed by the Newfoundland and Labrador *Endangered Species Act* and/or *Species at Risk Act*

Species	***NL ESA* Status**	***SARA* Designation**
Ivory Gull (*Pagophila eburnea*)	Endangered (October 2006)	Endangered – Schedule 1
Harlequin Duck (*Histrionicus histrionicus*)	Vulnerable (May 2001)	Special Concern – Schedule 1
Barrow's Goldeneye (*Bucephala islandica*)	Vulnerable (November 2000)	Special Concern – Schedule 1
Red Knot (*Calidris canutus rufa*)	Endangered (April 2007)	No Status, No Schedule
Eskimo Curlew (*Numenius borealis*)	Endangered (May 2000)	Endangered – Schedule 1
Piping Plover (*Charadrius melodus melodus*)	Endangered (May 2000)	Endangered – Schedule 1

Ivory Gull

The Ivory Gull winters among the pack ice of the Davis Strait, Labrador Sea, and Gulf of St. Lawrence, including the Strait of Belle Isle (Stenhouse 2004). The species occurs at times in the Strait, usually in association with Arctic sea ice. It has been observed often in association with Arctic sea ice along the coast of the Northern Peninsula (Peters and Burleigh 1951; Stenhouse 2004). Generally, records of Ivory Gull are rare and irregular (Stantec 2010). The species is listed under both *SARA* and the *NL ESA* as 'Endangered'; it was assessed by COSEWIC in April 2006 (COSEWIC 2010). Aboriginal traditional knowledge and recent intensive breeding colony surveys indicate that the Canadian breeding population of this seabird has declined by 80 percent over the last 20 years. Threats include contaminants in the food chain, continued hunting in Greenland, possible disturbance by mineral exploration at some breeding locations and degradation of ice-related foraging habitats as a result of climate change (COSEWIC 2010).

Harlequin Duck

Harlequin Duck is listed under *SARA* as 'Special Concern' and by *NL ESA* as 'Vulnerable'. The COSEWIC designation was previously 'Endangered', when assessed by COSEWIC in May 2001, it was listed in a lower risk category (COSEWIC 2010). The Study Area may be important for the Harlequin Duck that is known to nest on the Torrent River (Thomas 2008), and an estimated 20% of all wintering Harlequin Ducks in eastern North America overwinter on the Northern Peninsula (Gilliland et al. 2008). While only seven Harlequin Ducks were observed in the Study Area during the 1996 monitoring at Point Amour (Russell and Fifield 2001), this survey may have been too early in the year to detect this species. Furthermore, baseline information on their migration patterns is too limited to make inferences about the importance of the area based on a single survey. Furthermore, although population levels are increasing at key wintering locations (Thomas and Robert 2001), the eastern North American wintering population has yet to reach its goal of 3,000 wintering individuals in eastern North America as outlined by the 1995 recovery plan (EC 2007). Consequently, while the population is larger than previously thought, the species remains a high conservation priority. The tendency of Harlequin Ducks to congregate in fairly large groups when moulting and wintering, increases their vulnerability to environmental and other catastrophic events such as oil spills (COSEWIC 2010).

Barrow's Goldeneye

The Barrow's Goldeneye is known to migrate through the Strait of Belle Isle, and the majority of the population winters in the St. Lawrence estuary, with small numbers seen throughout Atlantic Canada and Maine (Schmelzer 2006; COSEWIC 2010). Schmelzer (2006) indicates that if breeding does occur in Newfoundland, it is probably sporadic and/or infrequent. During 1996 waterfowl surveys conducted from Point Amour only one sighting of Barrow's Goldeneye was recorded (CWS Unpublished Data 1996) however its close resemblance to Common Goldeneye may result in Barrow's Goldeneye being overlooked, particularly if visibility is low. This species is listed under both *SARA* as 'Special Concern' and by *NL ESA* as 'Vulnerable'. It was last assessed by COSEWIC in November 2000 (COSEWIC 2010). Reasons for designation include the small numbers of individuals in this eastern population. Limited habitat availability and oil spills are potential threats to this population, though none is currently at a scale that would negatively impact the population (COSEWIC 2010).

Red Knot

The Red Knot, a medium-sized shorebird, is listed under the *NL ESA* as 'Endangered'. Red Knots have been observed at Port aux Choix, Eddies Cove East on the Newfoundland side of the Strait, and at English Point – Forteau and L'Anse au Loup on the Labrador side. The Red Knot has no status or schedule under *SARA* and was last assessed by COSEWIC in April 2007 (COSEWIC 2010). Yet the *rufa* subspecies that breeds in the eastern Canadian Arctic has experienced population declines of about 70 percent over the past three generations (15 years; Baker et al. 2004). The Red Knot breeds in Arctic Canada, and the *rufa* subspecies migrates between Arctic breeding grounds to its wintering areas at the tip of South America, and passes along Newfoundland and Labrador during migration. The most important areas for this subspecies during migration are along the North Shore of the St. Lawrence, and no important areas have been identified for Red Knot in Labrador or Newfoundland (COSEWIC 2010), therefore occurrence in the Study Area would be considered uncommon. However observations of Red Knot at Port aux Choix (52 birds on 17 October 2007) and over seven occasions at Eddies Cove East (between 2 and 6 birds each time) during August to November suggests that Red Knots may periodically stopover in the area during fall migration (CWS unpublished data). Other sightings in and near the study area at Eddies Cove in Gros Morne National Park, St. Paul's Inlet, Stephenville Crossing and Belldown Point (20 on 24 September and ten on 18 September 2010). Threats to the *rufa* subspecies include a depletion of horseshoe crab eggs in Chesapeake Bay, a food critical source used during migration. There is no potential for rescue from other populations (COSEWIC 2010).

Eskimo Curlew

The Eskimo Curlew is a shorebird species listed under *SARA* as 'Endangered'. The last assessment by COSEWIC was in November 2009 (COSEWIC 2010). The Eskimo Curlew has 100 percent of its known breeding range in Arctic Canada. The population collapsed in the late 1800s, primarily owing to uncontrolled market hunting and dramatic losses in the amount and quality of spring stopover habitat (native grasslands). The population has never recovered and there have been no confirmed breeding records for over 100 years, or any confirmed records of birds (photographs/specimens) since 1963. Recent sight records suggest the possibility of a small population (fewer than 50 mature individuals) may still persist in remote Arctic landscapes. The occurrence of this species in the Study Area is therefore considered to be very unlikely. Factors affecting recovery include very low population size, no known chance of rescue from outside populations, and the historic and ongoing conversion of native grasslands on its spring staging areas in Canada and the U.S. and on its wintering grounds in Argentina (COSEWIC 2010).

Piping Plover

The Piping Plover, a shorebird, nests on some of the sandy beaches on Newfoundland's west coast (e.g., Shallow Bay, Gros Morne National Park) that are found outside the Study Area. It is included in this section because there is likelihood of its occurrence in the Study Area during it pre- and post-breeding movements. It is listed under the *NL ESA* as 'Endangered' (May 2001) and under *SARA* as 'Endangered'. The Piping Plover was last assessed by COSEWIC in May 2001 (COSEWIC 2010). Reasons for its designation include a small number of individuals which are breeding in Canada, and a decreasing quality, loss and destruction of nesting habitat. Predation, ATV habitat degradation and other disturbances are interfering with reproductive success. Strong conservation initiatives have failed to result in any significant increase in numbers of breeding pairs (COSEWIC 2010).

3.5.3 COSEWIC Designated Marine Mammal and Sea Turtle Species

Marine mammal species of special conservation concern that have been designated by COSEWIC that are known to occur in the Study Area include harbour porpoise, killer whale and beluga whale. Sea turtle species designated by COSEWIC include the loggerhead turtle. These species do not have the legal protection that species listed on Schedule 1 of *SARA* are provided. These species and their COSEWIC designation, including where applicable their Schedule 2 status under *SARA*, are outlined in Table 3.12.

A discussion of these four species follows Table 3.11 including reasons for their recommendation in the COSEWIC assessment.

Table 3.11 Marine Mammal and Sea Turtle Species that have COSEWIC Designations or are Listed Under Schedule 2 or 3 of *SARA*

Species	COSEWIC Designation	*SARA* Designation
Harbour porpoise (*Phocoena phocoena*) Northwest Atlantic population	Special Concern (April 2006)	Threatened Schedule 2

Killer whale (*Orcinas orca*) Northwest Atlantic/Eastern Arctic population	Special Concern (November 2008)	No Status
Beluga whale (*Delphinapterus leucas*) Ungava Bay population	Endangered (May 2004)	No Status
Beluga whale (*Delphinapterus leucas*) St. Lawrence estuary population	Threatened (May 2004)	No Status
Loggerhead turtle (*Caretta caretta*) Atlantic Ocean population	Endangered (April 2010)	No Status

Harbour Porpoise

The harbour porpoise is designated by COSEWIC as 'Special Concern', and under Schedule 2 of *SARA* as 'Threatened', but is not legally protected under *SARA*. It was last assessed by COSEWIC in April 2006 (COSEWIC 2010). Harbour porpoise is widely distributed in eastern Canadian marine waters. Population of this species remains abundant, although a major threat to the harbour porpoise is incidental catch in fishing gear, especially gillnets. Management measures in the Bay of Fundy and Gulf of Maine have shown to reduce bycatch rates in gillnets in these areas, though these measures have not been implemented in much of the species range, including the Gulf of St. Lawrence and Newfoundland and Labrador. There is also concern that acoustic harassment devices associated with aquaculture may exclude some porpoises from their habitat in the Bay of Fundy, and possibly other areas. Lack of good abundance information and lack of monitoring and mitigation in many relevant fisheries are reasons for concern (COSEWIC 2010).

Killer Whale

The killer whale population in the Northwest Atlantic/Eastern Arctic was designated by COSEWIC as 'Special Concern' in November 2008, but has no designation under *SARA*, and is therefore not legally protected. Threats to this population include hunting in Greenland, acoustical and physical disturbance and contaminants. Acoustical and physical disturbance is increasing and will become more intense as hydrocarbon exploration and shipping traffic increases in the in the region and in the Arctic. This population's small size (fewer than 1000 mature individuals and likely less than 250) and the species' life history and social attributes justify designation as 'Special Concern' (COSEWIC 2010).

Beluga Whale

Canadian beluga whales have been divided into seven populations based on disjunct summer distributions and genetic differences (COSEWIC 2010). For this report, the two populations in closest proximity to the Study Area are discussed. In May 2004, the Ungava Bay population and the St. Lawrence estuary population were designated by COSEWIC as 'Endangered' and 'Threatened' respectively. The summer distribution of both these populations does not extend into, or near the Study Area, however their occurrence does include the Atlantic Ocean for both of these populations (COSEWIC 2010), and sightings have been reported in the Strait of Belle Isle (Lawson and Gosselin 2009). The Ungava Bay population is very low, and has potentially been extirpated. Hunting has caused the population decline and continues in Ungava Bay. The St. Lawrence estuary population,

designated as 'Threatened', was severely reduced by hunting which continued until 1979. Current threats include contaminants, vessel traffic and industrialization of the St. Lawrence watershed (COSEWIC 2010).

Loggerhead Sea Turtle

The loggerhead sea turtle was designated as 'Endangered' by COSEWIC in April 2010. This species has experienced global decline, including the Northwest Atlantic population. Juveniles for the Northwest Atlantic population are known to feed in Atlantic Canadian waters. Threats to the Canadian population include commercial fishery, and loss of nesting sites in the U.S. and the Caribbean (COSEWIC 2010). Although they may possibly occur in the Strait of Belle Isle, their presence is likely rare.

4.0 SUMMARY

This study has assembled recent baseline information for marine mammals, sea turtles and seabirds 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 and to supplement information existing in the literature.

4.1 Marine Mammals

Recent information on marine mammals including whales (cetaceans) and seals (pinnipeds) in the Study Area was identified, compiled and reviewed. In support of the GOSLIM, a detailed summary of information and a comprehensive literature review for the Gulf of St. Lawrence, including the Strait of Belle Isle was compiled in 2007. This report was used extensively in identifying recent information sources, as well as relevant details regarding the Study Area. Information collected on marine mammals in the Strait of Belle Isle since 2000 is largely anecdotal in nature; however some systematic land-based, aerial and shipboard surveys have occurred. Both anecdotal records and scientific studies and surveys were reviewed.

Scientific reports included systematic aerial surveys in 1995, 1996, and 2002. Studies of movement and diving behaviour using satellite telemetry on hooded and grey seals in the Gulf of St. Lawrence were also conducted. The results of these surveys were reviewed in relation to the GOSLIM initiative, along with other relevant information sources. It was determined that at least 14 species of marine mammals may occur in the Study Area including: grey seal; harbor seal; hooded seal; harp seal; minke whale; blue whale; fin whale; humpback whale; killer whale; harbour porpoise; Atlantic white-sided dolphin; white-beaked dolphin; shortbeaked common dolphin; and long-finned pilot whale.

During the summer of 2007, a survey was conducted by DFO as part of the Trans North Atlantic Sightings Survey that identified eight species of marine mammals in the Strait of Belle Isle Study Area: beluga; blue whale; fin whale; harbour porpoise; humpback whale; minke whale; white-beaked dolphin; and the Atlantic white-sided dolphin. Aggregations of humpback whales were sighted more often in the Study Area than other species, while higher numbers of individual white-beaked dolphins were sighted during the survey in the Strait of Belle Isle than other species in the area, and had higher numbers in that area than other areas surveyed. Boat-based surveys have also been conducted in the area.

Historical sightings data which have not been previously presented in earlier Project reports were also examined. This includes information (sightings) from anecdotal sources and surveys, and compiled by the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations. Another source of information for marine mammals is the DFO historical sightings database. Both of these sightings databases were compiled and mapped to illustrate distributions of marine mammal sightings; however any type of analysis to determine abundance, density or any other type of estimation would not be feasible due to the nature of the data. Another source of information for marine mammals within the Study Area was anecdotal information from the Community Coastal Resource Inventory (CCRI) database.

Most of the species listed (with the exception of hooded seal) occur in the Study Area between May and December, whereas harp seals, fin whales and hooded seals regularly occur there between December and May. The Strait of Belle Isle serves as a feeding area for diverse and high biomasses of megafauna and serves as a migration path during spring and fall and as a breeding and pupping area during winter for seals.

4.2 Sea Turtles

Only a few records of sea turtle sightings exist in the Gulf of St. Lawrence, which indicates that sea turtles do not frequent this area. The species of sea turtles that could potentially occur in the Strait of Belle Isle include the leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). Both species are relatively common in the waters off Newfoundland during the summer and fall. The loggerhead turtle is more common off the Atlantic coast, and is found in higher numbers offshore.

4.3 Seabirds

The importance of the Strait of Belle Isle as a migratory corridor and breeding and wintering habitat for marine birds cannot be over emphasized. It is abundantly clear from the archaeological evidence that the richness of marine life in this passageway between the Labrador Sea in the Gulf of St. Lawrence provided key settlement sites for aboriginal peoples, Norse Vikings and early Europeans.

4.3.1 **Research Needed to Fill Information Gaps in Marine Bird Occurrences in the Strait of Belle Isle**

Some key research projects are needed to fill a number of information and data gaps regarding marine birds in the Strait of Belle Isle. These include 1) a comprehensive survey of the nesting birds on Herb Island, 2) systematic surveys of the seabird colonies in the cold northern waters of the Strait, 3) opportunistic (ferry) and dedicated surveys through the Strait during autumn, and the ice-free winter and spring periods to document migratory movements and winter occupancy, and 4) annual monitoring of the autumn migration of shorebirds at key stopover sites in the Strait of Belle Isle. The context and rationale for these recommendations are detailed in the following paragraphs.

Globally significant numbers of seabirds (e.g., >40,000 auks) and marine ducks (e.g., > 60,000 eiders) migrate through the Strait's narrow waterway during spring migration. Fall migration is likely an equally busy period however there are currently no data available on fall migration. Fall surveys are urgently needed to fully assess the importance of the Strait for migration of marine birds and waterfowl.

Large seabird colonies are located on the cold-water side in Labrador and Quebec with globally significant numbers of breeding Atlantic Puffins (Baie de Brador and Baie des Loups), Common Murres and Razorbills (Îles Sainte-Marie). During the last census numbers of auks at most sites (not Îles Sainte-Marie) were shown to have declined, but in light of recent increases of auk populations in other regions in Newfoundland and Labrador (e.g., Witless Bay Ecological Reserve; Robertson et al. 2004) due to reductions in hunting pressure and bycatch, new surveys are warranted to assess the current status of these populations.

Pelagic survey data also highlight the importance of the study area for a variety of species throughout the year including locally breeding birds (auks and gulls) and long-distance migrants (shearwaters and fulmars). Great

Shearwaters and Black-legged Kittiwakes were the most abundant species overall and Northern Fulmar was the most frequently observed species followed by Black-legged Kittiwake and Great Shearwater. Seasonal pulses in species composition and abundance were observed. Most birds were recorded during summer, composed primarily of gulls and non-resident shearwaters and Northern Fulmars. Few birds were observed during winter and spring when the Strait of Belle Isle is usually ice-covered, preventing vessel traffic. Vessel survey effort contributes strongly to the number and diversity of birds detected.

Numerous species of shorebirds occur at coastal headlands and beaches in the Strait of Belle Isle and along Newfoundland's west coast. Shorebird numbers peak in the region during the fall migration (August, September, October). Key feeding, roosting and stopover sites in the vicinity of the Study Area include Shoal Cove East, Shoal Cove West, Eddies Cove East, L'Anse au Loup, Pines Cove, Port Saunders and L'Anse aux Meadows. These important shorebird stopover sites need to be monitored each autumn.

4.4 Species of Special Conservation Concern

There are a number of 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 the 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. Some species of seabirds and shorebirds which may occur in the Study Area are also protected under the *NL ESA*.

Marine mammal species of special conservation concern that are known to or may occur within the Study Area which have legal protection under Schedule 1 of *SARA* include the blue whale and fin whale which are listed under the *SARA* Schedule 1 as 'Endangered' and 'Special Concern', respectively. The leatherback turtle is designated as 'Endangered' under Schedule 1 of *SARA*, and may occur in the Study Area.

Seabird species of special conservation concern status that occur in the Strait of Belle Isle area include Ivory Gull, Harlequin Duck, Barrow's Goldeneye and Red Knot. Listed species that may potentially occur include Piping Plover and Eskimo Curlew. Piping Plover, Eskimo Curlew and Ivory Gull have all been designated as 'Endangered' by the *NL ESA* and *SARA*, and the Red Knot has also been listed as 'Endangered' by the *NL ESA* only. Barrow's Goldeneye and Harlequin Duck have both been designated as 'Special Concern' by *SARA* and 'Vulnerable' under the *NL ESA*.

The COSEWIC has designated marine mammal and sea turtle species that may potentially occur within the Study Area. Marine mammal species potentially occurring in the Study Area include harbour porpoise, killer whale, and beluga whale. The harbour porpoise has been designated as a species of 'Special Concern' by COSEWIC, and is listed under Schedule 2 of the *SARA.* Killer whales, which have been observed in the Strait of Belle Isle region, have been given the designation of 'Special Concern' by COSEWIC. Observations of beluga whales have also been recorded in the Strait of Belle Isle and nearby populations have been designated by COSEWIC as 'Endangered' (Ungava Bay population) and 'Threatened' (St. Lawrence estuary population). The loggerhead sea turtle has also been designated as 'Endangered' by COSEWIC, however its presence in the Study Area is likely rare. These species have been designated by COSEWIC, but are not legally protected under *SARA.*

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APPENDIX A

Annotated Bibliography

Marine Mammals, Sea Turtles and Seabirds in the Strait of Belle Isle:

Information Compilation and Review

Annotated Bibliography

(Google Earth, 2010)

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

Recovery strategy for the leatherback turtle in Atlantic Canada.

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

A study looking at differences in reproductive strategies of hooded seals captured in the Gulf of St. Lawrence. This report outlines the seals moving through the Strait of Belle Isle during some periods.

Baker, A.J., P.M. Gonzalez, T. Perisma, L.J. Niles, L. J. I de LS do Nascimento, P.W. Atkinson, N.A. Clark, C.D.T. Minton, M. Peck and G. Aarts. 2004. Rapid population decline in Red Knots: Fitness consequences of decreased refuelling rates and late arrival in Delaware Bay. Proceedings of the Royal Society of London, Series B 271: 875-882.

This study provided information about the Red Knot, including population and estimations of declines.

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

This is the recovery strategy for the Blue Whale in the Northwest Atlantic, which was recently released and posted on the SARA registry.

Brown R. G. B. 1986. Revised Atlas of Eastern Canadian Seabirds. Supply and Services Canada, Ottawa.

This atlas provides distributions of birds at sea assessed from vessel surveys. The data in this atlas is now decades old. More recent information from surveys from the Strait of Belle Isle ferry can be found in LeGrow (1999) and more recent data from vessel surveys can be extracted from the Eastern Canadian Seabirds at Sea Data Base (See Wilhelm et al. 2010).

Cairns, D. K., G. Chapdelaine, W. A. Montevecchi. 1991. Prey harvest by seabirds in the Gulf of St. Lawrence. Pages 277-291 in: J. Therriault (Editor) Gulf of St. Lawrence: Small Ocean or Big Estuary? Canadian Special Publication of Fisheries and Aquatic Science. 113.

This study contains an analysis of fish consumption by breeding seabirds throughout the Gulf of St. Lawrence including Strait of Belle region. This is useful for visualizing the breeding distribution of seabird in Strait area and throughout the Gulf.

Cairns D. K., W. A. Montevecchi and W. Threlfall. 1989. Researcher's guide to Newfoundland seabird colonies. Memorial University of Newfoundland Occasional Papers in Biology. 14.

A compendium of the breeding seabird populations (colonies) of Newfoundland (not Labrador). The data is now decades old but some colonies do not have more recent surveys. More current data can be found on the

Canadian Wildlife Service website, at the Atlantic Conservation Data Centre, and in Montevecchi 2010 for the Gannet Islands and Hare Bay Ecological Reserves.

Chapdelaine, G. 1995. Fourteenth census of seabird populations in the sanctuaries of the North Shore of the Gulf of St. Lawrence. Canadian Field-Naturalist. 109: 220-226.

Census of seabird colonies along the North Shore of the Gulf of St. Lawrence, the region influenced by the inflowing Labrador Current.

Conestoga-Rovers & Associates. 2008. Environmental Assessment of Geophysical Surveys for Exploration Licenses 1097, 1098, 1103 and 1104 Western Newfoundland. Prepared for NWest Energy Inc. 221 p + App.

An Environmental Assessment (EA) prepared in support of seismic activity in Western Newfoundland. This EA has some relevant information on marine mammals that may be present in the Strait of Belle Isle Study Area, with most of the data sources taken from Lesage et al. 2007.

CWS (Canadian Wildlife Service). 1996. Unpublished data. Data provided by the Canadian Wildlife Service collected during the 1996 waterfowl surveys at Point Amour, Labrador.

Waterfowl surveys conducted in the Strait of Belle Isle in 1996, specifically at Point Amour, Labrador. This data indicated that the Barrow's Goldeneye was observed only once in the Study Area during this survey.

DFO (Fisheries and Oceans), 2005. 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), 2006. 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 in the workshop surrounding 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), 2007. 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, and its importance to marine mammals.

DFO (Fisheries and Oceans). 2010. Current Status of Northwest Atlantic Harp Seals, Pagophilus groenlandicus. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/074.

A status report on Harp Seals in the Northwest Atlantic. The resource status is estimated based on surveys and incorporates estimates of pup production, reproductive rates, and total population size. The report gives an indication of the range of the stock, which includes the Strait of Belle Isle area, the migratory routes and whelping locations. This resource status report indicates the importance of the Strait of Belle Isle as a migratory route and has an important whelping area north and just in the southern strait.

Environment Canada. 2006. Recovery Strategy for the Piping Plover (Charadrius melodus circumcinctus) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. vi + 30 pp.

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Hammill, M.O., L.N. Measures, J.-F. Gosselin, and V. Lesage. 2007. Lack of recovery in St. Lawrence Estuary beluga. DFO. Can. Sci. Advis. Sec. Res. Doc. 2007/026

This report looks at populations of beluga in the St. Lawrence Estuary, and does not have any relevant information for the Strait of Belle Isle Study Area, however demonstrates the presence of beluga in the St. Lawrence Estuary.

Hammill, M. O. and Stenson, G. B. 2010. Abundance of Northwest Atlantic harp seals (1952-2010). DFO Can. Sci. Advis. Sec. Res. Doc. 2009/114. iv + 12 p

A report detailing the results of a population model study of harp seals from 1952 to 2009. The study was conducted to determine abundance in the Northwest Atlantic. This does not include detailed information about the Strait of Belle Isle area; however it does give an overview of the abundance estimates for the harp seals that frequent this area.

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Ingstad, A.S. 1977. The Discovery of a Norse Settlement in America. Universitetsforlaget, Oslo.

A historic overview of the Norse Greenlanders' occupation at L'Anse aux Meadows. Saga of Karlsefarni indicates abundant nesting concentrations of eiders in the area.

Kingsley, M. C. S. and R.R. Reeves. 1998. Aerial surveys of cetaceans in the Gulf of St. Lawrence in 1995 and 1996. Can. J. Zool. 76: 1529-1550.

Aerial line-transect surveys of cetaceans were flown in the Gulf of St. Lawrence in late August and early September of 1995 and in late July and early August of 1996. Part of these aerial surveys were conducted in the Strait of Belle Isle study area.

L**awson, J., Benjamins, S., and Stenson, G. 2004. Harbour porpoise bycatch estimates for Newfoundland's 2002 nearshore cod fishery. Can. Sci. Advis. Sec. Res. Doc. 2004/066: 1-29.**

Provides estimates of bycatch of harbour porpoise in nearshore cod fishery for Newfoundland, and includes the area of 4Ra, which encompasses the area of the Strait of Belle. Shows relatively high bycatch rates in the area.

Lawson, J.W., T. Stevens, and D. Snow. 2007. Killer whales of Atlantic Canada, with particular reference to the Newfoundland and Labrador Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/062.

A report which was compiled through research results of sightings data and a multi-year photographic catalogue of killer whales in Atlantic Canada. The report provides a depiction of the migration routes of different pods and groups. The multi-year photographic catalogue includes data between 1864 to 2007, with most of the sightings recorded in the last seven years, between June to Sept in the NL region.

Lawson. J.W., and Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey - A component of the 2007 TNASS. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/031. vi + 28 p.

A report on the results of surveys conducted in 2007 for marine mammals, sea turtles and other mega-fauna, as part of the Trans North Atlantic Sightings Survey (TNASS), which encompasses the North Eastern USA, Canada to the United Kingdom. The main goal of these surveys was to determine abundance and distribution estimates for marine mammals. The report indicates sightings within the Strait of Belle Isle study area.

LeGrow, K. H. 1999. Distributions of marine birds in relation to water masses and fronts in the Strait of Belle Isle in the northwestern Atlantic. M.Sc. thesis. Memorial University of Newfoundland, St. John's.

Data from vessel transects aboard the Newfoundland – Labrador ferry and from land-based counts of marine birds were collected and analyzed to assess bird distributions and movements in association with oceanographic features (water masses, fronts) and wind conditions in the Strait.

Specifically, research assessed marine bird distributions during summer when the warm out-flowing current on the southern (Newfoundland) side of the Strait contrasts sharply with the cold inflowing Labrador Current on the northern (Labrador) side of the Strait. It was anticipated that consistent with colony distributions that the cold water mass associated with the Labrador Current diving species (auks, marine ducks) would be more common on the northern side of the Strait and that surface-feeding gulls would dominate seabird numbers on the south side of the Strait. The interface between the water masses was expected to be a productive site for pelagic seabirds.

Descriptions of the common marine bird species at different times of year are presented.

The vessel surveys were not able to systematically detect these trends likely owing to small sample sizes, though a more robust survey design could do so.

A simulation model for the number of transects needed to have adequate analytical power to capture seabird x environmental associations in the face of hyper-variability was produced.

Lesage, V., Keays, J., Turgeon, S., and Hurtubise, S. 2006. Bycatch of harbour porpoises (Phocoene phocoena) in gillnet fisheries of the Estuary and Gulf of St. Lawrence, Canada, 2002-02. Journal of Cetacean Research and Management 8: 67-78.

Provides estimates of harbour porpoise bycatches in gillnet fisheries within the Gulf of St. Lawrence, including the Strait of Belle Isle.

Lesage, V., J.-F. Gosselin, M. Hammill, M. C. S Kingsley, and J. Lawson. 2007. Ecologically and Biologically Significant Areas (EBSAs) in the Estuary and Gulf of St. Lawrence – A marine mammal perspective. DFO Can. Sci. Advis. Secr. Res. Doc. 2007/046.

This study evaluates various locations in and surrounding the Gulf of St. Lawrence that may be likely candidate areas for marine mammal Ecologically and Biologically Significant Areas (EBSAs). Important factors are observed, such as available food, habitat available (i.e., ice conditions) as well as the likely functions for each area. Information on surveys in the study areas are also reviewed, including marine mammal spotting, as well as biomass and population estimates.

Lock, A. R., R. G. B. Brown and S. H. Gerriets. 1994. Gazetteer of marine birds in Atlantic Canada. An Atlas of Seabird Vulnerability to Oil Pollution. Canadian Wildlife Service, Sackville, New Brunswick.

Documents colonies of seabirds in the North Gulf Shelf Region (see Montevecchi (1996) in Appendix A). Also gives the oil pollution vulnerabilities of seabirds at different times of year in different areas, including the Strait of Belle Isle and Gulf of St. Lawrence regions.

McKinnon, J., G. Gilchrist and D. A. Fifield. 2009. A pelagic seabird survey of Arctic and sub-Arctic Canadian waters during fall. Marine Ornithology. 37: 77-84.

Vessel surveys of seabirds along east coast of Baffin Island, Hudson Bay, Labrador coast and Strait of Belle Isle during September and October 2005. Highest densities encountered off the Labrador coast, mostly Northern Fulmars and Dovekies.

Meltzer Research and Consulting. 1996. Draft Regional Study Analysis: Identification of National Marine Conservation Areas in the Laurentian Channel Marine Region 7. Halifax, Nova Scotia.

Parks Canada Marine Conservation Plan for Atlantic Ocean Conservation Region 4 (North Gulf Shelf including the Strait of Belle Isle) and Region 7 (Laurentian Channel).

Montevecchi, W. A. 1996. Seabird colonies in the North Gulf Shelf Region 4 and in the Laurentian Channel Region 7. (Unpublished – Appendix A).

Overviews and lists seabird colonies in the North Gulf Shelf Region that includes the Strait of Belle Isle.

Montevecchi, W. A. 2010 under review. Seabird Capitals: The Ecological Seabird Reserves of Newfoundland and Labrador. Flanker Press, St. John's.

New book soon to be published on the Ecological Seabird Reserves of Newfoundland and Labrador. The most relevant of these for seabird considerations in the Strait of Belle Isle are 1) the Gannet Islands Ecological Reserve north of the Strait and through which the breeding seabirds pass during migration before and after breeding, and 2) the Hare Bay Ecological Reserve just south of the Strait on the east coast of the Northern Peninsula. Hare Bay has been important nesting site for Common Eiders and gulls and terns.

Montevecchi, W. A. and S. Anderson. 1998. Long-term population trends of seabirds in Gros Morne National Park. In. D. Anions and T. Berger (Editors). Ecosystem Monitoring in Gros Morne National Park. Parks Canada Report. Rocky harbor, Newfoundland.

This report documents the breeding population trends of terns and gulls in Gros Morne National Park primarily in the Cowhead area. These surveys have been maintained by Parks personnel, and current population information should be available through Parks staff.

Montevecchi, W. A., D. K. Cairns, A. E. Burger, R. D. Elliot and J. Wells. 1987. Status of Black-headed Gulls in Newfoundland and Labrador. American Birds. 41: 197-203.

Document the known breeding records and sites of the Black-headed Gull. Nests and frequently seen in Stephenville area on the west coast of Newfoundland.

Montevecchi W. A. and L. M. Tuck. 1987. Newfoundland Birds: Exploitation, Study, Conservation. Nuttall Ornithological Club, Cambridge, Massachusetts.

Historical compilation of knowledge about birds on the Island of Newfoundland. Overview of seabird colonies and of bird records compiled from archaeological sites in the Strait of Belle Isle region.

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

Physical oceanography of the Strait of Belle Isle.

Rees, E. I. S. 1963. Marine birds in the Gulf of St. Lawrence and Strait of Belle Isle during November. Canadian Field Naturalist. 77: 98-107.

Interesting survey of the birds located in and near the Strait of Belle Isle during November 1962. Low densities reported and some interesting seabirds (e.g. Greater Shearwaters).

Robillard, A., V. Lesage, and M.O. Hammill. 2005. Distribution and abundance of harbor seals (Phoca vitulina concolor) and grey seals (Halichoerus grypus) in the Estuary and Gulf of St. Lawrence, 1994–2001. Can. Tech. Rep. Fish. Aquat. Sci. 2613: 152 pp.

This report has no real information on the Strait of Belle Isle area, but has a description of surveys conducted further in the Gulf of St. Lawrence and estuary on harbor and grey seals. It demonstrates the effort that has been conducted further south.

Savenkoff, C., Castonguay, M., Méthot, R., Chabot, D., and Hammill, M. O. 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.

This report 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. This report needs to be assessed in terms of relevant data on marine mammals.

Schmelzer, I. 2006. A Management Plan for Barrow's Goldeneye *Bucephala islandica*; Eastern Population in Newfoundland. Available online: http://www.env.gov.nl.ca/env/wildlife/wildatrisk/BAGO_24July.pdf

A management plan for the Barrow's Goldeneye.

Schneider, D. C. 1990. Seabirds and fronts: A brief overview. Polar Research. 8: 17-21.

Useful paper in the study of seabirds at fronts, such as that created at the interface of the southern warm current outflow and the northern cold current inflow in the Strait of Belle Isle.

Sears, R. and Williamson, J.M. 1982. A preliminary aerial survey of marine mammals for the Gulf of St. Lawrence to determine their distribution and relative abundance. Mingan Island Cetacean Survey – Station de Recherches des Iles Mingans (MICS), Malmouth, Mass., and Sept.

Reports on the results of a preliminary aerial survey in the Gulf of St. Lawrence in the 1980's, and includes areas in the Study Area.

Sergeant, D. E., Mansfield, A. W., and Beck, B. 1970. In shore records of Cetacea for eastern Canada. Journal of the fisheries Research Board of Canada 27: 1903-1915.

This report provides evidence of historical records of fin whales in the Strait of Belle Isle, through entrapment in ice.

Sjare, B., D. Walsh, G.B. Stenson and S. Benjamins. 2005. An update on harp seal (Pagophilus groenlandicus) by-catch estimates in the Newfoundland lumpfish fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/049.

Report on by-catch estimates of harp seals in the Lumpfish Fishery, which occurs in the Gulf of St. Lawrence, including the Strait of Belle Isle. This report substantiates the idea that some harp seals may stick around in the Gulf of St. Lawrence during the ice-free period.

Sjare, B., and Stenson, G. B. 2010. Changes in the reproductive parameters of female harp seals (Pagophilus groenlandicus) in the Northwest Atlantic. ICES Journal of Marine Science. 67: 304–315.

Report focuses mostly on the reproductive changes for Harp Seals (female) in the Northwest Atlantic, however does point out some important whelping, and moulting areas. Moulting areas exist for this species in the Strait of Belle Isle.

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. Gives indication of important whale feeding grounds in the region.

Stantec Consulting Limited. 2010. Avifauna. Report prepared for Nalcor Energy.

A report prepared for the Labrador-Island Transmission Link Environmental Impact Statement. Provides an overview of all bird species located in the Study Area.

Stenhouse, I.J. 2004. Canadian Management Plan for the Ivory Gull (*Pagophila eburnea*). Canadian Wildlife Service, St. John's, Newfoundland and Labrador. 18 pp. + Appendices. Available online: http://www.env.gov.nl.ca/env/wildlife/wildatrisk/ivgu%20canadian_mgmnt_plan.pdf

Management plan for the Ivory Gull.

Stenson, G. B., M.O. Hammill, M.C.S. Kingsley, B. Sjare, W.G. Warren and R.A. Myers. 2002. Is there evidence of increased pup production in northwest Atlantic harp seals, Pagophilus groenlandicus? ICES J. Mar. Sci. 59:81-92.

A report on harp seal pup production in the Northwest Atlantic, including the area of the Strait of Belle Isle.

Stenson, G.B., M.O. Hammill, J. Lawson, J.F. Gosselin, and T. Haug. 2005. 2004 Pup production of Harp Seals Pagophilus groenlandicus, in the Northwest Atlantic. DFO Can. Sci. Advis. Secr. Res. Doc. 2005/037.

This report provides results of a study conducted in 2004 to determine pup production of Harp Seals off Newfoundland and Labrador, as well as the Gulf of St. Lawrence. The survey was a combination of photographic and aerial surveys of whelping areas, and included part of the Strait of Belle Isle study area.

Stenson, G.B., Hammill, M.O. and Lawson, J.W. 2010. Estimating pup production of Northwest Atlantic Harp Seals, Pagophilus groenlandicus: Results of the 2008 surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/103. iv + 39 p.

A report documenting results from aerial surveys for North West Atlantic Harp Seals in 2008. The survey covers the area from the Front to the northern Gulf of St. Lawrence. This survey was used to estimate the production of harp seals in the area. This report identifies the Strait of Belle Isle area as being important for seal whelping. Seal pups also travel from the Front to the northern Gulf of St. Lawrence through the Strait of Belle Isle on ice. The report documents the amount of sea ice in the area during the survey period (March of 2008).

Stenson, G. B., Rivest, J.-P., Hammill, M. O., Gosselin, J.-F., and Sjare, B. 2003. Estimating pup production of harp seals, Pagophilus groenlandicus, in the Northwest Atlantic. Marine Mammal Science19: 141-160.

An estimation of pup production of harp seals based on aerial surveys for the Northwest Atlantic. Gives an indication of timing of pupping and locations.

Thomas, P. 2008. Harlequin Ducks in Newfoundland. Waterbirds 31 (Special Publication 2): 44-49

Provides an overview of Harlequin Ducks in Newfoundland. Harlequin Ducks are known to use the Torrent River on the Northern Peninsula as a breeding site.

Toulany, B., B. Petrie and C. Garrett. 1987. The frequency-dependent structure and dynamics of flow fluctuations in the Strait of Belle Isle. Journal of Physical Oceanography. 17: 185-196.

Useful paper about fluctuating oceanographic conditions that could influence marine animal activities in the Strait of Belle Isle.

Tuck, J. A. 1975. Ancient People of Port au Choix. Memorial University, St. John's, Newfoundland.

Details the marine birds and mammals found in the archaeological sites used by the Maritime Archaic People.

Tuck, J. A. 1976. Newfoundland and Labrador Prehistory. Van Nostrand Rheinhold, Toronto.

Details the marine birds and mammals found in the archaeological sites throughout the Strait of Belle Isle.

Tuck, J. A. and R. Grenier. 1989. Red Bay Labrador – World Whaling Capital A.D. 1550-1600. Atlantic Archaeology, St, John's, Newfoundland.

Documents the Basque whaling station and activities in Red Bay.

Waring, G.T., D.L. Palka, P.J. Clapham, S. Swartz, M.C. Rossman, T.V.N. Cole, K.D. Bisack, and L. J. Hansen. 1999. U.S. Atlantic Marine Mammal Stock Assessments – 1998. NOAA Technical Memorandum NMFS-NE-116.

This report is a stock assessment for various marine mammals in the U.S. Atlantic. These marine mammals are the same that frequent waters in the Gulf of St. Lawrence, and Strait of Belle Isle area. The stock assessment for the Blue whale mentions the Strait of Belle Isle as being an important region during spring and summer. Newfoundland and Labrador areas are also mentioned in the geographic range for various other marine mammals.

Warkentin, I. and S. Newton. 2009. Birds of Newfoundland Field Guide. Boulder Publications. Portugal Cove - St. Phillip's, NL.

A field guide to birds found in Newfoundland.

Whales Online. 2010. Whales Species. Available At: http://www.whales-online.net/. Accessed May 2010.

This website provides information on whales that can be found in the Gulf of St. Lawrence, as well as research that is being conducted in the area.

Wilhelm S., C. Gjerdum and D. A. Fifield. 2010. Standardized protocol for pelagic seabird surveys in eastern Canada from moving and stationary platforms. Canadian Wildlife Service Technical Report Series: in press.

Procedures and methods for conducting vessel surveys of birds at sea.

Personal Communications

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Mike Hammill – DFO Quebec

Veronique Lesage – DFO Quebec

Peter Stevick – Year of the North Atlantic Humpback Whale - YoNaH

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 route and corridor selection process employed for the Project. For this study Larry was Project Manager responsible for client relations and team coordination.

Leroy Metcalfe B. Sc Project Lead – Marine Mammals and Seabirds. Leroy is an Inuk from Nain currently residing in St. John's. He has nearly 20 years of experience in environmental consulting, project management and resource management. He has participated in and led various component studies related to environmental assessments and monitoring for activities such as the Voisey's Bay Project and the Lower Churchill environmental assessment. His field survey experience includes extensive fisheries sampling for Lower Churchill Project, waterfowl surveys for various clients, marine mammal surveys, and application of GIS systems to data compilation and display. As part of these various works, he conducted literature reviews related to seal biology and survey methods; fish biology and methyl mercury in fish; and for materials related to the Torngat Mountains National Park. For this Project, Leroy was the Project Lead responsible for overseeing the project and final report preparation.

Dr. Tom Smith, Associate (sub-consultant), Advisor - Marine Mammals. Tom has been involved in research on marine and other mammals for 35 years. He worked as a research scientist with Fisheries and Oceans Canada for 23 years. For the past 15 years he has operated his consulting firm, EcoMarine Corporation (E.M.C.) which conducts environmental impact studies in Polar Regions. Tom has published over 200 scientific papers and reports and is known as a world authority on the Arctic Ringed seal and the Beluga whale both of which are keystone species in the arctic marine ecosystem. For this Project, Tom provided advice on literature sources and was responsible for senior review of the report on marine mammals.

Dr. Bill Montevecchi, Associate (sub-consultant), Advisor – Seabirds. Bill is a University Research Professor in Psychology, Biology and Ocean Sciences at Memorial University. Dr. Montevecchi is an internationally recognized expert in the study of birds as indicators of environmental conditions and ecosystem health. His long-term research program focuses on the roles of birds as environmental indicators in the Low Arctic terrestrial and marine ecosystems of Newfoundland and Labrador with an emphasis on conservation and sustainable ecological and economic development. Bill Montevecchi was responsible for the literature review on seabirds, as well as final 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 was responsible for geo-referencing and GIS support.

APPENDIX C

Marine Bird Distributions and Occurrences in the Strait of Belle Isle

Marine Bird Distributions and Occurrences in the Strait of Belle Isle

W. A. Montevecchi, C. M. Burke, E. E. Connelly and P. M. Regular

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Great Shearwater, a Southern Hemisphere breeder, that is abundant in the waters of Newfoundland and Labrador during summer (austral winter) and the most abundant species recorded from vessel surveys in the Strait of Belle Isle. (photo: W. A. Montevecchi)

Background

Systematic counts of seabirds from vessels have been carried out in the waters of Newfoundland and Labrador since the1960s (Rees 1963, Brown et al. 1975, Brown 1986, Lock, Brown and Gerriets 1994, LeGrow 1999, Gjerdrum, Fifield and Mahoney 2010, Gjerdrum, Fifield and Wilhelm 2012). Almost all of this effort was standardized and organized by the Canadian Wildlife Service (Brown et al. 1975). Through 1983, counts were based on 10-minute observation periods from moving vessels where all observed birds were recorded, as well as aspects of their behavior (e.g. flying, sitting on water) and plumage (age class distinctions). Observations of birds were coded with date, time, ship position and speed, weather and sea state conditions, and at times with oceanographic variables, such as sea surface temperature. From 1984 onward, following a review of pelagic survey methods by Tasker et al. (1984), counts were restricted to 300 meter wide fixed transects. This method and database referred to as the PIROP (Programme Intégré de recherches sur les oiseaux pélagiques) Program (Brown et al. 1975) was executed from 1966 – 1992. All data are archived and maintained by the Canadian Wildlife Service office in Halifax, Nova Scotia (Carina.Gjerdrum@EC.GC.CA).

Following a 13-year hiatus, the Canadian Wildlife Service initiated a new system of counts in 2005. The new program makes estimates of the distances of observed birds from the observer on the vessel, referred to as the distance sampling method (Buckland et al. 2001) that allows for corrections of missed birds by the observer. Counts of birds are restricted to within 300 meters of the vessel except when counts at longer distances do not interfere with observations within 300 meters. The new observation procedures and database are referred to as ECSAS (Eastern Canadian Seabirds at Sea) Program (Gjerdrum, Fifield and Wilhelm 2012).

Methodological changes in the surveys methods over the decades have to be considered carefully in the interpretation of results. As with the PIROP data, ECSAS files are archived and maintained by the Canadian Wildlife Service office in Halifax, Nova Scotia (Carina.Gjerdrum@EC.GC.CA).

In the Strait of Belle Isle, the longer duration PIROP records have more survey coverage and effort than the more systematic and recent ECSAS data (Figure 1). It needs to be emphasized that while the PIROP and ECSAS observers recorded birds using different methodologies for similar but distinct purposes, there are many compelling reasons for both combining and drawing comparisons between the two data sets in terms of the numbers of birds observed per kilometer. Such an approach maximizes use of the available information and permits long-term decadal assessments of historical changes in seabird species diversity and abundance in the Strait of Belle Isle. Recently, the PIROP and ECSAS datasets have been compared for the entire Atlantic Canada region (Gjerdrum and Mahoney 2010).

In an attempt to balance the survey data, we applied a randomization process whereby mean species-specific totals (birds/km) from 1000 permutations of 10 randomly selected surveys were used to compare abundance across groups. This improves comparisons and controls for some of the effects of an unbalanced design, but there may still be some residual effects. Abundance and diversity values from groupings that include broader spatial and temporal surveys (e.g. summer surveys) are likely more accurate than values from a group with few surveys. Groups with limited surveys are more prone to resampling and less likely to capture a representative sample of the seabird population in the area. Diversity and abundance values may therefore be lower for groups with limited coverage.

In the present exercise, we integrate, compare and interrogate all the available information on numbers of birds observed per kilometer from the PIROP and ECSAS databases, which provides a comparable measure of seabird abundances and occurrences. We more fully examine species occurrences, their relative abundances and diversity and their seasonal and decadal fluctuations in the Strait of Belle Isle from the 1960s to the present. We draw conclusions about what is known and about existing information gaps. We make general conclusions and recommendations to help fill knowledge gaps.

Methods

Information on seabird abundances and occurrences in the Strait of Belle Isle were extracted from systematic counts of seabirds from the PIROP and ECSAS survey program databases. PIROP survey data for the Strait of Belle Isle were available for 14 years spanning the period from 1969 to 1987. There were no survey data available for the Strait of Belle Isle during the 1990s. ECSAS data for the area were available for 5 years from 2005 – 2009. A total of 8739.9 km was surveyed in the Strait of Belle during these two programs, including 7700.2 km from PIROP and 1039.7 km ECSAS (Figure 1).

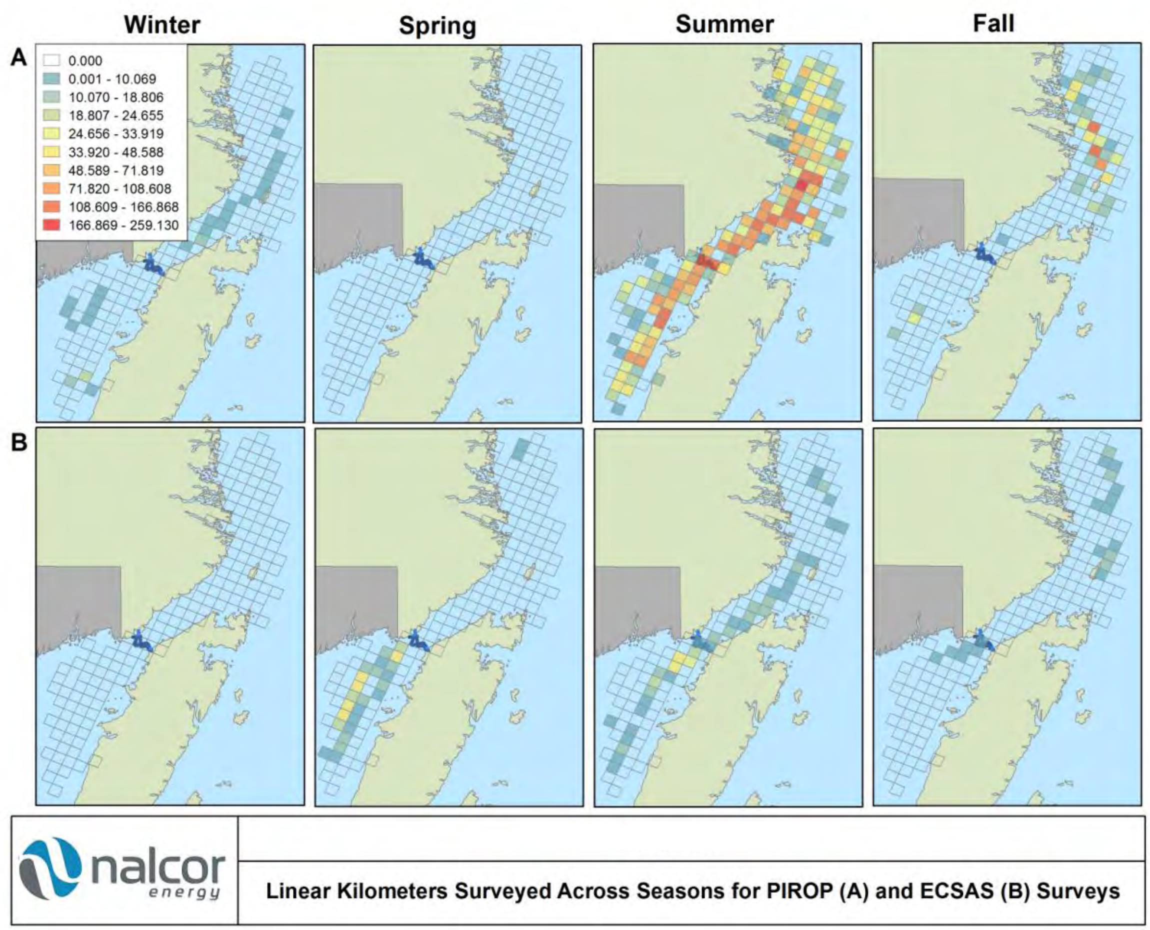

***Figure 1** – Linear kilometers surveyed across all seasons through PIROP (1960s – 1980s; A) and ECSAS (2000s; B) surveys.*

Estimates of seabird abundance were generated using information on the total number of birds (according to species and taxonomic groups) as a function of effort (total # kilometers surveyed) expressed as # birds per kilometer. Differences in the survey methods over time do not permit a comparison of densities (# birds/km^2). Survey data were mapped to examine overall effort and effort according to seasons (based on the equinoxes and solstices) for the two survey methods (PIROP and ECSAS; Figure 1). Linear kilometers of survey effort were totaled for each 10 x 10 km grid cell and mapped using ArcGIS 10. Only surveys on the western side of the Northern Peninsula were included. Secondly, linear densities for all birds were mapped and this was controlled for effort by dividing the total counts for all surveyed birds in that 10 x 10 km grid cell by the total amount of survey effort within that area, for the appropriate time period.

Accounting for effort is challenging. Next to density (which was not possible to calculate for all data), birds/km seems like the most appropriate value to use. The ubiquitous issue is that with increased effort, observed abundance and diversity improves. This problem can, in part, be balanced by applying a randomization technique like we have applied. Yet, one must keep in mind that reliability and accuracy likely increases with effort

Information on seabird species composition in the Strait of Belle Isle is presented as percent relative abundance and percent frequency of occurrence. Percent relative abundance was calculated by dividing species or family-specific totals by the total number of birds/km observed across surveys, and percent frequency of occurrence by dividing the number of surveys a species was recorded (>1 bird) by the total number of surveys. To account for the effects of unbalanced survey effort across decades and seasons, datasets were balanced by calculating the average of species-specific totals (birds/km) from 1000 permutations of 10 randomly selected surveys within each group. Percent relative abundance was then calculated using the values output from this randomization technique. This presentation of the data provides information on changes in the numbers and composition of species occurring in the Strait of Belle Isle across decades and seasons. Survey data were processed, tabulated, graphed and analyzed using R 2.10.1, a statistical and graphical programming language (R development core team 2010).

Results and Discussion

Most survey effort occurred during the PIROP surveys, though the more limited ECSAS survey effort has good coverage around the proposed cable area during spring and summer though survey effort during fall and winter is needed (Figure 1). The total survey effort map in Figure 2A shows high survey effort in the Strait of Belle Isle, including the proposed location of the underground transmission cable. Most vessel surveys in the study area were during the summer PIROP surveys (Figure 1A). There is very poor survey coverage during fall, winter and spring (Figure 1A). More survey effort during these periods is urgently needed to adequately assess the importance of this area to marine birds throughout the year, particularly during fall and spring migration.

Figure 2B shows the total linear densities of birds within the Strait of Belle Isle during all seasons (PIROP and ECSAS combined) in relation to the proposed cable site. Based on the PIROP summer surveys, which had the highest survey coverage, we see that the Strait of Belle Isle is a high use area for seabirds during this period. Information for other seasons is limited due to lack of adequate coverage, making analysis of important areas these periods difficult. ECSAS surveys show lower densities throughout the study area for the autumn surveys, while the spring and summer surveys reveal moderate bird densities just south of the proposed cable area. The current survey coverage is very limited for the fall period, again highlighting the need of more extensive seasonal coverage.

Overall, a high diversity of seabird species make use of the areas over the proposed cable tracks: Atlantic Puffins, Arctic Terns, Black-legged Kittiwakes, Black Guillemots, Common Terns, Common Murres, Glaucous Gulls, Great Black-backed Gulls, Great Shearwaters, Great Skuas, Herring Gulls, Leach’s Storm-Petrels, Northern Gannets, Northern Fulmars, Parasitic and Pomarine Jaegers, Razorbills, and Sooty Shearwaters. The species composition of birds using the area is described in greater detail below.

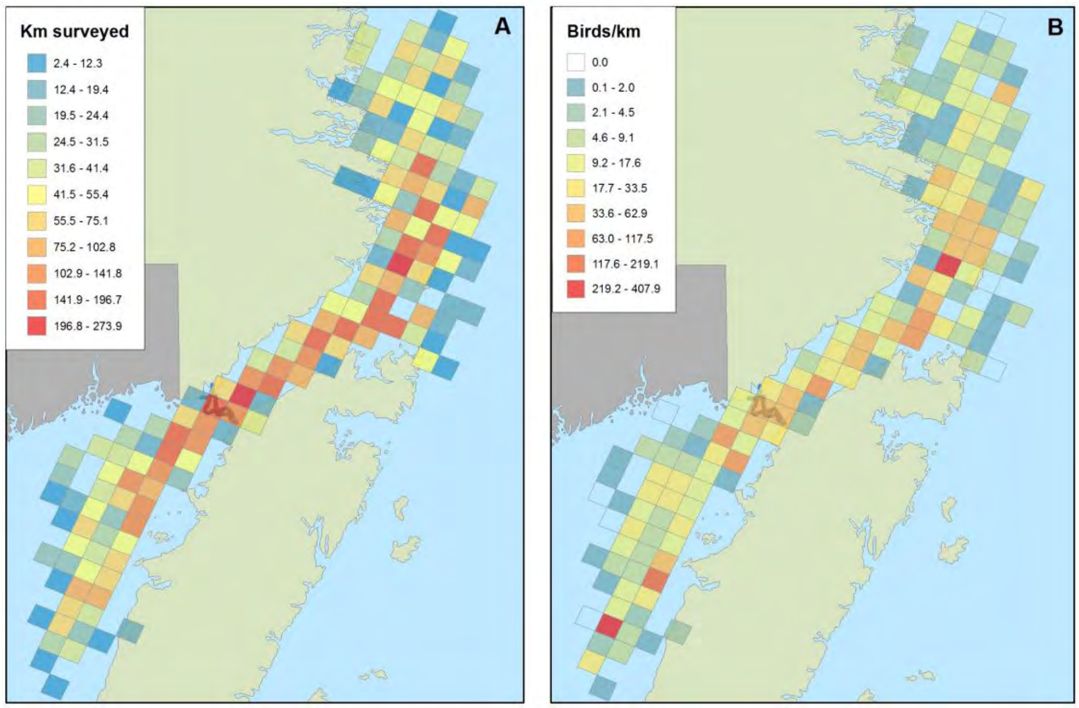

Figure 2 – *Linear kilometers surveyed during all survey periods (A) and total birds surveyed controlled for effort (B).*

Species Composition

Twenty-six species of marine birds were recorded in the Study Area (Table 1). Great Shearwaters and Black-legged Kittiwakes were the most abundant species, accounting for 21.3% and 18.4% relative abundance respectively, followed by Northern Fulmar (16.9% RA). Other gulls, including Herring Gull and Great Black-backed Gull accounted for a high proportion (10.2% and 8.8% RA) of the total number of species observed. Northern Fulmar was observed on most surveys (11% FO) followed by Black-legged Kittiwake and Great Shearwater (10.5% and 10% FO, respectively). The correlation between the relative abundance and frequency of occurrence scores is quite robust ($r = 0.93$, $df = 32$, $P < 0.0001$).

Table 1 – Percent relative abundance and percent frequency of occurrence of all seabird species and species groups observed during PIROP and ECSAS surveys. Species are sorted by percent relative abundance.

Species	Relative Abundance (%)	Frequency Occurrence (%)
Great Shearwater	21.3	10
Black-legged Kittiwake	18.4	10.5
Northern Fulmar	16.9	11
Herring Gull	10.2	9.7
Great Black-backed Gull	8.8	7.8
Sooty Shearwater	7.5	7.8
Common Murre	2.7	3.7
Atlantic Puffin	1.8	4.1
Leach's Storm-Petrel	1.7	1.8
Northern Gannet	1.4	3.9
Dovekie	0.6	1.6
Iceland Gull	0.5	1.2
Thayer's Gull	0.5	0.2
Pomarine Jaeger	0.4	1.5
Razorbill	0.3	1
Red Phalarope	0.2	0.3
Glaucous Gull	0.2	0.7
Wilson's Storm-Petrel	0.2	0.6
Black Guillemot	0.1	0.7
Thick-billed Murre	0.1	0.6
Arctic Tern	0.1	0.6
Parasitic Jaeger	0.1	0.3
Common Tern	0.1	0.3
Great Skua	0	0.2
Manx Shearwater	0	0.1
Long-tailed Jaeger	0	0.2
Seabirds Not Identified to Species		
Murres	1.8	4.3
Phalaropes	1.5	0.6
Auks	1.1	2.2
Gulls	0.7	1
Shearwaters	0.5	0.9
Jaegers	0.3	1.4
Terns	0.2	0.8
Storm-Petrels	0.1	0.3

Figure 3 *– Black-legged Kittiwake, the second most abundant seabird species during systematic vessel surveys in the Strait of Belle Isle. (photo: W. A. Montevecchi).*

Table 2 summarizes the percent relative abundance (%RA) and percent frequency of occurrence (%FO) ranking scores for seabirds according to taxonomic groups (PIROP and ECSAS). Gulls (including six species) were the most abundant taxonomic group (39.1% RA), followed by shearwaters (29.3% RA), Northern Fulmar (16.9% RA) and auks (six species; 8.6% RA). Gulls were the most frequently observed group during surveys (31.1% FO), gannets, jaegers, storm petrels, terns, and phalaropes were the least frequently observed species groups (all less than 5% FO). Clearly, the Strait of Belle Isle is an important movement corridor for many species of marine birds, with many species using the Strait to move in and out of the Gulf of St. Lawrence.

In comparison with the Gulf of St. Lawrence, the Grand Bank and the Labrador Sea, the Strait of Belle Isle is clearly an important area for marine birds (Brown 1986, Gjerfdrum, Head and Fifield 2011). Clearly, the Strait is an ecologically critical passage way for marine birds and mammals moving between the Labrdor Sea and the Gulf of St. Lawrence, especially during fall and spring.

Table 2 - Ranking of species groups in all decades according to percent relative abundance (expressed as percentages) using PIROP (1960s through 1980s) and ECSAS (2000s) methods.

Species Group	Relative Abundance (%)	Frequency Occurrence (%)
Gulls	39.1	31.1
Shearwaters	29.3	18.9
Fulmar[1]	16.9	11
Auks	8.6	18.3
Storm-Petrels	1.9	2.7
Phalaropes	1.7	0.9
Gannet[2]	1.4	3.9
Jaegers	0.8	3.6
Terns	0.3	1.7

[1] category contains only one species (Northern Fulmar)
[2] category contains only one species (Northern Gannet)

***Figure 4**. Northern Fulmar, an abundant seabird species in the Strait of Belle Isle. (photo: W. A. Montevecchi)*

Decadal comparisons indicate declines in the relative abundances of seabirds during the current decade. It is Important to recognize that decadal changes may be confounded by changes in methods in the two major surveys (i.e., PIROP vs. ECSAS). Even with randomization, lower densities in later surveys may still be a result of a more narrow survey area. Gjerdrum et al. (2010) also show a striking southerly shift in the distribution of shearwaters and an offshore movement of gulls away from the Strait of Belle Isle during the 2000s. It seems likely that at least some of this long-term decrease in seabird numbers and biodiversity in the Strait of Belle Isle is related to ocean climate change. Informative investigations could involve relating changes in the temperature and salinity of the southerly flowing Arctic water being moved into the Gulf of St. Lawrence through the northern Strait by the Labrador Current. As well, changes in the warmer water flowing out through the southern part of the Strait could influence marine productivity and the occurrences and distributions of prey species that in turn drive changing distributional patterns of top seabird predators. On top of ocean climate influences, the commercial gill-net fishery for Atlantic salmon and northern cod closed in the early 1990s, removing massive tonnages of discards and offal that scavenging seabirds like gulls and shearwaters exploit, and hence could influence changes in their distributions.

Seasonal Trends

The monthly occurrences of the most abundant seabird groups are shown in Figure 5. Most birds were recorded during the summer, composed primarily of gulls and shearwaters which are migrants from southern latitudes and therefore unlike most other species observed during the summer are not associated with breeding colonies (Figure 5). Non-breeding Northern Fulmars are also relatively abundant during summer. Few birds were observed during winter and spring when the Strait of Belle Isle is usually ice-covered, preventing vessel traffic.

It is evident from the monthly analysis of seabird data that the number and diversity of birds detected is a function of survey effort (see also LeGrow 1999). Figure 6 clarifies this relationship in a direct comparison of seabird occurrences and vessel survey effort. The conclusion is straight-forward, more surveys result in the detection of more birds and more species diversity. This stands true even if surveys are balanced by random selection because there will be more resampling in smaller samples. In other words, fewer surveys will observe fewer birds, and as such there is a higher probability that random samples will include surveys with fewer birds.

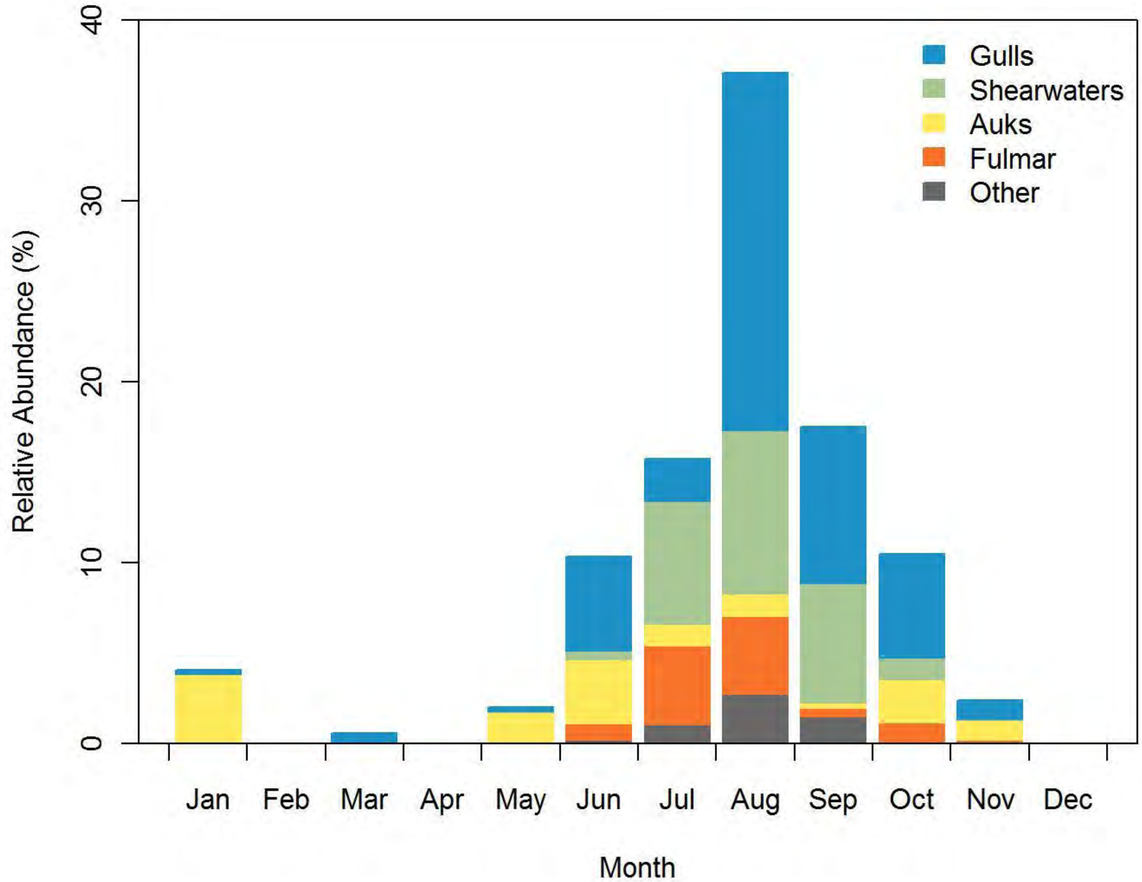

***Figure 5** – Monthly relative abundances (% RA) of the most abundant species groups recorded during all PIROP and ECSAS surveys combined.*

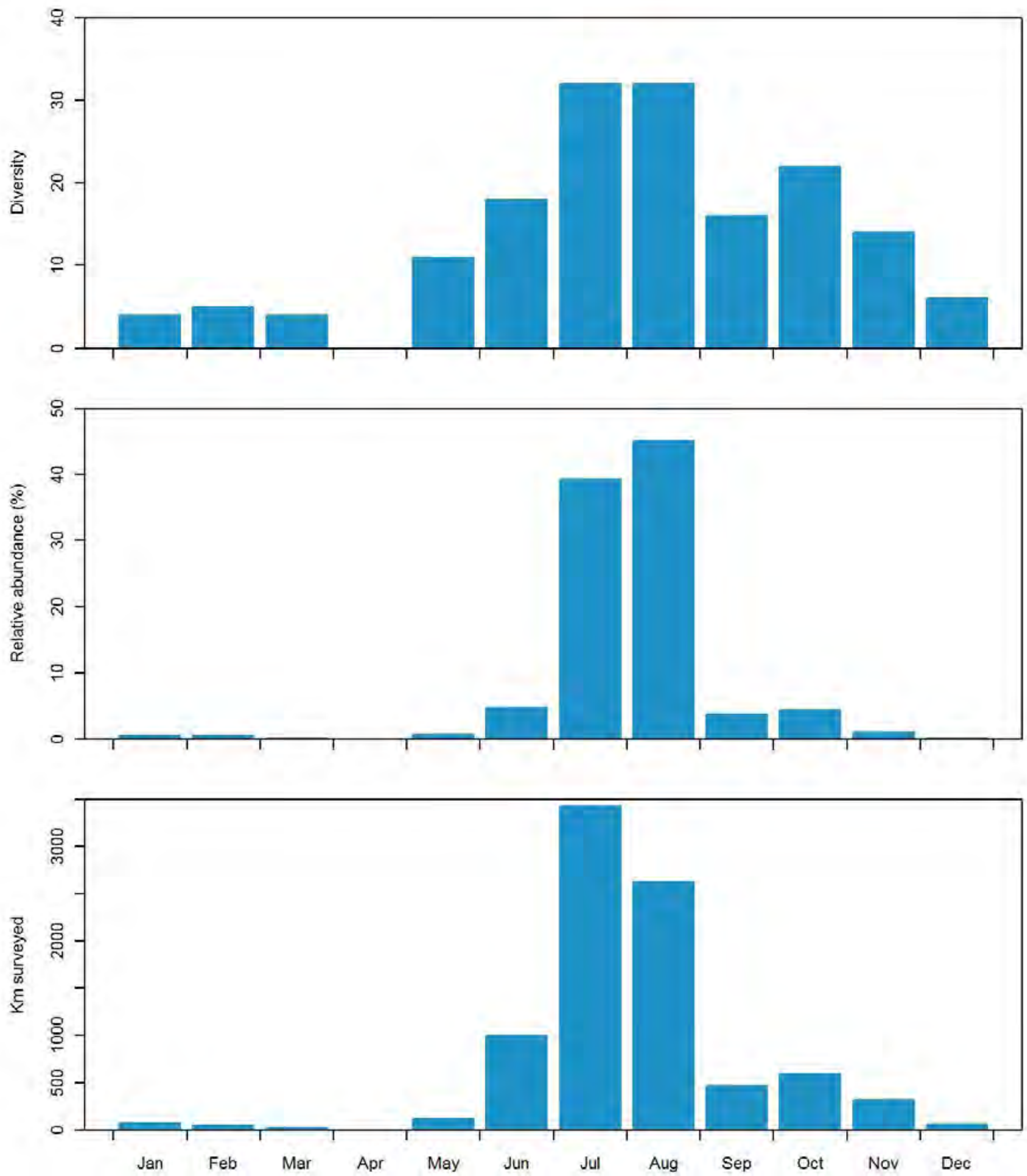

***Figure 6** – Monthly diversity, relative abundance and survey effort recorded during all PIROP and ECSAS surveys combined.*

Conclusions

- It is informative to maximize use of all available data from seabird surveys in the Strait of Belle Isle from the 1960s through 2010 by both integrating and comparing the numbers of birds observed per kilometer from the PIROP and ECSAS datasets.
- Gulls, shearwaters, fulmars and auks are the most commonly sighted seabirds in the Strait of Belle Isle. Storm-petrels, gannets, jaegers and terns are also frequently observed.
- Significant decadal changes in seabird abundances and species diversity appeared to have occurred in the Strait of Belle Isle from the 1960s through 2010, though these trends may be confounded by changes in survey methodology during the present century.
- The observed changes in seabird distribution may be associated with ocean basin scale shifts in seabird distributions that may be related to climate changes and possibly fishery activities in the Strait of Belle Isle and wider region.
- Seabirds are most abundant in the Strait of Belle Isle during summer and composed primarily of gulls and shearwaters.
- Very few seabirds have been recorded during winter and spring when the Strait of Belle Isle is usually ice-covered and vessel traffic is precluded.
- Vessel survey effort determines the number and diversity of birds detected. More surveys will improve information about seabird occurrences and species diversity.
- More surveys would be particularly useful at present to more precisely delineate current seabird distributions.
- Vessel and land-based surveys during the fall and spring migration periods would be particularly informative.

Recommendations

- Relate basic physical oceanographic data (temperature, salinity) and changes in fishing activities to changing decadal patterns of seabird diversity, abundance and distribution

- Initiate a seasonal program of systematic vessel surveys in the Strait of Belle Isle using Newfoundland – Labrador ferry as a platform. Increase the number of spring and early summer and surveys.
- Initiate a seasonal program of systematic land-based marine bird observations conducted during fall, winter and spring to help fill these seasonal data gaps.

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JWEL PROJECT NO. 1203

MARINE MAMMALS AND SEABIRDS IN THE STRAIT OF BELLE ISLE

LHP 98-12

PREPARED FOR

NEWFOUNDLAND AND LABRADOR HYDRO
LABRADOR HYDRO PROJECT
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MICHAEL KINGSLEY

November 8, 2000

With Updated *Executive Summary and Introduction*
by Nalcor Energy – November 2009

EXECUTIVE SUMMARY

Updated by Nalcor Energy – November 2009

The proposed *Labrador-Island Transmission Link* includes the installation of a submarine cable across the Strait of Belle Isle. Construction activity in and adjacent to the marine environment associated with cable installation has the potential to interact with marine mammals and seabirds in the project area.

The primary objective of the 1998 marine mammal and seabird survey in the Strait of Belle Isle was to estimate the relative abundance of marine mammals and seabirds in the Strait and surrounding area during the ice-free season. These baseline data will contribute to the requirements for a future environmental assessment and any follow-up monitoring, if required. Aerial and boat-based surveys were conducted approximately every three weeks from July to December, 1998. The aerial survey covered the entire Strait of Belle Isle and the northeast Gulf of St. Lawrence, an area of approximately 5,400 km^2. The boat-based survey covered an area of approximately 725 km^2 in the general area of the proposed cable crossing corridors.

Nine species of whales and dolphins and two species of seals were sighted during the 1998 marine mammal survey of the Strait of Belle Isle. Marine mammals in the Strait of Belle Isle were most abundant in August, with harbour porpoise, white-sided dolphin, and humpback, fin and the minke whales at their peak relative abundance. The relative abundance of most species, except the white-sided and white-beaked dolphins, declined after August.

The most common baleen whale, the humpback, appears to be most frequent near Belle Isle and along transects running southeast to the Northern Peninsula from L'Anse au Loup to L'Anse au Clair. The harbour porpoise, the most abundant species during the survey, was most frequent near the western end of the study area, along the transects running northwest to Labrador from Castor's River to Eddie's Cove West and along transects running southeast to the Northern Peninsula from L'Anse au Clair to Blanc Sablon. Overall, there appeared to be a preference for the Labrador side of the Strait by most marine mammals.

A dedicated observer conducted seabird surveys during four of the boat-based mammal surveys between August and October. A total of 29 seabird species were seen during the surveys between August and October. When considering all surveys together, there were just 10 species that comprise the five most abundant species during each survey. The total number of species seen for each of the surveys was consistent. However, species composition and abundance varied greatly between surveys. Species that breed in the area in relatively large numbers (Greater Black-backed Gulls, Herring Gulls, Atlantic Puffin, and Common Murre) were most abundant in the August survey.

The results of the 1998 marine mammal and seabird survey and literature review reported herein will be used in the Project's Environmental Impact Statement (EIS), along with any additional information and literature that has become available since that time, in order to describe the existing (baseline) conditions in the Strait of Belle Isle area which could potentially interact with Project works and activities.

TABLE OF CONTENTS

Page No.

LIST OF APPENDICES

LIST OF FIGURES

Page No.

LIST OF TABLES

Page No.

1.0 INTRODUCTION

This Section Updated by Nalcor Energy - November 2009

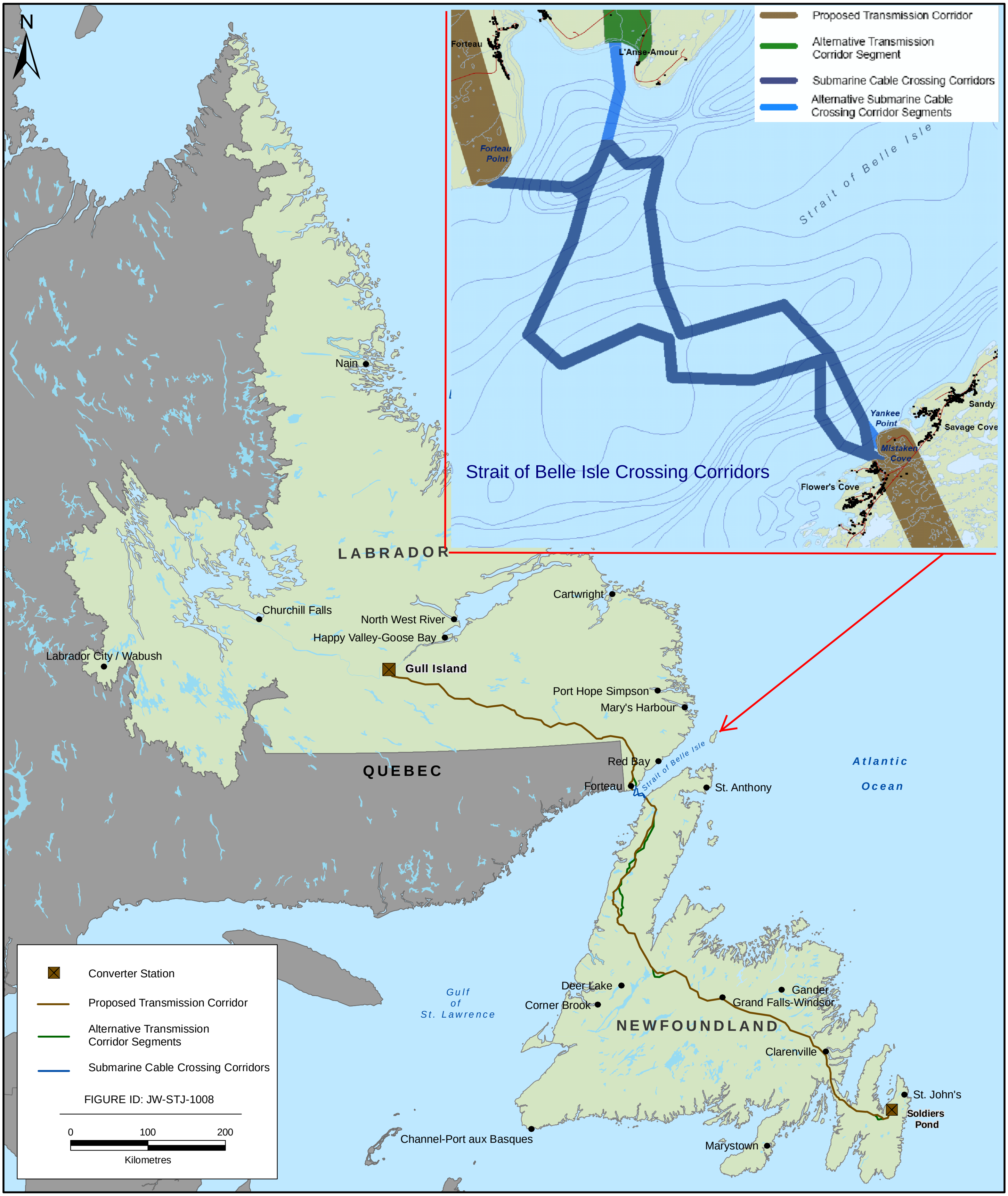
1.1 Project Overview

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. Nalcor Energy is proposing to establish a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to Soldiers Pond on the Island's Avalon Peninsula. The Project will include the installation and operation of submarine power cables across the Strait of Belle Isle between Labrador and the Island of Newfoundland.

The proposed transmission system, as currently planned, will include the following key components (Figure 1.1):

- an ac-dc converter station on the lower Churchill River, adjacent to the Lower Churchill Hydroelectric Generation Project;
- an HVdc transmission line extending 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 consist of single galvanized steel lattice towers;
- cable crossings of the Strait of Belle Isle with associated infrastructure (Figure 1.1 - Inset), which may involve placing three to five cables within identified corridors across the Strait 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 of Newfoundland 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 transmission line and 500 m wide corridors for the proposed Strait of Belle Isle cable crossings. 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.



nalcor energy

FIGURE 1.1

Labrador - Island Transmission Link

The HVdc transmission line will extend from Central Labrador to a crossing point on the Labrador side of the Strait of Belle Isle. From there, cables will extend under and across the Strait and make landfall on the northwestern side of the Island of Newfoundland's Northern Peninsula. Two alternative cable landing sites have been identified and are being considered on the Labrador side - Forteau Point and L'Anse Amour. On the Newfoundland side, two options are also being considered - Mistaken Cove and nearby Yankee Point.

Two proposed submarine cable corridors have also been identified for these cable crossings, which extend from these potential landing sites and across the Strait. These cable corridors are approximately 25 – 35 km in length, depending upon the specific landing site alternatives involved. Construction of the submarine crossings would include the placement of three to five cables within two separate corridors across the Strait (two to four cables to carry the power and one to be used as a spare). Both cable crossing corridors would therefore be used, minus the inshore segments connecting the alternative landing site options that are not eventually selected for development. The eventual selection of specific cable routes within the two currently identified 500 m wide corridors is the subject of ongoing engineering analysis. A number of methods will likely be used to protect the cables across the Strait of Belle Isle. Primarily, the currently identified corridors 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 ocean bed contours and to provide further required protection, various cable protection techniques are under consideration, including tunnelling 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 cable protection along the route and specific portions of it 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.

1.2 Marine Mammal and Seabird Survey: Study Purpose and Rationale

The purpose of this study was to conduct a marine mammal and seabird survey in the Strait of Belle Isle, in order to understand the presence, abundance and distribution of marine mammals and seabirds in the general vicinity of the proposed submarine cable crossings through the collection of additional, primary data. The study area for the marine mammal and seabird survey encompasses the northern Gulf of St. Lawrence and the Strait of Belle Isle, delineated by longitudes 58°00'W and 55°30'W (Figure 1.2).[1]

The field survey was intended to collect and present additional information on marine mammals and seabirds in this area, in order to supplement the existing and available literature. The results of the 1998 survey and literature review reported herein will be used in the Project's Environmental Impact Statement (EIS), along with any additional information and literature that has become available since that time, in order to describe the existing (baseline) conditions in the Strait of Belle Isle area which could potentially interact with the Project works and activities.

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1 Please note that references to the COSEWIC (Committee on the Status of Endangered Wildlife in Canada) designations of various species outlined in this report were current as of the time the survey was completed (1998), but in some cases have since been revised.

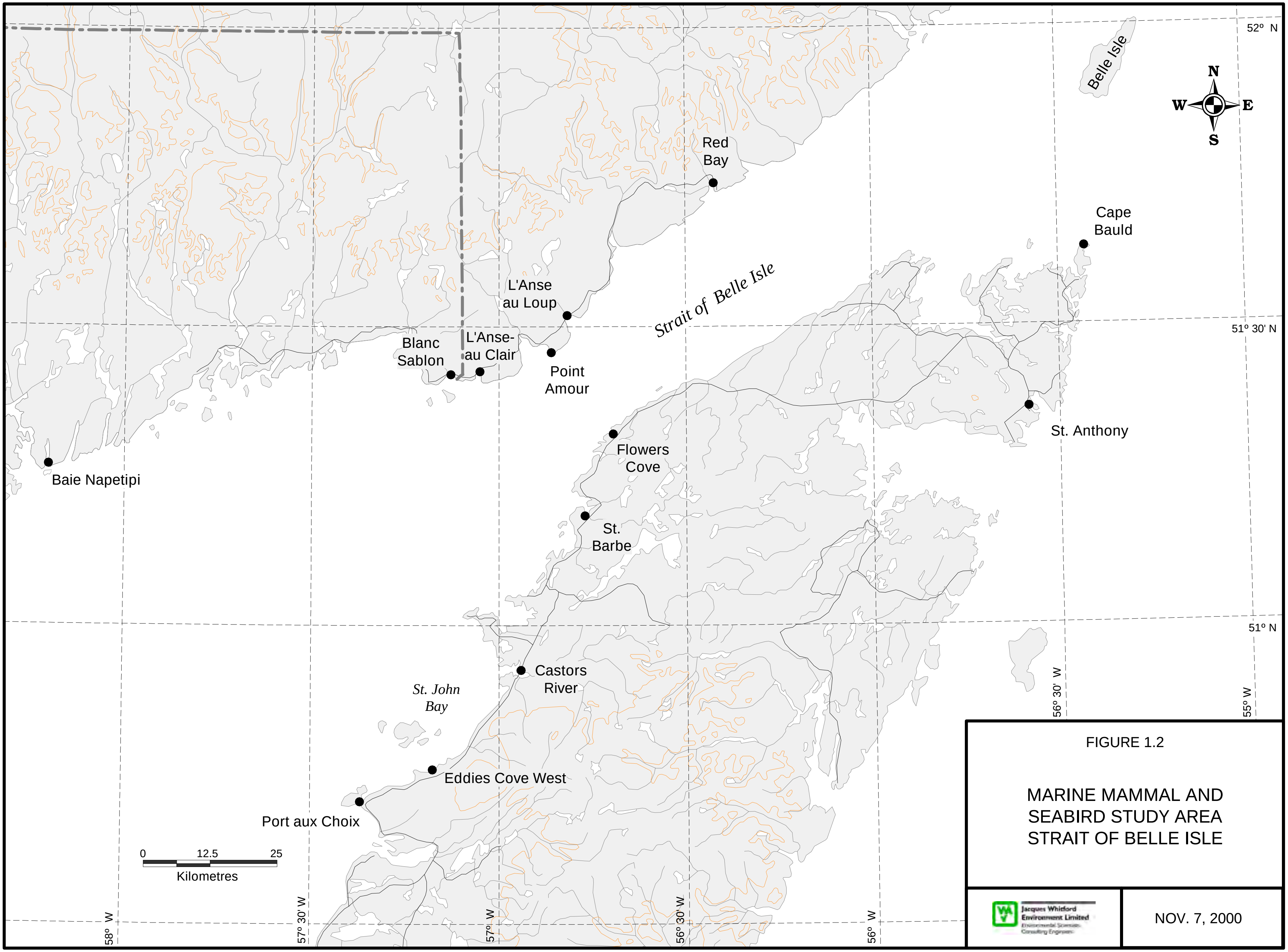

FIGURE 1.2

MARINE MAMMAL AND SEABIRD STUDY AREA STRAIT OF BELLE ISLE

Jacques Whitford Environment Limited

NOV. 7, 2000

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2.0 DESCRIPTION OF STUDY TEAM

The marine mammal and seabird study was conducted by Jacques Whitford Environment Limited (JWEL). The 1998 marine mammal and seabird study team included a scientific authority, field crew leaders, navigators, observers, and data management personnel (Table 2.1). All team members have in-depth knowledge and experience in their fields. The proportion of team members residing in Newfoundland and Labrador is approximately 89%. Brief biographical statements, highlighting project roles and responsibilities and relevant education and employment experience, are provided below.

Table 2.1 Study Team - Marine Mammals and Seabirds in the Strait of Belle Isle

Participant	Role	Affiliation
David Pinsent	Project Manager/ Field Crew Leader - Plane	JWEL – St. John's
Michael Kingsley	Scientific Authority	Independent
Holly Hogan	Field Crew Leader - Boat	JWEL – St. John's
Stephen Bettles	Navigator - Plane	JWEL – St. John's
Natasha Smith	Navigator/Observer - Boat	JWEL – St. John's
Malindi Shinkle	Observer - Boat	JWEL – St. John's
Stephanie Barnes	Observer - Boat	JWEL - St. John's
Richard Neville	Observer - Plane	JWEL – Goose Bay
Bruce Mactavish	Seabird Observer - Boat	JWEL - St. John's

David Pinsent, M.Sc. (**Memorial University of Newfoundland**), is a marine biologist with JWEL in St. John's. Mr. Pinsent served as Project Manager for the marine mammal survey as well as Field Crew Leader for the aerial surveys. He was responsible for the overall execution of the field programs, report production, and budget management.

Mr. Pinsent has more than 14 years experience in the study and application of marine science. He has spent several years studying the abundance and distribution of plankton, fish and marine mammals in coastal and offshore waters. Mr. Pinsent designed, conducted and authored the marine resources, ringed seal and marine mammal surveys during the Voisey's Bay Mine/Mill Environmental Assessment. Mr. Pinsent has also been involved in the design, sampling and reporting for the Terra Nova EEM Baseline Program, as well as the marine component studies for the Newfoundland Transshipment Terminal and the Argentia Nickel Smelter/Refinery projects. He was also a senior author of the environmental assessment documents for the Voisey's Bay Mine/Mill, the Argentia Nickel Smelter/Refinery and the Newfoundland Transshipment Terminal projects. During the mid-1980s, Mr. Pinsent was employed with the Whale Research Group of Memorial University as a biologist and observer to conduct marine mammal surveys along the coast of Newfoundland and Labrador.

Michael C.S. Kingsley, M.A. acted as the scientific authority for the mammal survey. He designed the survey program and conducted the data analysis.

Mr. Kingsley has 25 years experience in wildlife and marine mammal research and management. Mr. Kingsley's experience was founded on expertise in mathematics and statistics, and developed into fields of population estimation and assessment and related areas of biological study. His scientific activities have remained strongly oriented toward population estimation by survey and other means, population dynamics (including mathematical modelling), and population analysis and assessment. This emphasis has led to frequent involvement in environmental impact assessment and environmental monitoring activities. Most recently, Mr. Kingsley controlled the research program of the region on the St. Lawrence beluga whale under the St. Lawrence Action Plan, and maintained research into other (cetacean) species for the Department of Fisheries and Oceans. Mr. Kingsley has a great deal of experience in conducting aerial surveys of marine mammals, and much of his surveying experience was within the St. Lawrence region. Among Mr. Kingsley's numerous publications, several in particular which demonstrate this knowledge and experience, of aerial surveys of marine mammals within the St. Lawrence region.

Holly Hogan, M.Sc., is a wildlife biologist with JWEL in St. John's. She acted as the Field Crew Leader for the boat-based marine mammal surveys and also assisted in data compilation, analysis and report writing.

Ms. Hogan has been involved in designing and implementing studies relating to marine and terrestrial ecology for 14 years and has had extensive field experience. She conducted daily marine mammal surveys in the Witless Bay Seabird Ecological Reserve for a five-month period and was employed with the Whale Research Group to release entrapped whales as well as to conduct whale identification workshops. Ms. Hogan has conducted several ship-board marine mammal surveys in the offshore waters of Newfoundland and Alaska.

Stephen Bettles, M.Sc., is a marine biologist with JWEL in St. John's. He was the data recorder/navigator during the aerial surveys, assisting the pilot to maintain course and recording the GPS position, time, altitude and survey conditions of each mammal sighting. Mr. Bettles assisted in data collection, analysis and report preparation.

Mr. Bettles has prepared Environmental Quality Assessments for two Atlantic Coastal Action Program Sites in Prince Edward Island. He has also performed intertidal habitat assessments and juvenile fish population surveys with the Department of Fisheries and Oceans. Having over eight years experience in marine biology and six years in aquaculture, he has used many sampling techniques for both marine and freshwater studies and has conducted aquaculture site assessments in Placentia Bay and St. Mary's Bay. Mr. Bettles also worked with the Island Nature Trust in Prince Edward Island and conducted many intensive botanical surveys. He is also an advanced SCUBA diver and has much experience with scientific diving as well as small boat safety.

Natasha J. Smith, Graduate Diploma - Environmental Technology, is an Environmental Technician with JWEL in St. John's. Ms. Smith was the data recorder/navigator as well as an additional observer during the boat-based portion of the marine mammal survey. She recorded GPS position, time, direction, distance from vessel and survey conditions for each mammal sighting. Ms. Smith also assisted in the data compilation and report preparation.

Ms. Smith assists in the coordination of project tasks at JWEL and collects environmental data and samples. Prior to joining JWEL, Ms. Smith was an Environmental Effects Officer with Environment Canada where she reviewed and provided technical advice on aquatic EEM programs for 19 pulp and paper mills in Atlantic Canada; prepared technical reports on the results of the programs and participated in the amendment of several requirements and guidance documents for Cycle 2 of the Pulp and Paper EEM program. Ms. Smith has experience with fish surveys, benthic invertebrate surveys, effluent sampling, sediment sampling and marine mammal surveys and is an open water SCUBA diver.

Malindi A. Shinkle, B.Sc., is a junior biologist and data manager with JWEL in St. John's. She was an observer during the boat-based survey and assisted in data management and report preparation.

Ms. Shinkle has been associated with the company since the completion of her Bachelors degree in April, 1998. She has considerable experience using Windows-based programs and is responsible for data management (data entry and storage, data QA/QC, data summary and reduction, etc.) for numerous JWEL projects including: environmental impact assessments, baseline data collection and environmental effects monitoring programs. Ms. Shinkle's field experience includes: marine and freshwater habitat assessment, air quality monitoring techniques, water quality testing, benthos sampling, and marine mammal identification.

Stephanie Barnes, MES, is an Environmental Scientist with JWEL in St. John's. She was an alternate during the boat-based survey and assisted in the research and report writing.

Ms. Barnes has a strong academic background in natural resource planning with a focus on marine conservation and public participation. She has considerable field and laboratory experience including: freshwater and marine habitat assessment, water quality testing, benthos and sediment sampling, and marine mammal identification. Ms. Barnes has held term employment with the Department of Environment and Labour as Project Coordinator for an insecticide monitoring program as well as with the Newfoundland and Labrador Conservation Corps as Regional Supervisor of environmental projects.

Richard Neville is a junior environmental technician with JWEL in the Goose Bay office. Mr. Neville served as an observer during the aerial surveys.

Mr. Neville is a Labrador resident and a recent graduate of the Environmental Field Assistant Program at the College of the North Atlantic. Mr. Neville has a general knowledge of marine and freshwater environments throughout Atlantic Canada. Prior to this program, his mammal identification training has been gained through years spent as a commercial fisher on the south Labrador coast. Additional field experience includes participation in field studies to monitor eider populations and habitat in Eagle River. Mr. Neville's safety and emergency training includes First Aid, Restricted Radio Operators certification, Helicopter Safety Training, Canadian Firearms and Small Craft Survival/Flat Water Canoe Level I Certification.

Bruce Mactavish is a widely recognized authority on bird distribution and identification in eastern Canada. He was responsible for the design and execution of the boat-based seabird surveys.

Mr. Mactavish has been a field consultant on numerous avifauna-related projects in Newfoundland and Labrador over the past 25 years. These include: research associated with the original avifauna surveys of Gros Morne National Park and L'Anse-aux-Meadows National Historic Park; three seasons of conducting a series of 18 Breeding Bird Surveys across Newfoundland for Memorial University; four seasons of intensive songbird biodiversity studies in old growth and second growth balsam fir forest in western Newfoundland for Forestry Canada; aerial and ground surveys throughout Northern Labrador for National Defence; and numerous site surveys of avifauna and other wildlife in support of environmental assessments for JWEL and others.

3.0 SUMMARY OF STUDY OBJECTIVES

3.1 Marine Mammals Surveys

The objectives of the marine mammals survey in the Strait of Belle Isle study were to: 1) conduct a literature/data review of the marine mammal sightings within and near the Strait of Belle Isle; 2) summarize the possible project-related interactions and effects on these species; and 3) estimate the relative abundance of marine mammals in the Strait and the surrounding area during the ice-free season.

3.2 Seabird Surveys

The Strait of Belle Isle has rich and diverse seabird populations. These populations are highly variable, both temporally and spatially. Species abundance and composition is affected not only by season, but also by local weather conditions. The objective of the seabird monitoring program was to gain a general overview of seabird species diversity and abundance found during the late summer and fall in the area of the proposed submarine cables in the Strait of Belle Isle.

4.0 DESCRIPTION OF THE STUDY AREA

4.1 Study Area

The Strait of Belle Isle separates the northern part of Newfoundland from the southeastern coast of Labrador. It extends for approximately 118 km in a northeast-southwest direction. The narrowest part, near Point Amour at the southern end, is approximately 15 km wide. At the northern end of the Strait, is Belle Isle, located in the centre of the channel approximately 20 km from the islands off the coast of Labrador and about 22 km from Cape Bauld (Figure 1.2).

4.2 Coastal Geomorphology

The bedrock in the Strait of Belle Isle is composed of Precambrian and Cambrian sedimentary rocks with northeast-southwest to east-west structural trends (Woodward-Clyde Consultants 1980). The coast of Labrador along the Strait is steep granite which rises to flat-topped ridges and summits ranging from 300 to 390 m above sea-level (asl). The Newfoundland coast is low, with shorelines rising to only approximately 30 m. The greatest water depths in the Strait are on the Labrador side and the range varies from 30 to 146 m. Centre Bank, in the middle of the southern part of the Strait, has depths ranging from 43 to 55 m. The shallowest part, having a depth of about 29 m, is in the northern end of the Strait near Fairway Bank (Cooper 1960).

4.3 Oceanography

The inshore branch of the Labrador current flows southwesterly into the Strait and along the north side of the Labrador Coast before entering the Gulf of St. Lawrence. Warmer and less saline water from the Gulf flows northeasterly into the Strait along the coast of Newfoundland. The turbulence created by the mixing of the cold Labrador current with warmer water from the Gulf of St. Lawrence creates a front of nutrient-rich water and an area of increased productivity. Water temperatures recorded from July to October during a 1981 field program (Lower Churchill Development Corporation 1984) found that the average water temperatures were highest on the Newfoundland side, followed by the Labrador side and coldest in the centre of the Strait. Water temperatures varied from 0^{o}C to 12^{o}C during the period, with a mean of 4^{o}C. The average salinity was found to be in the order of 32 parts per thousand (ppt).

Water movement through the Strait is predominately tidal; the water regularly turns and runs both eastward and westward with equal strength while under the control of the tide alone. This is complicated by a frequent tendency for a "dominant flow" to be greater in one direction than the other. The dominant flow may last several days to a week or more. A mixed semi-diurnal tide occurs in the Strait of Belle Isle, with considerable variation occurring between the height of the two high tides and the two low tides each day. The normal tidal range in the Strait is approximately 1 m for mean tides and 1.5 m for spring tides. The average period of the tides is half a lunar day (Lower Churchill Development Corporation 1984).

4.4 Meteorology

During the winter months, the average atmospheric pressure decreases from southwestward to northeastward. Depressions are numerous and these regions are often stormy, with gale force winds that may suddenly change in direction and force. The Strait of Belle Isle is often in the cold air of a depression, with winds from the northwest. The average pressure gradient is less pronounced in the spring and winds become more variable with northeasterly winds more frequent (Cooper 1960). Most winds are westerly and southwesterly during the summer months. Winds speeds are the lowest in June, July and August and then increase through to December (Lower Churchill Development Corporation 1984). In late summer and autumn, the wind in the Strait of Belle Isle tends to blow along the length of the Strait in a northeasterly or southwesterly direction.

The mean daily air temperatures for Daniel's Harbour (approximately 60 km south of study area), measured from 1946 to 1990 by Atmospheric Environment stations (AES) in the area (Environment Canada 1998), are considered a representative source due to the proximity of the town to the proposed cable crossing area. Air temperatures measured during the winter months, December to March, ranged from -4.1 to -8.6^{o}C and during the summer months, June to August, ranged from 9.7 to 14.4^{o}C.

4.5 Ice Conditions

The period of open navigation in the Strait of Belle Isle varies from year to year but is generally from July to October (Cooper 1960). Open water conditions may prevail through December but usually by January new ice forms and covers most of the Strait. However, in recent years, including 1999, January has been virtually ice free. A substantial amount of ice can develop in the Strait during a severe winter; February and March have the heaviest ice conditions and often the Strait is congested with only occasional zones of open water (Lower Churchill Development Corporation 1984). Under the effect of prevailing westerly winds, a lane of open water follows the north side of the Strait as far west as Forteau Bay. By early April, the amount of ice decreases and open water zones are more frequent, however, easterly winds often drive first-year ice into the Strait from the Labrador Sea. Navigation through the Strait is usually possible by late May or early June.

Icebergs are numerous in the Strait from April until September or October. They are relatively small and enter mainly under the combined pressure of strong easterly winds and ice fields off the southern Labrador coast (Cooper 1960). Otherwise, the Strait is often clear of icebergs, which are moved out of the area passing under the influence of westerly winds between Belle Isle and Cape Bauld.

5.0 METHODS

5.1 Aerial Survey

5.1.1 Aerial Survey Design

The total marine mammal survey area is approximately 5,400 km^2. It extends from the northeastern tip of the Northern Peninsula of Newfoundland, southwestward to a line approximately from Port au Choix to the Baie Napetipi in Quebec. To cover this area, an aerial transect pattern was laid out on headings of 320 and 140 degrees true, at a spacing of 7.4 km (4 nautical miles) (Figure 5.1). A spacing further apart would risk mammals being missed and a closer spacing would risk duplicating mammal observations. This northwest-southeast orientation provided good coverage of various habitat types and water depths throughout the Strait. Twenty-five transects, for a total estimated length of 1,200 km (648 nautical miles), were flown during the aerial surveys. This survey design permitted thorough coverage of the study area within a single day, thereby reducing temporal sampling error. The study area was surveyed twice over two consecutive days when weather permitted. Consecutive surveys act as study area duplicates and give greater statistical power to the data, thus providing population estimates with better confidence limits.

Line-transect methods are used in surveys where targets are rare so that all sightings may be useful and in cases where targets become less visible with distance from the platform, but at an unknown rate. In such cases, strip-transect surveys may incur bias by using too wide a strip and useful off-transect sightings may be inconsistently recorded. Line-transect methods have become standard for shipboard surveys for cetaceans in the open sea. Aerial line-transect surveys for both marine and terrestrial species are increasingly replacing strip-transect methods. Field methods for line-transect survey consist of recording all targets detected together with a best measure of their distances from the platform or from the transect line. The recorded sightings distances are then analyzed to estimate the decline of visibility with distance. The resulting estimated “relative detection curve” is then applied to the recorded sightings to estimate density and numbers. Line-transect methodology was used during this survey.

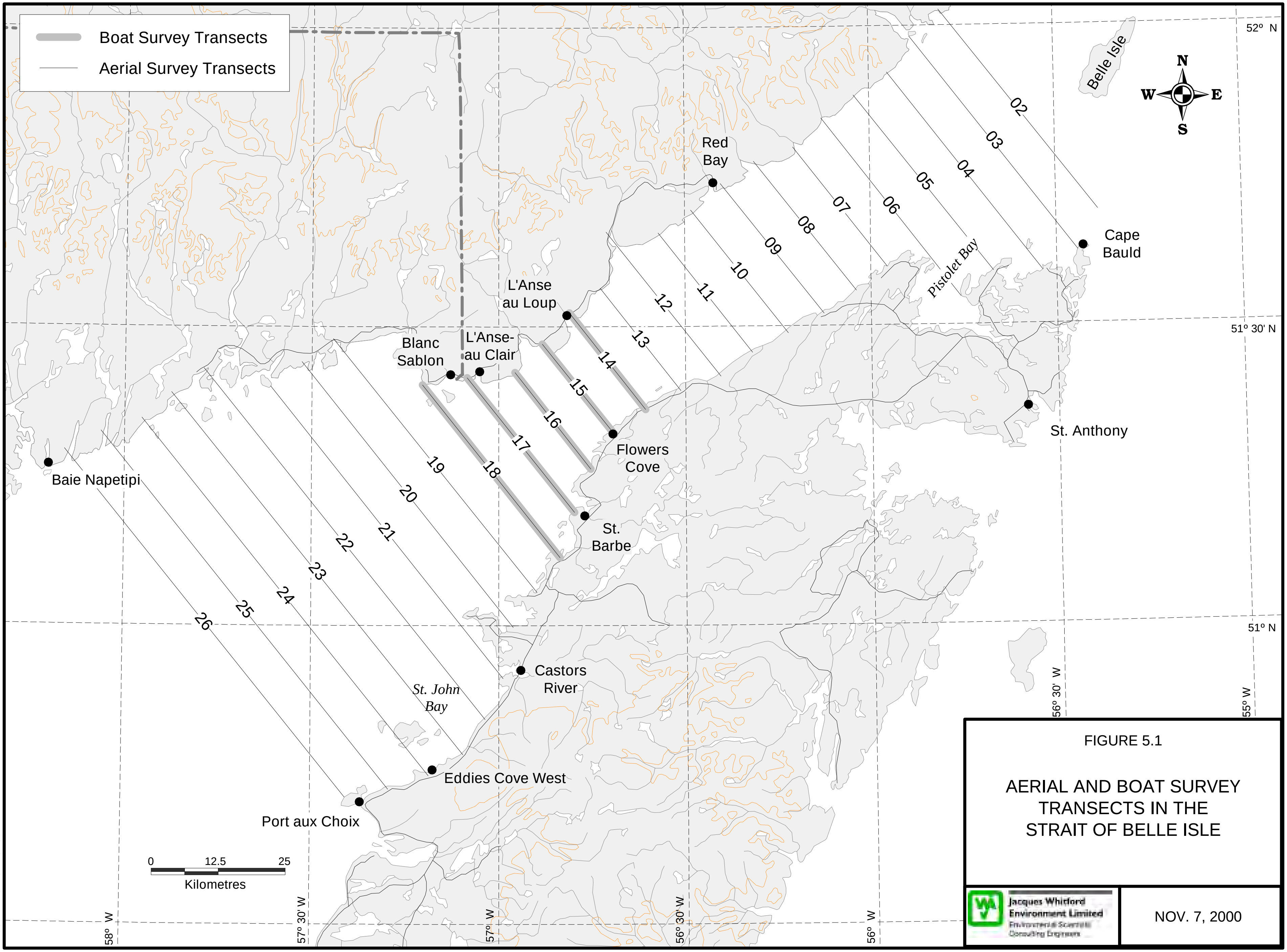


FIGURE 5.1

AERIAL AND BOAT SURVEY TRANSECTS IN THE STRAIT OF BELLE ISLE

5.1.2 Aerial Survey Execution

Marine mammal surveys were conducted only on days when wind speeds were forecasted less than 15 knots, with a Beaufort scale wind force of 3 or less, visible from land. There were occasions, however, when conditions exceeded these limits due to the patchiness of wind and wave conditions across the Strait. This patchiness is primarily due to the variation in fetch and current direction in the Strait. Aerial surveys were flown in a Partenavia P68C twin-engine, fixed-wing aircraft at a target ground speed of 100 knots. Surveys were flown at 210 to 220 m altitude. The aerial surveys were flown approximately every three weeks but varied due to weather conditions.

Mammal counts were recorded by an observer sitting in the rear, on each side of the aircraft. Mammal observations were recorded to species only when there was a positive identification, otherwise sightings were recorded as accurately as possible (i.e., dolphin species). The entire field of view was continuously scanned to the side and slightly ahead of the aircraft's path. There was a blind spot under the aircraft approximately 300 m wide. Clinometer readings of each observation were recorded to estimate the distance of the mammal from the track or transect line. Each time a mammal was spotted, the navigator would mark the position with the Global Positioning System (GPS), thus giving it a waypoint (see data sheet in Appendix A). The navigator was also responsible for assisting the pilot to stay on the predetermined transect line.

5.2 Boat-Based Survey

5.2.1 Marine Mammals

Boat surveys were conducted at three-week intervals to coincide as closely as possible with aerial surveys. The vessels used to conduct the surveys were Canadian Coast Guard-certified longliners. During the first two survey periods (August 5 to 8 and August 29 to 30), 16.8 m (55-foot) longliners were used. All subsequent surveys were conducted aboard the "Cabot Brothers", a 13.7 m (45-foot) vessel. Aerial transect lines 14 to 18 were surveyed by boat (see Figure 5.1), covering transect distance of over 110 km (60 nautical miles) at a cruising speed of 7 to 9 knots. Each transect was surveyed twice per survey period, except during the October 7 survey (Survey 4), when all lines were surveyed only once. Following Survey 4, transect line 18 was no longer surveyed due to weather and daylight limitations. The survey team consisted of one data recorder/navigator and two observers, one observer scanning 90 degrees to the starboard side and the other scanning 90 degrees to the port side. The recorder/navigator was responsible for providing headings and GPS data and recording marine mammal data, and also scanning when possible. The observers were positioned on the top of the wheel house, 5 m from the waterline. Observers recorded the sighting angle of the whales as well as the group size and an estimate of distance from the transect. For each transect the following data were recorded (see also Appendix A):

- At the start and end of each transect, the heading and a position reading were taken from the GPS. Transect start and end time were also recorded.
- Weather conditions were recorded at the start of each survey, including wind direction/speed, sea state (Beaufort scale), visibility and cloud cover. Surveys were not conducted in wind conditions exceeding 15 knots.

- The surface of the water was scanned constantly while travelling on the transect using a combination of binoculars and the naked eye.
- Each time a marine mammal was spotted, a separate observation entry was made in the data sheet. Each observation was assigned an identifying letter. Repeat sightings of the same individual were assigned the same identifying letter. Sightings at times other than during dedicated surveys were entered as "incidental".
- For each sighting, the species was recorded, the time and UTM coordinates of the boat, as well as the distance and the relative position (in degrees) of the marine mammal from the boat using a sighting board. Comments regarding behaviour or identification attributes were recorded when appropriate.

5.2.2 Seabirds

Seabird surveys were conducted concurrently with four of the boat-based marine mammal surveys by a dedicated seabird observer. The seabird survey team consisted of one observer/recorder. Headings and GPS data were provided by the marine mammal survey recorder/navigator. The seabird observer was also positioned on top of the wheel house, 5 m from the waterline, and scanned 90 degrees to starboard and port (for a total of 180 degrees) to a distance of 50 m from the boat.

For each transect the following data were recorded (see also Appendix A):

- At the start and end of each transect, the heading and a position reading were taken from the GPS. Start and end time were also recorded.
- Weather conditions were recorded at the start of each survey, including wind direction/speed, sea state (Beaufort scale), visibility and cloud cover. Surveys were not conducted in wind conditions exceeding 15 knots.
- Each transect was divided into 10-minute intervals. The time and UTM coordinates were recorded at the start of each interval.
- The surface of the water was scanned constantly while travelling on the transect, using a combination of binoculars and the naked eye.
- During each 10-minute interval, all birds seen within the 50 m radius were identified and counted. Any noteworthy comments or observations were recorded where appropriate.

5.3 Mammal Survey Data Analysis

The survey data were analyzed using line-transect methods. In line-transect analysis, all sightings are recorded with an estimate or a measure of their distance from the trackline. The strip width that can be effectively scanned by the observers (the Effective Strip Width, or ESW) is subsequently estimated by analyzing the distribution of recorded distances between the trackline and the sightings. Line-transect methods avoid the problem of sightings being missed at the outer edge of an over-ambitious fixed-width survey strip (Burnham et al. 1980; Buckland et al. 1993). To collect line-transect data, the sighting angle to all marine mammals sighted was measured with hand-held clinometers in percentage grade, and later converted to a lateral distance of the sighting from the trackline.

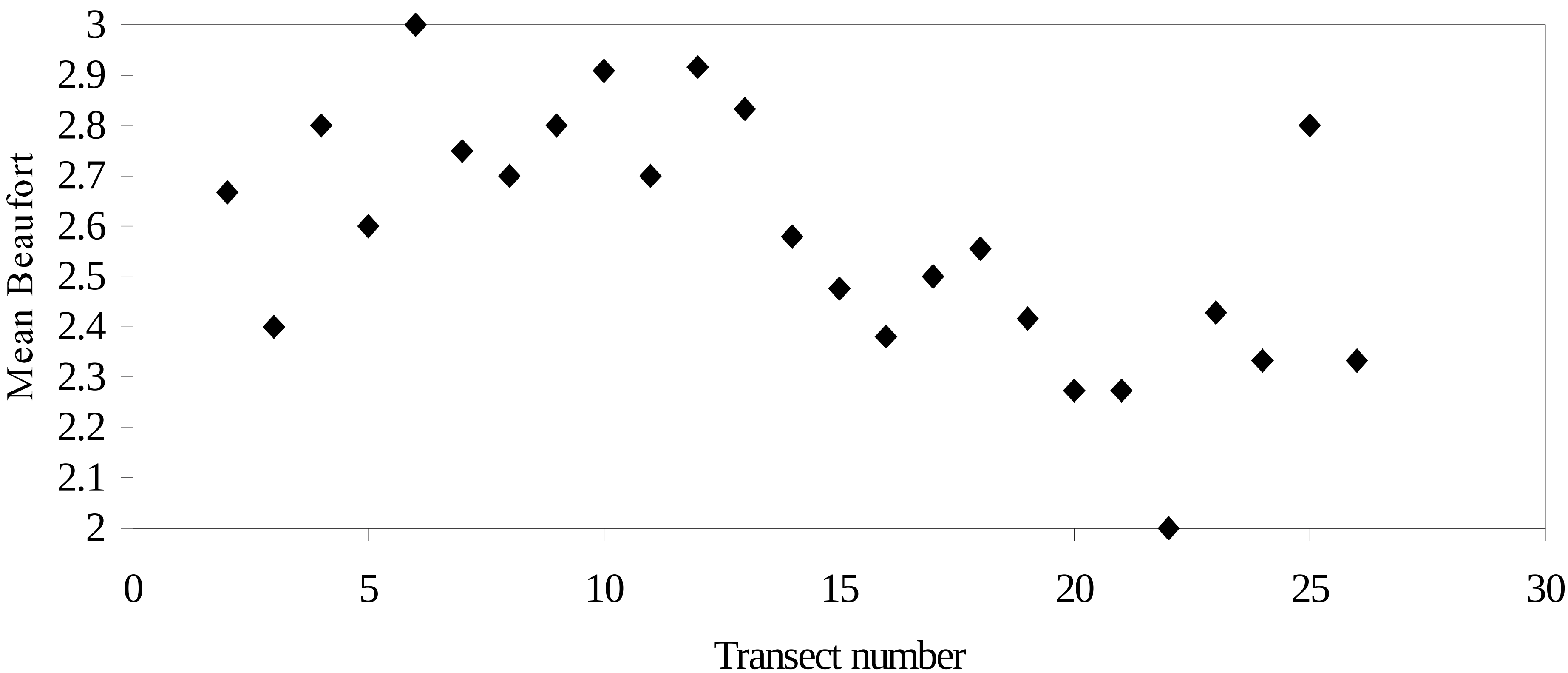
The survey program was designed on a three week repeat period. Every three weeks, an aerial and a boat survey was to be conducted, each twice. It was considered desirable to carry out the surveys only in winds of less than 15 knots, but such good weather was difficult to obtain in the study area. Most of the aerial survey mileage was flown in sea states recorded as Beaufort 2 (47%) and 3 (35%) (i.e., in winds of 7 to 10 knots).

The first aerial survey took place in weather that was somewhat windier than desirable, and there was no coincident boat survey owing to delay in finding and equipping a suitable vessel. After that, the three-weekly schedule of surveys was adhered to with only slight adjustments for weather. However, operational arrangements sometimes prevented the two surveys from taking place on the same days (Table 5.1).

The mean sea state for each transect for the entire survey program was calculated. It appeared that transects 2-13 on average tended to be windier than the transects further south-west. The mean Beaufort sea state was calculated for each transect. There appeared to be a tendency for rougher seas east of approximately transect 14, compared with calmer seas south-west of transect 15 (Figure 5.2).

Table 5.1 Progress of Aerial and Boat-Based Mammal Survey

Survey		Dates	Transect Coverage / Survey			Distance (km) in Bft				
			Once	Twice	3x or more	1	2	3	4+	Total
Aerial	**1**	9–10 Jul	14–26	2–13	-	-	83.9	577.8	784.7	1446.4
	2	4–5 Aug	26	2–14; 18–25	15–17	-	1517.7	866.1	114.8	2498.6
	3	29 Aug – 1 Sep	8–13; 22–26	14–21	-	468	628	177.4	-	1273.4
	4	19-Sep	3–13; 19–21	14–18	-	-	608	259.1	-	867.1
	5	5–7/10	3–1; 20–21	12–13, 19	14–17	-	22.8	965.8	275.9	1264.5
	6	24–25 Oct	8–11; 18–25	Dec-13	14–17	-	503.1	602.6	-	1105.7
	7	20–21 Nov	7–13; 21–24	19–20	14–18	348.5	594.4	297.8	30.9	1271.6
	8	7–9 Dec	7–13; 19–23	14–16	17–18	59.2	791	73.6	-	923.8
Boat	**2**	5–8 Aug	-	14–18	-	75.8	30.6	63.9	50.5	220.8
	3	29–30 Aug.	-	14–18	-	-	76.3	79.8	64.7	220.8
	4	15–18 Sept.	-	14–18	-	16.4	34.1	97.1	73.2	220.8
	5	7 Oct.	14–18	-	-	-	-	61.6	48.8	110.4
	6	27–29 Oct.	14–15	16–17	-	-	27.5	18.2	76.2	122
	7	18–20 Nov.	14	15–17	-	-	-	59.9	76.3	136.2
	8	7–9 Dec.	15–18	-	-	-	34.1	-	59.9	94



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Jacques Whitford Environment Limited

Environmental Scientists
Consulting Engineers

FIGURE 5.2

MEAN BEAUFORT SEA STATE DURING AERIAL SURVEY TRANSECTS

5.3.1 Line-Transect Analysis of Boat Survey Sightings

Boat survey sightings were analyzed using line-transect analysis. A single sighting curve was calculated for all surveys pooled. A cut-off Beaufort sea state was subjectively assigned to reject observations in sea states with apparently low encounter rates, provided that not too high a proportion of sightings would be lost. The distance and bearing data was converted to a lateral distance off the transect line. A 3-parameter hazard-rate sighting curve was fitted to the off-transect distances, assuming that all species could be seen on the track-line as well as, or better than, at any distance off track. The data was censored at a distance that gave a sighting rate of about 7–8% of the maximum (assumed to occur at distance 0). The ESW was calculated by integrating the censored sighting curve.

Four common species harbour porpoise, white-beaked dolphin, minke whale, and humpback whale had enough sightings (Table 5.2) to fit reasonable sighting curves and to obtain good estimates of the ESWs and their standard errors (Table 5.3). Cetacean species seen more rarely such as sei whale, fin whale, and pilot whale as well as all seals, could not be analyzed by line-transect methods, because there were not enough sightings.

Table 5.2 Gross Encounter Rates by Beaufort Sea State for Common Species of Cetacean for Boat Surveys in the Belle Isle Strait Narrows, Summer 1998

Species	Overall Average Encounter Rate (/100 km) in Beaufort			
	1	2	3	4+
Harbour porpoise	54.2	22	12.1	2.67
White-beaked dolphin	22.78	9.87	9.20	6.34
Minke whale	14	5.9	2.9	2.67
Humpback whale	1.08	4.44	4.47	3.11

Table 5.3 Effective Strip Widths for Boat Surveys for the Commonest Species of Cetaceans in Belle Isle Strait, August - December 1998

	Harbour Porpoise	White-beaked Dolphin	Minke Whale	Humpback Whale
Effective number of sightings*	41.1	12.9	34.4	25.8
Censoring distance (m)	300	350	500	1500
One-sided ESW (m) (est. SE)	101 (19)	99.5 (20.6)	132 (25)	728 (120)

Limit Beaufort sea states for line-transect analysis: harbour porpoise 3; white-beaked dolphin 3; minke whale 4; humpback whale 4.

* effective number of sightings: number of animals seen divided by CHM** of animals per sighting

**CHM (contraharmonic mean) – the size of the group containing the average animal. It is calculated as the sum of squares of the group size divided by the sum of the group sizes (total number of animals seen).

The ESWs for all these species were smaller than expected. For the three small species, harbour porpoise, white-beaked dolphins, and minke whales, the ESWs were of the order of only 100 m. These species are all expected to be hard to see, but larger ESWs may be obtained (*cf* Kingsley and Reeves 1998). The small ESWs in this survey are probably due to the less than ideal weather conditions and to the height of the observers above the water surface. However, the small ESWs imply large survey expansion factors and the necessity of inferring large populations in the study area from a relatively small number of sightings. The ESW for humpback whales was difficult to estimate owing to a relatively high proportion of sightings recorded right on the trackline; it was necessary to assume that humpbacks were equally visible at all distances out to at least 250 m to get a sensible answer.

5.3.2 Line-Transect Analysis of Aerial Survey Sightings

Three species, harbour porpoise, minke whale, and humpback whale, had enough observations to permit quantitative line-transect analysis. Preliminary analyses were carried out to determine the incidence of variable weather conditions and their effect on the visibility of these species.

It is expected that Beaufort sea state will affect the visibility of most marine mammals, particularly the smaller species. For porpoises and minke whale observations in this study, there was a decrease in the gross encounter rate with increasing Beaufort sea state (Table 5.4). This was especially marked for harbour porpoises, where 88% of individuals were sighted in the 8.2% of the flown mileage that was in Beaufort 1. Furthermore, the observations made in Beaufort 2 conditions were distributed differently, much closer to the trackline than those made in Beaufort 1. Therefore, for quantitative analyses of harbour porpoise observations on aerial survey, only the observations made in sea state 1 were used.

Table 5.4 Overall Encounter Rates (Individuals per 100 km) of Common Cetaceans in Aerial Survey of the Belle Isle Strait

	Estimated one-sided ESW* (m)	Overall Encounter Rate (/100 km) in Beaufort Sea State			
		1	2	3	4
Harbour Porpoise	174	15.530	0.232	0.183	0
Minke Whale	242	0.571	0.274	0.079	0.091
Humpback Whale	552	0.685	0.421	0.707	0.637
Dolphins (all)		1.256	0.747	0.314	0
* Limited Beaufort sea state for line transect analysis was 1 for harbour porpoise, 2 for minke whale, and 3 for humpback whale					

For minke whales, the encounter rate recorded for Beaufort 2 was half that for Beaufort 1 and for Beaufort sea state 3 was almost four times smaller again. However, the distance flown over sea states 2 and 3 was so large that to have rejected that data would have unacceptably reduced the available number of sightings. Analyses for minke whale were based on aerial survey effort in sea states 1 or 2.

Conversely, for humpback whales, sea state did not appear greatly to affect the recorded encounter rate (Table 5.4). From Beaufort 1 all the way up to Beaufort 4 or 5, the encounter rate appeared to stay about the same. The cue for humpback whales appeared, from the results of the line transect analysis, to be the blow rather than the body, and this is less apt to be obscured by rough water. However, distribution may be confounded with sea state, in that humpbacks may have a preference (for other reasons, such as food availability) for the part of the study area where seas were often rougher, the higher density in that area being thus offset in the observation records by a reduced visibility. For humpback whales, analyses were based on observations made in sea states 1 to 3.

Line-transect analysis for porpoises was based on effort and observations in Beaufort sea state 1. Few observations were made in higher sea states, so omitting them lost little information, and the encounter rate at higher sea states was so different that it was impossible to combine the data. The few observations in sea state 2 were all within 250 m of the trackline, much closer than those made in sea state 1, which were distributed out to 750 m. The data and the sighting curve were censored at 610 m (2,500 ft), corresponding to a relative visibility of 10.5%. No observations were recorded at any greater distance. Aerial observations of porpoises were curious, in that most of them were made in good conditions on Survey 3, but on that survey there were rather few aerial observations of anything else.

For minke whales, analyses were based on observations in sea states 1 and 2. Although the recorded encounter rates were different, most of the observations would have been rejected if sea state 2 had been excluded from the analyses because most of the flying was in those conditions. Sighting data was censored at 610 m.

For both porpoises and minke whales, the closest sightings were at a sighting angle of about 52° below the horizon, which is normal for aerial surveys in flat-windowed aircraft (Kingsley and Reeves 1998) This corresponded to a distance of approximately 165 m (540 ft) from the trackline. Observations of humpback whales began further out, at approximately 235 m (540 ft) out from the trackline. It is not obvious why this should be so, except perhaps that the longer dive times of humpbacks may make them hard to detect close to the aircraft, where each spot on the surface is only in view for a short time.

All observations of humpback whales up to Beaufort 3 were included in line transect analysis, as the encounter rate did not decrease much with sea state and as many observations were made in sea state 3 as in sea state 2. Few humpbacks were recorded in Beaufort sea state 1, possibly because the species is usually found in waters that are seldom so calm. As noted above, there were few observations of species other than harbour porpoise on the only survey that encountered such Beaufort 1 conditions. Sighting distances in sea state 2 were distributed relatively evenly between 400 and 1400 m from the trackline, but those in sea state 3 were concentrated between 700 and 800 m. The ESW for humpback whales in aerial survey was surprisingly small at 552 m, largely because sightings did not start until well out from the trackline.

5.3.3 Comparison of Boat Survey with Aerial Survey Sighting Rates

To compare sighting rates, aerial survey observations were screened on the basis of the sea state and censoring cut-off distance, and encounter rates were calculated by transect, and by survey. Boat survey observations were screened to remove resightings of animals already seen. Encounter rates (animals per 100 km) were tabulated by transect and by survey for the transects covered by both the aerial and boat-based surveys.

5.4 Quality Assurance/Quality Control

Data management involves a number of systematic processes and protocols that are designed to provide a framework for providing quality environmental data with a high degree of credibility (CCME 1993). The major components of the data management system used for the LHP environmental studies include:

- data documentation (computer programs, and statistical, normalization and error control procedures);
- data recording (field notebooks, field maps and auxiliary data records);
- data custody and transfer (chain of custody records, QA/QC procedures for authorizing changes to data, QA/QC documentation of transfer formats, data recording forms, and data verification and validation);
- data validation (data identification, transmittal errors, flagged or rejected data, data comparability, and data review and evaluation);
- data verification (sample results reported and checked for transmission errors, data review, flagging and screening);
- data presentation (tables, graphs and figures); and
- data storage (digital format and hard copy).

JWEL developed and implemented a QA/QC procedure for data management. The following description provides a brief overview of the procedures that JWEL established and how they were carried out by JWEL's field crews.

Field data were recorded in field log books and then entered into electronic format (Microsoft Excel, Version 5.0) by the field crews. Electronic files containing field data were then verified against field records to eliminate transcription errors due to manual data entry. Daily log books, field note books, field records and electronic files were forwarded to JWEL's data coordinator in St. John's. All data and related information were stored in duplicate form.

6.0 RESULTS

6.1 Literature Review of Historical Marine Mammal Data

Literature reviews were conducted at JWEL, Memorial University of Newfoundland and the Department of Fisheries and Oceans libraries. Literature searches summarized published marine mammal sighting and stranding data in the Strait of Belle Isle area. A separate literature review summarized the potential effects of underwater construction and blasting on marine mammal species.

6.1.1 Whales

There is a limited body of existing literature on marine mammal distribution in the Strait of Belle Isle. There are few scientific surveys but several anecdotal records (Table 6.1; see Appendix B for list of references). Interpretation of marine mammal distribution based on historical records is imprecise due to some inherent biases. Since some of the records are from systematic surveys, while other sources are anecdotal, coverage and precision of mammal identifications vary widely. For anecdotal records, populated areas like headlands with lighthouses, and the ferry route between St. Barbe and Blanc Sablon would receive greater coverage than would remote locations. In addition, large conspicuous species would be observed and reported more frequently than dolphins and porpoises, which could easily be missed or considered less remarkable. Even with these limitations, the historical records provide valuable information. These records provide species absence/presence and relative abundance information (when interpreted carefully) and suggest areas of greater concentration as well as temporal distribution.

The historical literature indicates that the Strait of Belle Isle is an important area for several whale species (Figure 6.1). Abundances are particularly high between the months of May to August and when all whale species are considered together, distribution patterns emerge. Taking into account the unequal observation effort, there appear to be “hot spots” where reports of whale observations frequently recur (Figure 6.1). The area off the coast of Labrador between L’anse au Clair and L’anse au Loup, and the area around Red Bay, appear to be areas of high relative density in the Strait. The Port au Choix area also has many whale records, but these records are comprised almost entirely of dead or entrapped whales. The headland near Port au Choix juts out into the Gulf and may be the first land mass that an animal travelling in the Gulf current would encounter, as the Gulf of St. Lawrence narrows toward the Strait of Belle Isle.

Table 6.1 Summary of Historical Marine Mammal Sightings in the Strait of Belle Isle

Species	Number	Date	Location	Circumstances	Source
Beluga whale	1	13 June, 1990	St. Lunaire, NF	Dead in lumpnet	16
Beluga whale	1	28 June, 1993	L'Anse au Loup, Lab.	Stranded - alive	18
Beluga whale	1	18 June, 1985	L'Anse au Loup, Lab.	Entrapped in gillnet - released alive	11
Beluga whale (probably)	1	early 1968	Goose Cove, St. Anthony district (51° 18'N, 55° 38'W)	Dead (caught in a seal net)	2
Beluga whale or Pothead whale	1	24 July, 1993	Red Bay, Lab.	Stranded - dead; disappeared	18
Blue whale	1	27 July, 1982	St. Anthony, NF	Dead at sea, reported by Coast Guard	8
Blue whale	1	22 July, 1988	Eddie's Cove, NF	Dead (?), examined by DFO	14
Blue whale	1	15 Nov., 1988	Port aux Choix, NF	Very old, decomposed	14
Blue whale	1	late August - early Sept. 1995	near Blanc Sablon	Aerial survey	22
Dolphins (likely were white beaked)	2	25 July, 1986	Camp Islands, Lab.	Caught in salmon nets - dead.	12
Fin whale	8	21 July - 12 Aug., 1981	Cape Bauld, NF	Shore and shipboard watches	1
Fin whale	2 or same individual twice	10 Aug., 1981	Strait of Belle Isle	During each of two ferry crossings	1
Fin whale	1	30 June- 7 July, 1975	51°-52°N, 56°-58°W	Boat based survey	3
Fin whale	1	9 & 16-21 July, 1975	51°-52°N, 54°-56°W	Boat based survey	3
Fin whale	1	22 Sept., 1981	Reefs Harbour, NF	Caught in a herring net - dead	5 (J. Lien data)
Fin whale	1	7 Sept., 1982	L'Anse au Loup, Lab.	Stranded	8
Fin whale	1	3 Aug., 1979	Castor River South, St. Barbe District	Entrapped in gillnet - whale released self	20
Fin whale	1	4 Aug., 1980	St. John's Bay, Castor River South	Entrapped in herring net - dead	20
Fin whale or Blue whale (?)	1	3 Aug., 1987	SE St. Anthony, NF	Stranded	13
Harbour porpoise	1	3-10 Sept., 1981	Eastern side of the Strait of Belle Isle	Aerial survey	1
Harbour porpoise	1	18 Sept., 1981	Eastern side of the Strait of Belle Isle	Aerial survey	1
Harbour porpoise	4	18 Sept., 1981	Western side of the Strait of Belle Isle	Aerial survey	1
Harbour porpoise	9	late Aug. - early Sept., 1995	Strait of Belle Isle	Aerial survey	22
Harbour seal	2	9 Sept., 1981	Western side of the Strait of Belle Isle	Aerial survey	1
Harbour seal	1	18-19 Sept., 1981	Eastern side of the Strait of Belle Isle	Aerial survey	1
Harp Seal	aprx. 1600	29 April, 1981	In the Strait of Belle Isle	Aerial survey	1
Harp Seal	2	1 June, 1981	In the Strait of Belle Isle	Aerial survey	1
Harp Seal	140	April, 1982	In the Strait of Belle Isle	Aerial survey	1
Hooded Seal	1	15-16 April, 1982	In the Strait of Belle Isle	Aerial survey	1

Species	Number	Date	Location	Circumstances	Source
Humpback whale	7	29 April, 1981	East of St. Anthony	Aerial survey	1
Humpback whale	39	19 May and 1 June, 1981	In or near the Strait of Belle Isle	Aerial survey	1
Humpback whale	1	13 June and 26 June, 1981	In or near the Strait of Belle Isle	Aerial survey	1
Humpback whale	14	12 July, 1981	Most seen in the middle of the Strait of Belle Isle	Aerial survey	1
Humpback whale	1	10 Aug., 1981	In the Strait of Belle Isle	Shipboard watch from the MV Northern Cruiser	1
Humpback whale	1	30 June, 1981	Port aux Choix, NF	Caught in cod trap - alive (released)	5 (J. Lien data)
Humpback whale	1	5 June, 1981	Battle Harbour, Lab.	Caught in salmon net - alive	5 (J. Lien data)
Humpback whale	1	16 June, 1981	Brig Bay, NF	Caught in cod trap - alive	5 (J. Lien data)
Humpback whale	1	30 June, 1981	Port aux Choix, NF	Caught in cod trap - alive	5 (J. Lien data)
Humpback whale	1	30 July, 1981	Fox Harbour, Lab.	Caught in a cod trap - dead	5 (J. Lien data)
Humpback whale	1	30 July, 1981	St. Lewis, Lab.	Caught in a cod trap - dead	5 (J. Lien data)
Humpback whale	10 or 15	23 June, 1980	Pointe Amour, Lab.	Boat or shore based sighting	6
Humpback whale	10 or 15	24 June, 1980	Pointe Amour, Lab.	Boat or shore based sighting	6
Humpback whale	10 or 15	25 June, 1980	Pointe Amour, Lab.	Boat or shore based sighting	6
Humpback whale	1	16 July, 1980	Near Flower's Cove, Strait of Belle Isle	Boat or shore based sighting	6
Humpback whale	plentiful	15-21 June, 1980	Red Bay, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	25-30 May, 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	8-14 June, 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	15-21 June, 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	plentiful	22-28 June, 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	29 June-5 July, 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	11-17 Aug., 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	few	24-31 Aug., 1980	Pointe Amour, Lab.	Shore based sighting (lighthouse keeper)	6
Humpback whale	1	16 July, 1979	52°18' N, 55°30' W	Aerial or boat based survey	7
Humpback whale	6 or 8	17 July, 1979	52°21' N, 55°31' W	Aerial or boat based survey	7
Humpback whale	1	18 June, 1983	L'Anse au Loup, Lab.	Entrapped in codtrap - alive	9
Humpback whale	1	29 June, 1983	Indian Cove, Lab.	Entrapped in salmon net - dead	9
Humpback whale	1	30 June, 1983	Petty Harbour, Lab.	Entrapped in codtrap - alive	9
Humpback whale	1	13 July, 1984	St. Anthony, NF	Entrapped in gillnet -	10

Species	Number	Date	Location	Circumstances	Source
				released alive	
Humpback whale	1	9 July, 1985	Quirpon, NF	Entrapped in codtrap - released alive	11
Humpback whale	1	16 July, 1985	Petty Harbour, Lab.	Entrapped in salmon net - live release	11
Humpback whale	1	30 Aug., 1985	Camp Islands, Lab.	Entrapped in codtrap - dead	11
Humpback whale	1	1 July, 1986	Cook's Harbour, NF	Whale towed nets off. Later (4 July) caught in Noddy Bay	12
Humpback whale	1	4 July, 1986	Noddy Bay, NF	Whale towing gillnets. By the time it was released it had caught aprx. 50 nets	12
Humpback whale	1	9 Sept., 1986	Camp Islands, Lab.	Entrapped in gillnet(s), whale observed towing gear off	12
Humpback whale	1	1 Sept., 1986	Camp Islands, Lab.	Floating dead - verified by Coast Guard	12
Humpback whale	1	12 May, 1987	Port Saunders, NF	Entrapped in lobster pots and gillnets - released alive	13
Humpback whale	1	21 May, 1987	Port Saunders, NF	Entrapped in gillnets - released alive	13
Humpback whale	1	22 June, 1987	Eddie's Cove, NF	Entrapped in lumpnets - released alive	13
Humpback whale	1	30 June, 1987	Green Island Cove, NF	Entrapped in codtrap - released alive	13
Humpback whale	1	3 July, 1987	St. Anthony, NF	Entrapped in gillnet - whale towed gear off	13
Humpback whale	1	4 Aug., 1987	Battle Harbour, Lab.	Entrapped in salmon net - released alive	13
Humpback whale	1	28 Aug., 1987	Strait of Belle Isle	Entrapped in gillnet - released alive	13
Humpback whale	1	15 July, 1988	Flower's Cove, NF	Entrapped in codtrap - dead	14
Humpback whale	1	19 July, 1988	Eddie's Cove, NF	Floating dead (?) - evidence of gear entrapment	14
Humpback whale	1	19 July, 1988	Griquet, NF	Entrapped in codtrap - self release	14
Humpback whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in codtrap - self release	14
Humpback whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in codtrap - released alive	14
Humpback whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in gillnets - towed gear off	14
Humpback whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in gillnets - towed gear off	14
Humpback whale	1	25 July, 1988	St. Anthony, NF	Entrapped in gillnets - towed gear off	14
Humpback whale	1	28 July, 1989	Murray Harbour, Lab.	Entrapped in codtrap - released alive	15
Humpback whale	1	28 July, 1990	St. Anthony, NF	Entrapped in codtrap - dead	16

Species	Number	Date	Location	Circumstances	Source
Humpback whale	1	30 July, 1990	St. Anthony, NF	Entrapped in salmon net - released alive	16
Humpback whale	1	27 June, 1992	L'Anse Amour, Lab.	Entrapped in salmon net - self release	17
Humpback whale	1	15 July, 1992	Fox Harbour, Lab.	Entrapped in gillnet - released alive	17
Humpback whale	1	24 July, 1992	St. Anthony, NF	Entrapped in salmon - towed gear off	17
Humpback whale	1	25 July, 1992	Main Brook, NF	Entrapped in gillnet - released alive	17
Humpback whale	1	5 Sept., 1992	L'Anse au Loup, Lab.	Entrapped in fishing gear - whale towing gear	17
Humpback whale	1	22 June, 1993	Bird Cove, NF	Entrapped in codtrap - dead, sunk with gear.	18
Humpback whale	1	2 July, 1993	Boat Harbour, Cape Norman, NF	Entrapped in codtrap - dead, part of fluke taken.	18
Humpback whale	1	15 Sept., 1993	Blanc Sablon, Que.	Entrapped in fishing gear - whale towing gear	18
Humpback whale	1	15 Oct., 1993	Red Bay, Lab.	Entrapped in fishing gear - towed gear off	19
Humpback whale	many	6 Jan., 1993	St. Lunaires/Griquet, NF	Unusual sighting - capelin spawning on beach, many humpbacks feeding near beach	19
Humpback whale	1	21 June, 1980	Deadmans Cove, St. Barbe	Entrapped in gillnet - alive	20
Humpback whale	1	18 July, 1980	Eddies Cove East, NF	Entrapped in fishing gear - dead	20
Humpback whale	1	15 Aug., 1980	St. John's Bay, St. Barbe	Entrapped in gillnet - dead	20
Killer whale	4	1 June, 1981	Cape Bauld, NF		23
Killer whale	2	13 June, 1981	Southeast entrance of the Strait of Belle Isle	Aerial survey	1
Killer whale	1	13 June, 1981	Northwest entrance of the Strait of Belle Isle	Aerial survey	1
Killer whale	4	8 July, 1981	20 naut. Miles off Ferolle Pt.		23
Killer whale	3	22 July, 1981	Cape Bauld, NF	Shore watch	1
Killer whale	1	late February 1960	Green Island Cove, Strait of Belle Isle of Belle Isle (51° 22'N, 56° 34'W)	Dead	2
Killer whale	6	2 May, 1953	ca. 51° 30'N, 57° 00' W	Swimming north along edge of icefield	4 (H.D. Fisher)
Killer whale	1	26 June, 1951	50° 40'N, 57° 20' W		4 (M.S. Gordon)
Killer whale	1	19 June, 1951	51° 35'N, 55° 25' W		4 (M.S. Gordon)
Killer whale	3	3 July, 1951	52°13'-53°00' N, 55°50'-55°55' W		4 (M.S. Gordon)
Killer whale	1	17 July, 1953	51°09' N, 57°11' W	Scavenging around longlining vessel	4 (F.K. Spencer)
Killer whale	1	14 Aug., 1951	53°15' N, 56°00' W		4 (M.S. Gordon)
Minke whale	3	21 July, 1981	Cape Bauld, NF	Shore watch	1

Species	Number	Date	Location	Circumstances	Source
Minke whale	1	25 Aug., 1981	Cape Bauld, NF	Shore watch	1
Minke whale	1	26 Aug., 1981	Cape Bauld, NF	Shore watch	1
Minke whale	2	25-26 June, 1981	In the Strait of Belle Isle	Aerial survey	1
Minke whale	1	12-13 July, 1981	In the middle northern section of the Strait of Belle Isle	Aerial survey	1
Minke whale	1	20-21 Aug., 1981	Western end of the Strait of Belle Isle	Aerial survey	1
Minke whale	4 seen singly, 2 pairs and 2 groups of 3-5 individuals	30 June - 7 July, 1975	51°-52°N, 56°-58°W	Boat based survey	3
Minke whale	7 seen singly, 2 pairs and 1 group of 3-5 individuals	9 & 16-21 July, 1975	51°-52°N, 54°-56°W	Boat based survey	3
Minke whale	1	17 July, 1980	Near Flower's Cove, Strait of Belle Isle	Boat or shore based sighting	6
Minke whale	1	11 Aug., 1980	Near Red Bay, Lab.	Boat based sighting	6
Minke whale	few	15-21 June, 1980	Red Bay, Lab.	Shore based sighting (lighthouse keeper)	6
Minke whale	1	4 July, 1984	Belle Isle, NF	Entrapped in codtrap - released alive	10
Minke whale	1	19 June, 1987	North Boat Harbour, NF	Entrapped in lumpnets - whale towed nets off	13
Minke whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in salmon net - dead (?)	14
Minke whale	1	20 July, 1988	Battle Harbour, Lab.	Entrapped in salmon net - dead (?)	14
Minke whale	1	22 July, 1988	Labrador Ferry	Decomposed, floating	14
Minke whale	1	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial Survey	22
Minke whale	2	late Aug-early Sept., 1995	near L'anse au Clair	Aerial Survey	22
Minke whale	1	late Aug-early Sept., 1995	near Blanc Sablon	Aerial Survey	22
Minke whale	1	late Aug-early Sept., 1995	St. John Bay	Aerial Survey	22
Pilot whale	very large herd	12 Aug., 1953	Ingornachoix Bay, NF	Mixed with tuna *Thunnus thynnus* L.	4 (F.K. Spencer)
Pilot whale	2 or 3	24 June, 1980	Pointe Barque, Quebec	Boat or shore based sighting	6
Pilot whale	4	14 Dec., 1990	St. Anthony, NF	Dead; old	16
Pothead whale	3	13 July - 27 Oct., 1981	In the Strait of Belle Isle	Aerial survey	1
Pothead whale	1	30 Nov., 1980	L'Anse aux Meadows, NF	Dead	20
Rorqual (probably a Fin whale)	1	28 March, 1968	Port aux Choix (50° 42'N, 57° 25'W)	Dead (caught in ice), found floating in the water, identified by Fishery Officer	2
Rorqual (probably a Fin	4	before 22 April, 1968	Forteau and Fox Cove, Labrador (51° 23'N, 57°	Dead (caught in ice)	2

Species	Number	Date	Location	Circumstances	Source
whale)			00'W)		
Rorqual (probably a Fin whale)	3	before 22 April, 1968	Hawke Bay (50° 40'N, 57° 20'W)	Dead (caught in ice)	2
Sperm whale	1	14 Oct., 1981	Reefs Harbour, NF	Remained alive in small estuary for 1 week, then beached and died	5 (J. Lien data)
Unidentified dolphins	63 (from six different groups)	29 June - 18 Aug., 1981	In the Strait of Belle Isle	Ship and shore watches	1
Unidentified whale	1	16 July, 1979	52°20' N, 55°31' W	Aerial or boat based survey	7
Unidentified whale	1	16 July, 1979	52°21' N, 55°31' W	Aerial or boat based survey	7
Unidentified whales	4	16 July, 1979	52°21' N, 55°31' W	Aerial or boat based survey	7
Unidentified whales	2	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial survey	22
Unidentified whales	3	late Aug-early Sept., 1995	southwest Strait of Belle Isle	Aerial survey	22
Unidentified whales	1	late Aug-early Sept., 1995	St. John Bay	Aerial survey	22
Unknown whale	2	13 Aug., 1980	Port Saunders, NF	Boat based sighting	6
Unknown whale	1	20 June, 1983	L'Anse au Loup, Lab.	Entrapped in codtrap - alive	9
Unknown whale	1	1 July, 1983	Port aux Choix, NF	Entrapped in codtrap - alive	9
White beaked dolphins	28	24 July and 9 Sept., 1981	North coast of the Strait of Belle Isle	Aerial survey	1
White beaked dolphins	49 (from 5 different groups)	22 July - 14 Aug., 1981	South coast of the Strait of Belle Isle	Shore watches	1
White beaked dolphins	2 or 3	16 July, 1979	52°21' N, 55°31' W	Aerial or boat based survey	7
White beaked dolphins	3 or 4	17 July, 1979	52°21' N, 55°31' W	Aerial or boat based survey	7
White beaked dolphins	6	late Aug-early Sept., 1995	northeast Strait of Belle Isle	Aerial survey	22
White beaked dolphins	3	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial survey	22
White beaked dolphins	22	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial survey	22
White beaked dolphins	25	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial survey	22
White beaked dolphins	7	late Aug-early Sept., 1995	Strait of Belle Isle	Aerial survey	22
White beaked dolphins	3	late Aug-early Sept., 1995	southwest Strait of Belle Isle	Aerial survey	22
White sided dolphins	total of 14 in nearshore waters	14 June - 19 Dec., 1981	In the Strait of Belle Isle or in Notre Dame Bay	Aerial surveys	1
White sided dolphins	13	5 Sept., 1981	East of St. Anthony	Incidental sighting (seen with 9 plunge-diving	1

Species	Number	Date	Location	Circumstances	Source
				gannets)	
White sided dolphins	19	late Aug-early Sept., 1995	Brador Bay	Aerial survey	22
White sided dolphins	20-25	21 Aug., 1954	20 miles north of St. Lewis Sound, Lab.	Sight record from M.S. Gordon	4

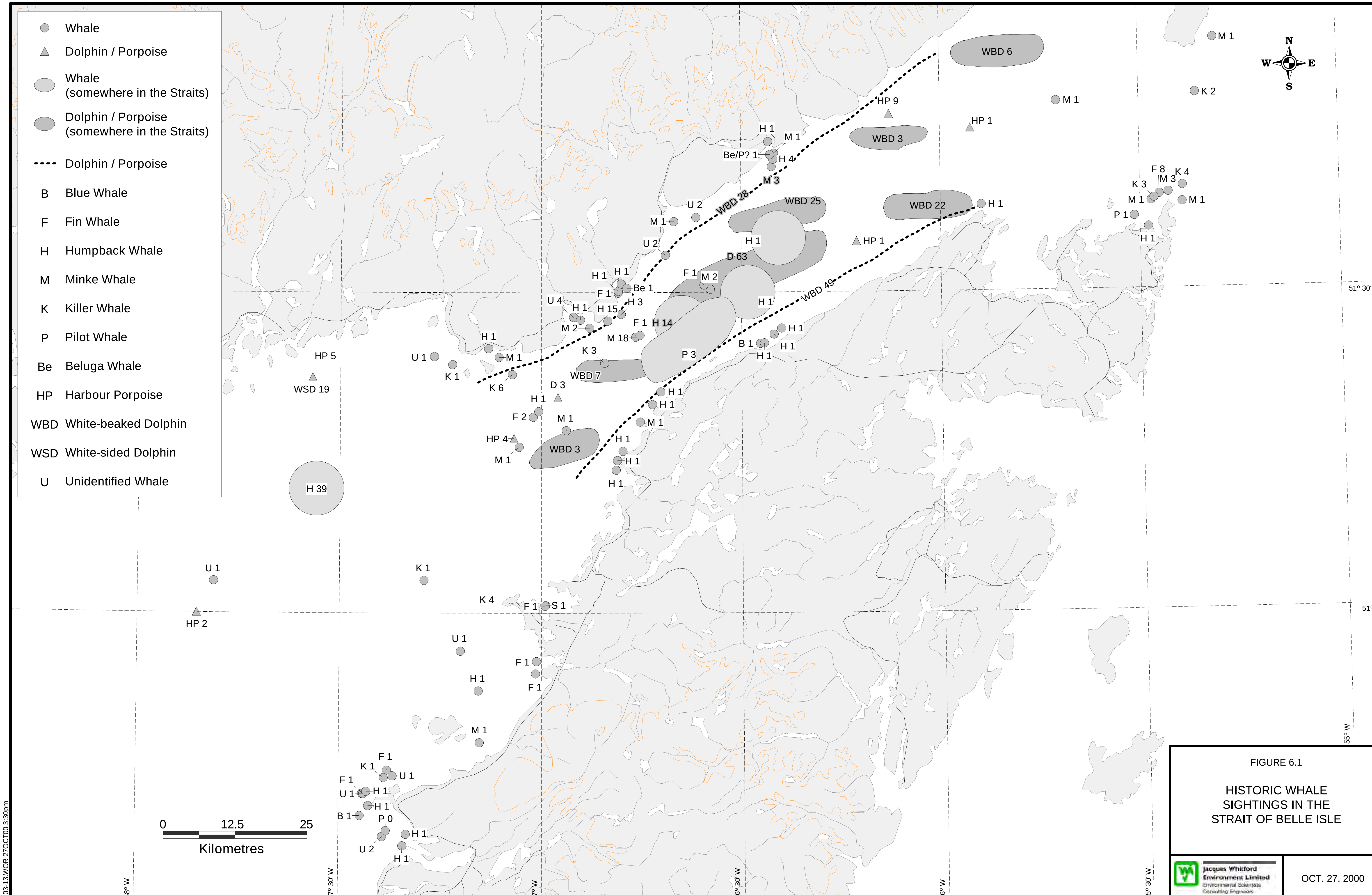

FIGURE 6.1

HISTORIC WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

OCT. 27, 2000

Fin (*Balaenoptera physalus*) and blue (*Balaenoptera musculus*) whales are infrequently reported. Only two records of blue whales occurring near the Strait of Belle Isle were found in the literature, and both of these were dead animals that washed ashore. Although these species are highly conspicuous, they are not as widely known as humpbacks (*Megaptera novaeangliae*) and minkes (*Balaenoptera acutorostrata*), and would be less likely to be correctly identified. The cluster of stranded fin and blue whale records for Port au Choix (Figure 6.2), likely died elsewhere in the Gulf of St. Lawrence and were carried by the Gulf current, where they hung up on the headland at Port au Choix. Similarly, all fin whale records for the western side of the Northern Peninsula (St. John and St. Margaret Bays) are dead animals. Their positions along the southwestern side of the Strait of Belle Isle are most likely a result of passive drift with the Gulf current. Other records of fin whales appear to be randomly distributed throughout the Strait. The large number near Cape Bauld (Figure 6.2) is an artifact of a concentrated survey effort there from July 21 to August 12, 1981 (Table 6.1).

Humpback whales appear to be common in the Strait from May to August (Figure 6.3), with greatest numbers recorded in June and July. This species is the most frequently reported and abundant of the large whales. Most reports refer generally to “The Strait of Belle Isle”. However, references to specific locations indicate that the area between Point Amour and L’anse au Loup is a preferred area. This record is probably not biased, as observation efforts here are likely no different from any other community in the Strait. The cluster of observations in the Port au Choix area represent entrapments in fishing gear. It is difficult to determine whether these whales were attracted to the area to feed, or if they simply encountered fishing gear in this area en route to other feeding areas, due to the local physiography.

Minke whales also seem common in the Strait of Belle Isle from May to August, with the majority of minke sightings occurring during the months of July and August (Figure 6.4). Minkes were also reported more frequently in September than humpbacks. Minkes are less conspicuous than humpbacks, with blows that are smaller and more diffuse, and sometimes near impossible to see. These data suggest that minkes are more common than humpbacks in September. Minkes have been sighted throughout the Strait of Belle Isle and it is difficult to ascertain areas of concentration. However, they do appear to have been sighted more often on the northern (Labrador) side of the Strait (Figure 6.4). The minke records for the Cape Bauld area result from shore-based observations on three occasions in July and August of 1981.

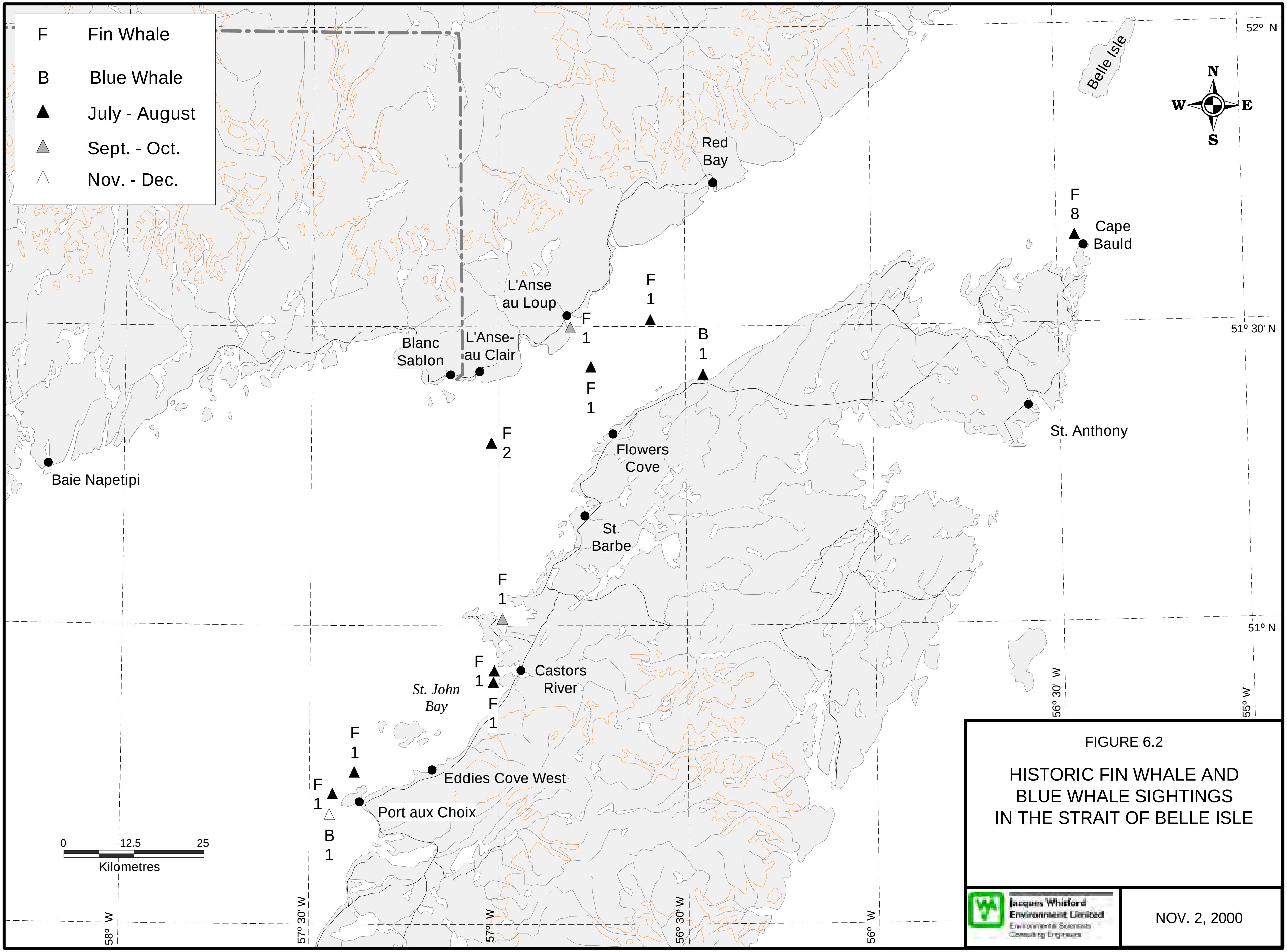

FIGURE 6.2

HISTORIC FIN WHALE AND BLUE WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

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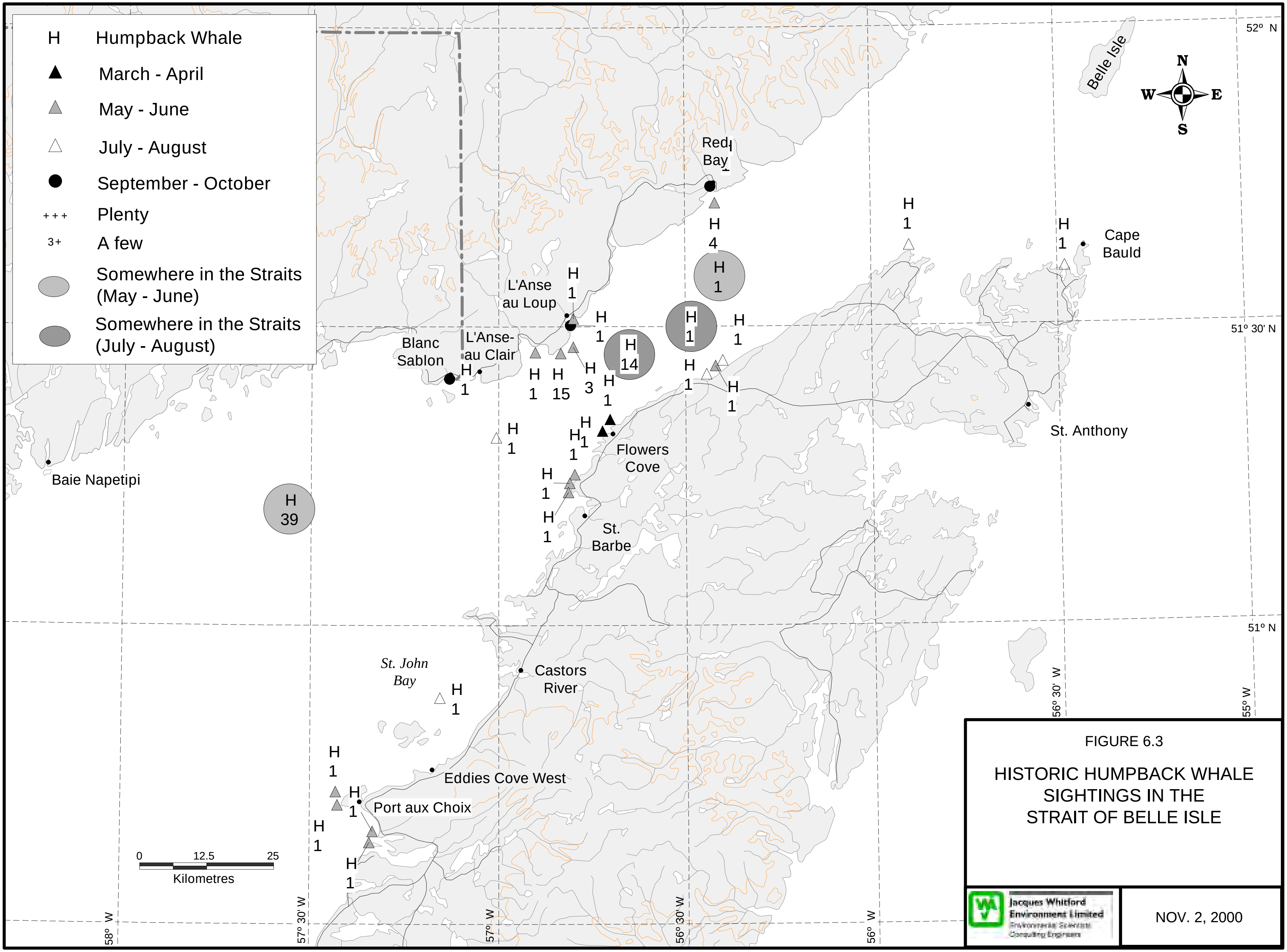

FIGURE 6.3

HISTORIC HUMPBACK WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

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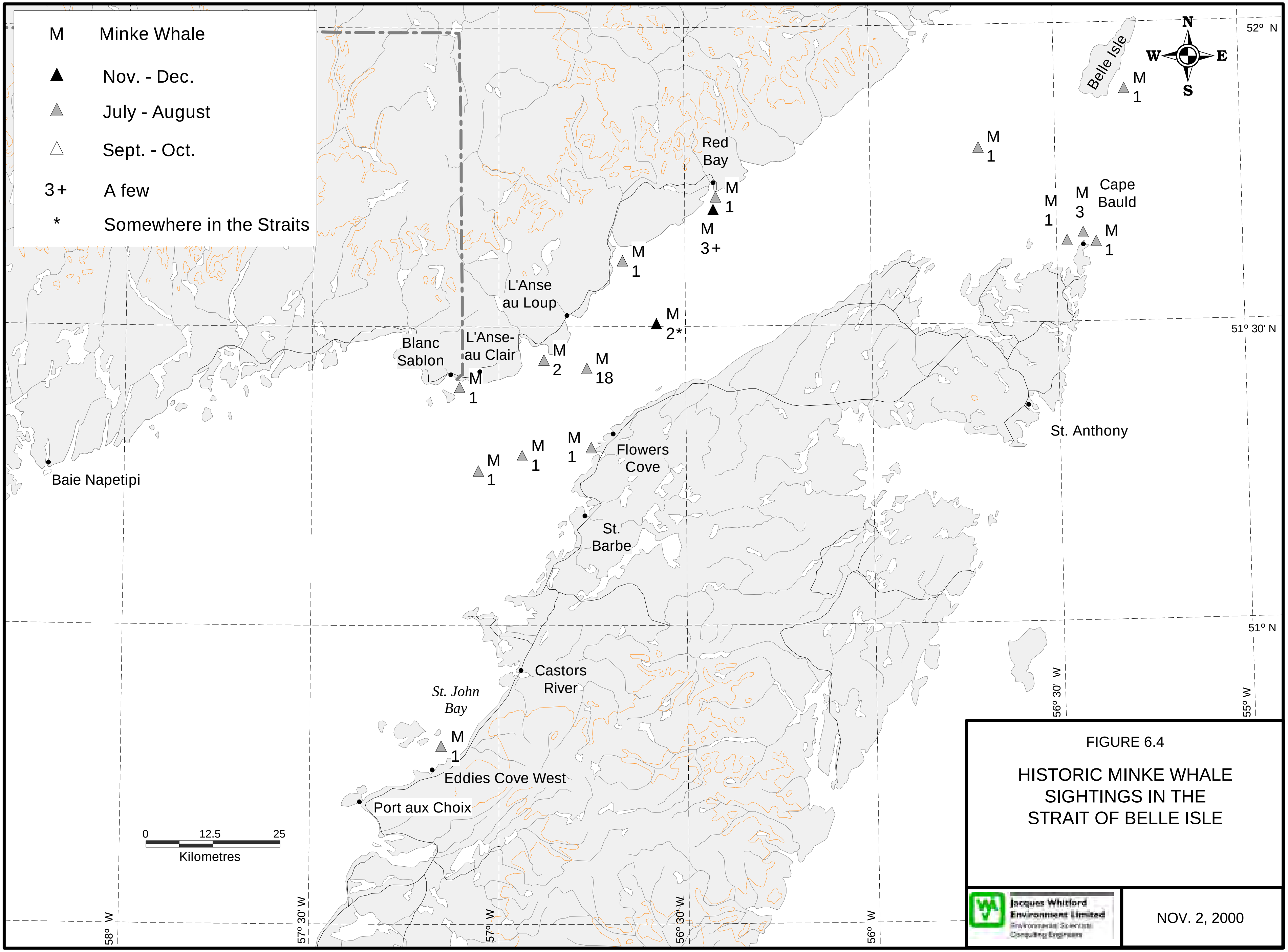

FIGURE 6.4

HISTORIC MINKE WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

1203-10.WOR 02NOV00

White-beaked dolphins (*Lagenorhynchus albirostris*) are also very commonly reported throughout the Strait of Belle Isle (Figure 6.5). Reported observations cite coastal Newfoundland and Labrador, as well as many general references to the "Strait of Belle Isle". This species, though small, is fairly conspicuous when demonstrating certain behaviours. Locally known as "jumpers", white-beaked dolphins travel in small groups and often jump out of the water while swimming. Like many other dolphins, they will also ride a vessel's bow wave. Atlantic white-sided dolphins (*Lagenorhynchus acutus*) have been reported only once near the Quebec north shore (Figure 6.5).

Records for live harbour porpoise (*Phocoena phocoena*) are scarce (Figure 6.5). Harbour porpoises are small and inconspicuous, with a dorsal fin that is easily confused with small waves. This species is visible at close range, and only under very calm sea states; conditions which are not common in the Strait of Belle Isle. However, a large incidental catch of harbour porpoise has been documented in the northern Gulf of St. Lawrence, largely resulting from entrapment of these animals in groundfish gill nets while foraging for capelin and herring. The impact of by-catch on the harbour porpoise population in this region is unknown due to insufficient information on the population size (Fontaine et al. 1994). A reported 1,900 porpoises were taken in 1989/1990 in fishing gear in the northern Gulf, western Gulf and St. Lawrence estuary regions (Palka et al. 1996). One of the highest by-catch rates, as determined from a 1992 survey, was the northeastern Gulf region. A reported four to five harbour porpoises were taken per ton of fish landed. However, the absence of a measure of total fishing effort precluded estimation of the total by-catch (Palka et al. 1996).

Killer whales (*Orcinus orca*) have been seen occasionally in the Strait (Figure 6.6). Sightings are infrequent but recurring, having been reported at different times between 1951 to 1981 (Table 6.1). There is no obvious pattern of abundance to suggest preferred areas. They likely enter the Straits on their migration along the Labrador coast each year.

Pilot whales (*Globicephala melanena*) have been reported very infrequently, and are not likely common to the area (Figure 6.7). One large herd was reported in Ingornachoix Bay in August, 1953 (Table. 6.1). There is only one record of a beluga whale (*Delphinapterus leucas*), seen stranded in L'anse au Loup in July 1993 (Figure 6.7; Table 6.1). An undetermined beluga or pilot whale was seen dead a month later in Red Bay. It is quite likely the same animal; a vagrant from the St. Lawrence Beluga population, possibly.

There is only one sperm whale (*Physeter macrocephalus*) record for the Strait of Belle Isle. This rare species was seen in Reefs Harbour (Figure 6.8; Table 6.1) in October 1981, and later died.

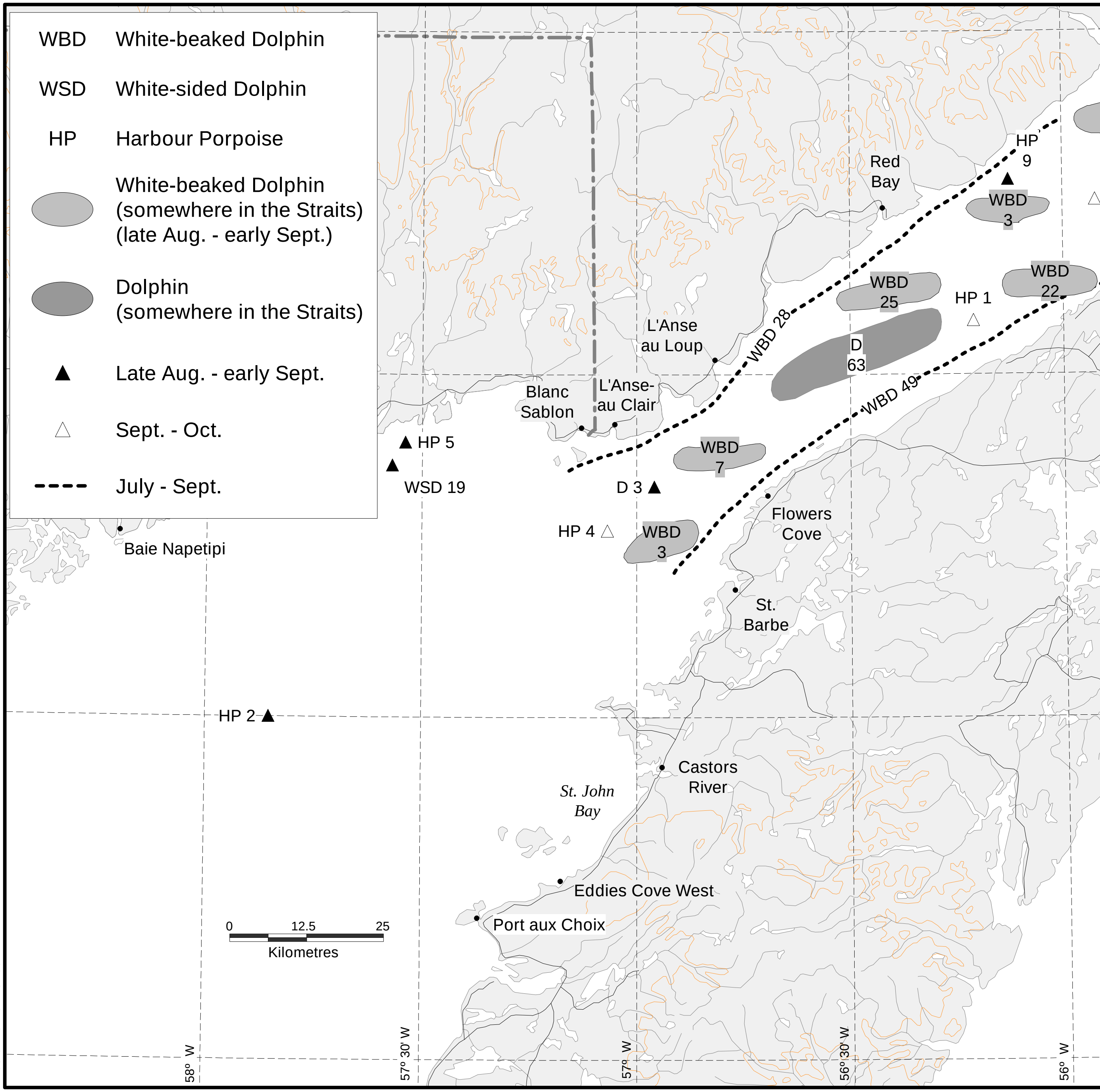

FIGURE 6.5

HISTORIC DOLPHIN AND PORPOISE SIGHTINGS IN THE STRAIT OF BELLE ISLE

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Consulting Engineers

NOV. 2, 2000

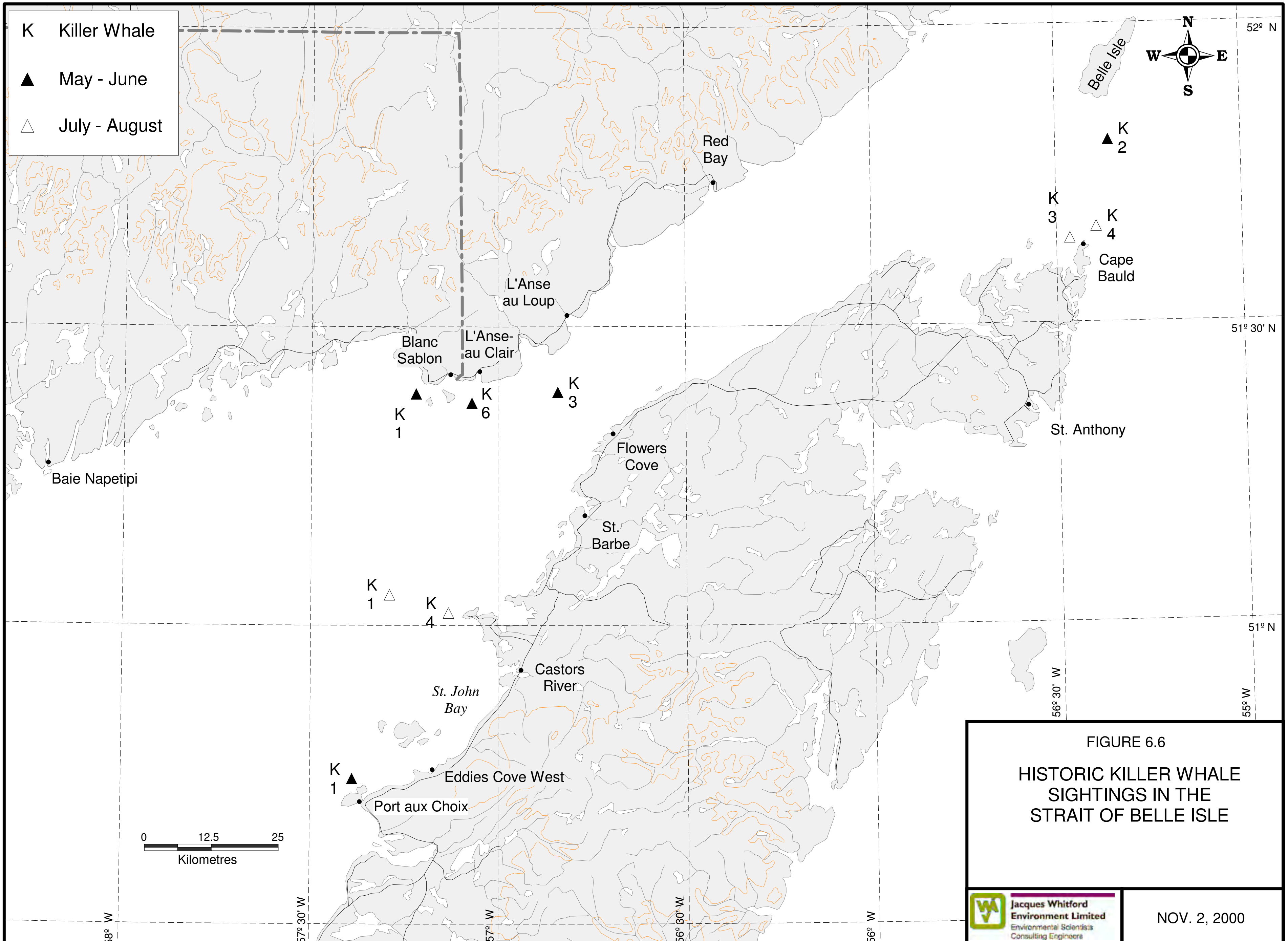

FIGURE 6.6

HISTORIC KILLER WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

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Consulting Engineers

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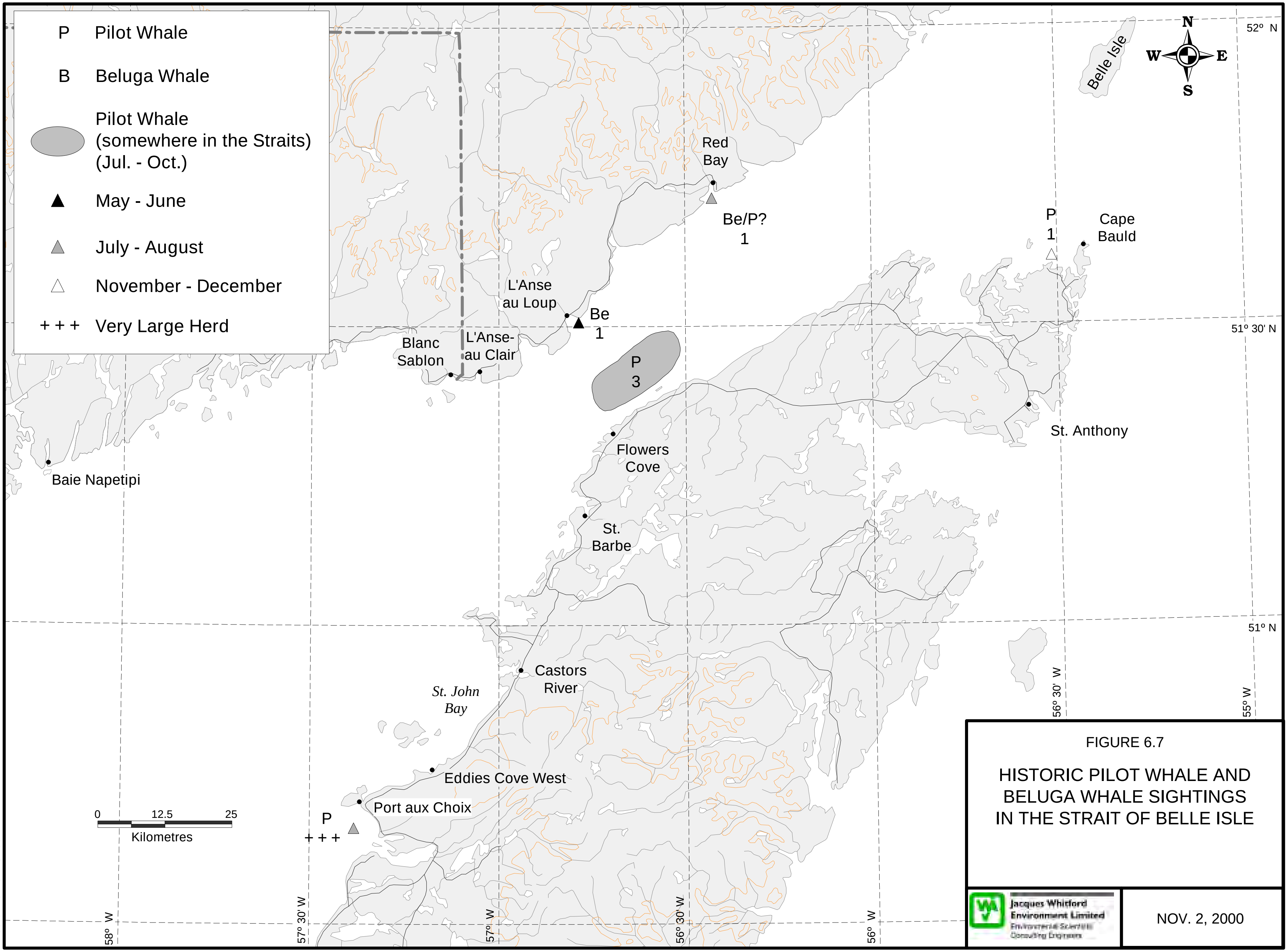

FIGURE 6.7

HISTORIC PILOT WHALE AND BELUGA WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

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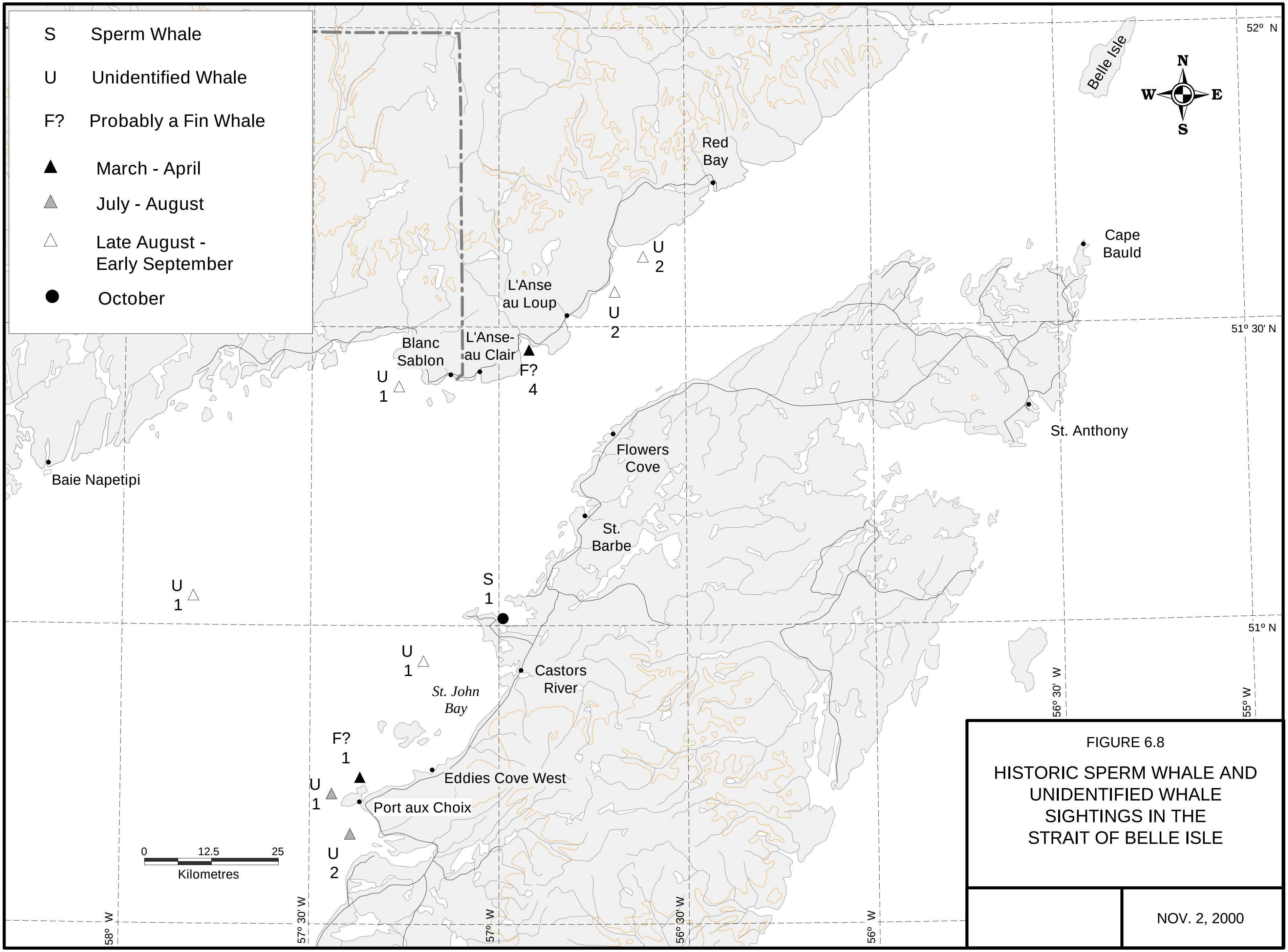

FIGURE 6.8

HISTORIC SPERM WHALE AND UNIDENTIFIED WHALE SIGHTINGS IN THE STRAIT OF BELLE ISLE

NOV. 2, 2000

Sightings of unidentified whales are also presented in Figure 6.8. The distribution of unidentified whales is primarily near-shore, and is a result of entrapment or stranding. Reports were probably made because of the unusual circumstances, thus biasing the data for near-shore observations. Also, it is not possible to determine whether the whales were actively feeding in the area, or if they were caught in gear en route to another destination. These records therefore offer little in terms of interpreting natural distributions.

6.1.2 Seals

The only reference to seal populations are from aerial surveys conducted in 1981 and 1982 (Figure 6.9, Table 6.1). These surveys indicated that harp seal (*Phoca groenlandica*) herds are present in early spring, in association with pack ice. The only historical hooded seal (*Cystophora cristata*) record is an individual animal seen in April, 1981. There are two records of harbour seal (*Phoca vitulina*), seen in September, 1981. Harp and hooded seals are known to migrate through the Strait of Belle Isle during winter, on their way to their breeding grounds near the Magdalen Islands and during the spring on their way to feeding grounds along the Labrador and Greenland coasts.

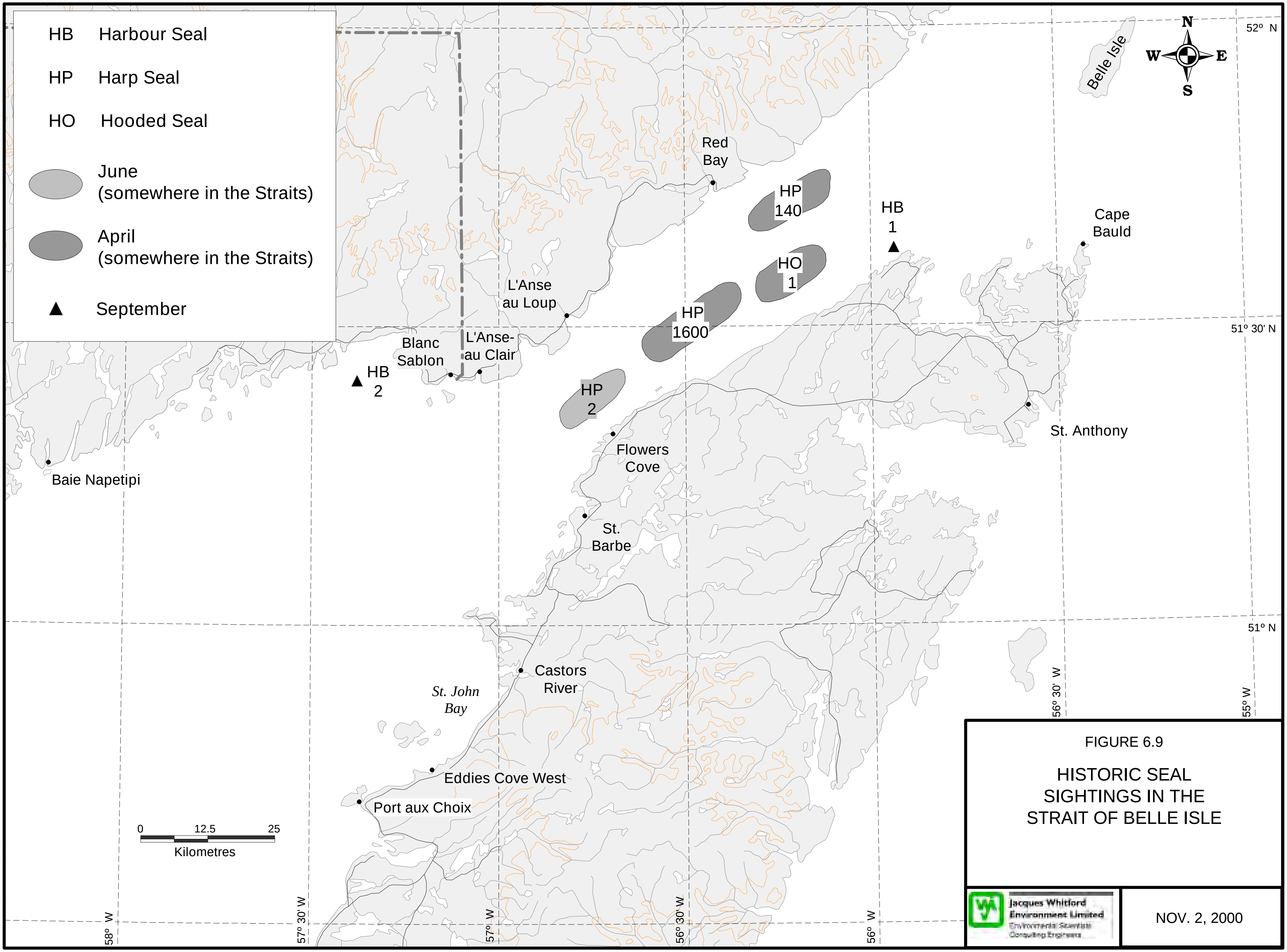

FIGURE 6.9

HISTORIC SEAL SIGHTINGS IN THE STRAIT OF BELLE ISLE

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6.2 Effects of Construction on Marine Mammals

The following is a synopsis of a literature search on the effects of underwater construction noise, a project-related effect that could interact with marine mammals. Other relevant references are provided in Section 8.2.

Sound travels efficiently through water and there is concern regarding deleterious effects of man-made noise on marine mammals. This could happen through interference with the mammal's ability to detect calls from others, echolocation pulses, or other important natural sounds (Richardson et al. 1995). It has been documented in the literature that blasting and underwater construction can have behavioural, physiological and psychological effects on marine mammals (e.g., Wright 1981; Myrberg 1990; Ketten 1995; Lien 1995).

Blasting is the strongest point source of sound in the ocean, with the possible exception of strong earthquakes and volcanic eruptions. Pressure pulses, caused by marine explosions, are known to cause injury and death in marine mammals (Richardson et al. 1995). One of the physiological effects of blasting on marine mammals is injury causing temporary or permanent reductions in hearing sensitivity. Since marine mammals rely heavily on acoustic cues for communication and navigation, the effects of acoustic trauma have been well studied.

Ketten (1995) examined the physical parameters of two underwater detonations of Class A explosives (TNT derivatives with fast rise-time waveforms), for their potential to induce blast injury and acoustic trauma in marine mammals. Ketten (1995) also examined differences in the structure of the ear in marine versus land mammals, and how these anatomical differences may affect the incidence and severity of acoustic trauma. The concepts of temporary versus permanent threshold shifts are summarized.

The results of an in-air auditory testing study on a harbour seal (Kastak and Schusterman 1996) indicated that exposure to broadband construction noise for six days, averaging 6 to 7 hours of intermittent exposure per day, resulted in a temporary threshold shift (TTS) of 8 dB at 100 Hz. In addition, the animal's false alarm rate increased from 7% in the pre-exposure session to 30% in the post-exposure test session. Following one week of recovery, the seal's threshold was within 2 dB of its original level, and the false alarm rate was less than 10%. The data suggest that TTS can be induced in seals, and that the seal may have suffered from tinnitus, resulting in a reduced ability to distinguish signal-present from signal-absent trials.

In a discussion paper on the effects of explosives in fish and marine mammals in the waters of the Northwest Territories, Wright (1981) noted that underwater shock waves resulting from the detonation of high velocity chemical explosives have been demonstrated to be lethal to marine mammals, and sublethal damage to their auditory systems could occur at considerable distances from explosions. Seismic exploration surveys in seal pupping areas may result in an abandonment of prime habitat and may weaken the mother-pup bonding response, resulting in decreased survival of the pups.

Wright (1981) also reviewed the methods that have been developed to predict the damage zone for underwater explosions. These include peak pressure (P_{max}), energy flux density (E_f) and impulse (I). Wright (1981) concluded that the impulse model is the best of these in predicting lethal and safe ranges and has been chosen by the Department of Fisheries and Oceans to predict the zone of damage to fish and marine mammals.

Lien and Borggaard (1995) compared the behavioural and physiological manifestations of marine blasting that occurred at the Bull Arm site, Trinity Bay, Newfoundland. Blasting was required for infrastructure construction and subsequent towing of the platform to deeper water. The blasting program coincided with peak abundance of humpback whales which were feeding in the area. Observations of fishermen indicated that whale collisions with their fishing gear increased during blasting. A monitoring program was undertaken to identify individual whales and track their movements and behavior. Initial results indicated no measurable effects of blasting on whale abundance or movements. However, the incidence of collisions with fishing gear were higher during the period of most frequent blasting and highest whale abundance (in 1992-93) compared with long term rates of such events documented in the study area.

Whales orient to objects by echolocation. A shift in threshold, or damage to hearing could result from exposure to intense underwater noise, and affect their ability to detect and avoid fishing gear. Dead whales removed from fishing gear near the site of the construction and from non-industrial areas were autopsied and their ears examined. Ears from whales that died near the construction site showed damage. By examining orientation performance, and with the opportunity to examine ears of dead whales, this study provided new data regarding the impact of explosions on cetaceans that has not been previously available. Results suggest that avoidance behavior alone, the primary data used to evaluate the impact of explosions on whales, is not adequate and that evaluations of hearing and orientation abilities is required, as the effects may be more pronounced than previously believed.

In a study of the possible effects of offshore oil and gas development on marine mammals, Geraci and St. Aubin (1979) investigated the possible physiological, behavioral and psychological effects of offshore oil development activities on marine mammals. These activities include shock waves from explosions. It was determined that shock waves with high peak pressures and rapid rates of pressure can result in damage and death in living organisms. The authors also determined that impact noise, such as explosions, evoke a startle reflex on marine mammals. Some respond to impact noise by sounding, aggregating, or dispersing and subsequently regrouping the social structure.

Low-frequency sound may also affect marine mammal behavior. In a review of the effect of low-frequency sound on marine mammals (NRC 1994), it was concluded that human-made noise affects the ability of marine mammals to communicate and to receive information about their environment. High levels of human-made sound can cause disruptions in marine mammals, such as frightening, annoying or distracting the animals, which can lead to physiological and behavioural disturbances.

The National Research Council reviewed current literature on the effect of low frequency sound on marine mammals (NRC 1994), and provided an objective overview of the current state of knowledge. The report recommended changes in the U.S. regulatory structure for reducing regulatory barriers and facilitating valuable research, and recommended further research that would provide some of the missing information on the effect of low-frequency sound on marine mammals. The authors concluded that human-made noise can be assumed to affect the ability of marine mammals to communicate and receive information about their environment.

Another review of the effects of man-made noise on the behavior of marine animals (Myrberg 1990) reports similar findings. Field studies have shown aversion by various whales to the noise accompanying offshore petroleum exploration and production. Variation in response involves level of source-noise, on-going activity at the time of exposure and, to an uncertain degree, the species involved.

One such field study assessed the effects of industrial activity on humpback whales, minke whales, and harbor porpoise, at Bull Arm, Trinity Bay, Newfoundland, in association with the construction of the gravity-based structure (Bohggard 1996). Tracking individual animals provided some evidence of the short-term effects from industrial activity. In 1994, when dredging was the predominant activity, humpback whales were less likely to be resighted near the industrial activity and exhibited movement away from the site; no such changes were observed during blasting in 1992 (Todd et al. 1996) or during vessel activity in 1995. Humpback resightings and residency were comparatively higher in 1995 than in other years. Furthermore, minke whale resightings occurred in an area of heavy vessel activity in 1995. Reactions by individual cetaceans appeared to depend on the type of industrial activity.

Resightings of individually identified animals between years suggested long-term effects of industrial activity on cetaceans. Humpback whales photo-identified in Trinity Bay in 1992 were observed less frequently in Newfoundland in 1993 than were whales identified in other inshore bays. In addition, a lower proportion of humpback whales identified in Trinity Bay in 1992 were resighted in Newfoundland in 1993, compared with animals identified in an undisturbed area. Individual minke whales were resighted in the industrial area in a subsequent year. Individually identified whales, monitored for several years, were a more sensitive indicator of long term impacts of anthropogenic than abundance, distribution, and respiration measures.

Richardson and Green (1990) conducted a study to determine reactions of bowhead whales (*Balaena mysticetus*), to drilling and dredging noise in the Canadian Beaufort Sea. Bowheads were monitored for their behavioral response to seven 30 to 40 minute underwater playbacks of recorded drillship and dredge noise. Some bowheads oriented away when received noise levels and spectral characteristics were comparable to those several kilometers from actual drillships and dredges. During some playback tests, call rates decreased, feeding ceased, and cycles of surfacing, respiration and diving may have changed. Sensitivity of various whales to noise differed. Roughly half responded when the received level of noise was about 115 dB re 1 mu-Pa on a broadband basis, or about 110 dB in one 1/3-octave band (20 to 30 dB above ambient). Such levels occurred 3 to 11 km from a drillship and dredge in the Canadian Beaufort Sea. Bowheads occasionally were seen less than 5 km from actual drillships and dredges, where received noise levels were at least as high as during our brief playbacks. Thus, some bowheads may habituate to prolonged noise exposure. Alternatively, only the less sensitive individual whales may occur less than 5 km from drillships and dredges.

6.3 Survey Results

6.3.1 Marine Mammals

Estimated total visible numbers for each species are presented in Table 6.2. These estimates are of visible numbers, and no corrections have been applied either for the diving behavior of the animals, the possible variability in observer acuity or the effects of weather, all of which may prevent available animals from being detected. Total numbers, especially of species with long dive times, may be several times the tabulated estimates. These biases do not prevent making definite statements about the seasonal presence of different species, their distributions, or although with a little less confidence, species composition.

6.3.1.1 Blue Whale

Three blue whales were spotted during the 1998 surveys (Figure 6.10). The three were spotted together on August 29 near some fishing vessels on Transect 18, a few kilometres from Blanc-Sablon. The blue whale is designated as vulnerable by COSEWIC in 1998 and is not numerous in the Gulf. It is a regular summer visitor in some areas, including areas off the Mingan Island in the northern Gulf, Pointe des Monts in the north-western Gulf, and Les-Escoumins–Forestville in the St. Lawrence estuary. No previous reports would have led to an expectation of numerous blue whales in the Strait of Belle Isle.

6.3.1.2 Minke Whale

The aerial survey estimate of minke whale numbers is small relative to the boat survey (Tables 6.2 and 6.3); this species is not easy to see from any platform but especially difficult from a moving aircraft. Kingsley and Reeves (1998) estimated about 700 visible on an aerial survey for the whole northern Gulf, and this species is ubiquitous. If observers on the boat survey tended to underestimate distances, the line-transect ESW would be underestimated, and numbers overestimated, in the same proportion. However, minke whales are not too hard to detect close to a boat, as they surface quite frequently.

Table 6.2 Estimated Average Visible Numbers of Common Cetaceans During the Boat (Transects 14-18) and Aerial Surveys

Species	Dates	Beaufort	Estimated Numbers	
			Boat†	Aerial‡
Harbour porpoise	04/08–01/09	1		5580*
Harbour porpoise	05/08–07/10	1–3	840	
White-beaked dolphin	29/08–29/10	1–3	940	
Minke whale	04/08–19/09	1–2		90
Minke whale	05/08–18/09	1–4	200	
Humpback whale	09/07–01/09	1–3		60
Humpback whale	05/08–18/09	1–4	40	

† Estimated numbers are those mammals visible on or near the trackline, in the given Beaufort sea states, averaged over the survey dates given.

‡ Estimated numbers visible at the optimal distance to airborne observers (700 feet in a flat-windowed aircraft), in the given Beaufort sea states, averaged over the survey dates given

* This estimate of harbour porpoise numbers assumes that densities measured on transects in Beaufort sea state 1 can be extended to parts of the study area where such sea states were never obtained. If this assumption is erroneous, this estimate of numbers would be too high, possible by a factor of about 2.

Figure 6.10 Mean Number of Sightings of Marine Mammals in the Strait of Belle Isle (Boat Survey)

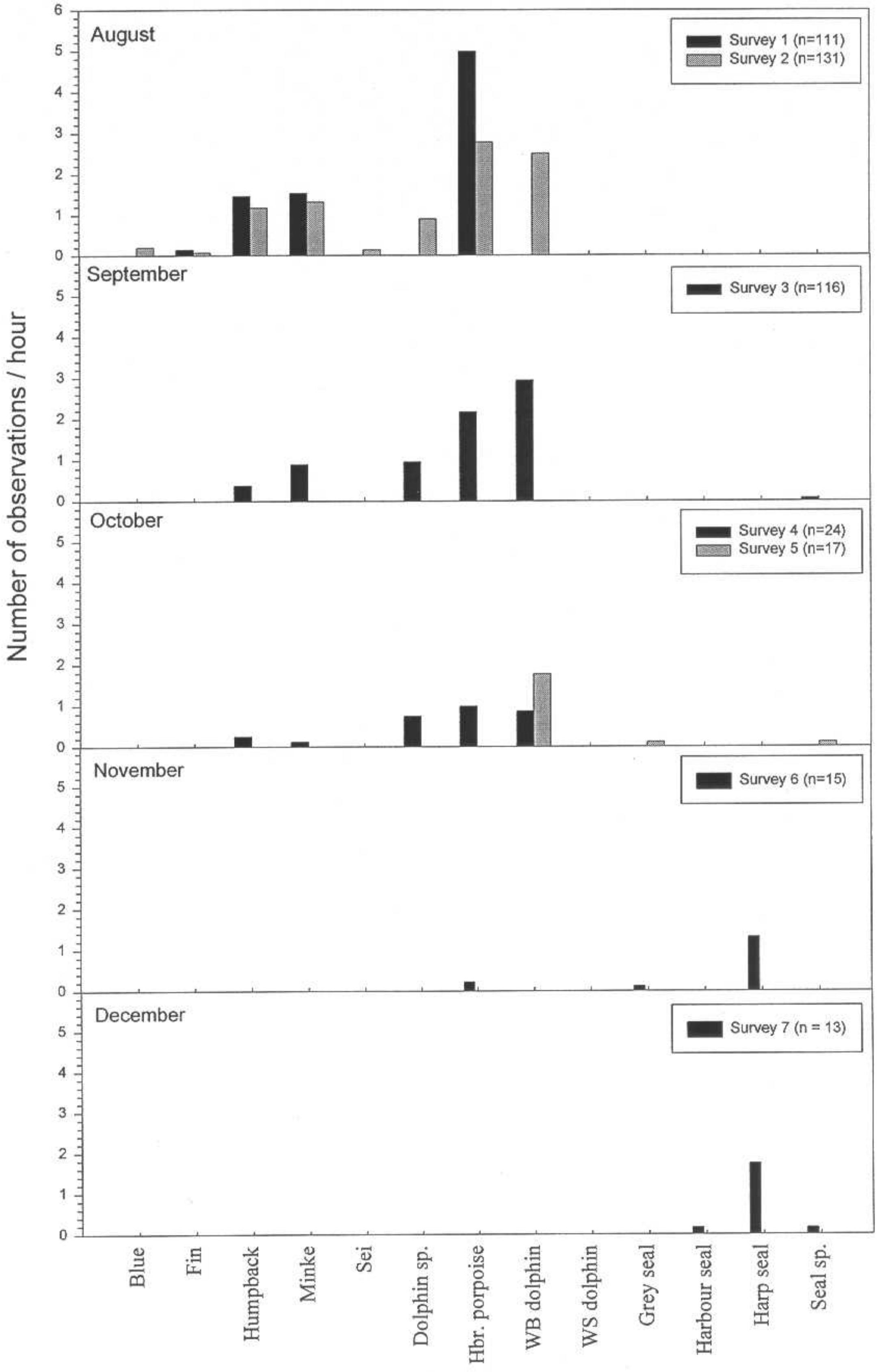

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Table 6.3 Encounter Rates (per 100 Km) for Minke Whales in Aerial and Boat Surveys of the Belle Isle Strait Narrows

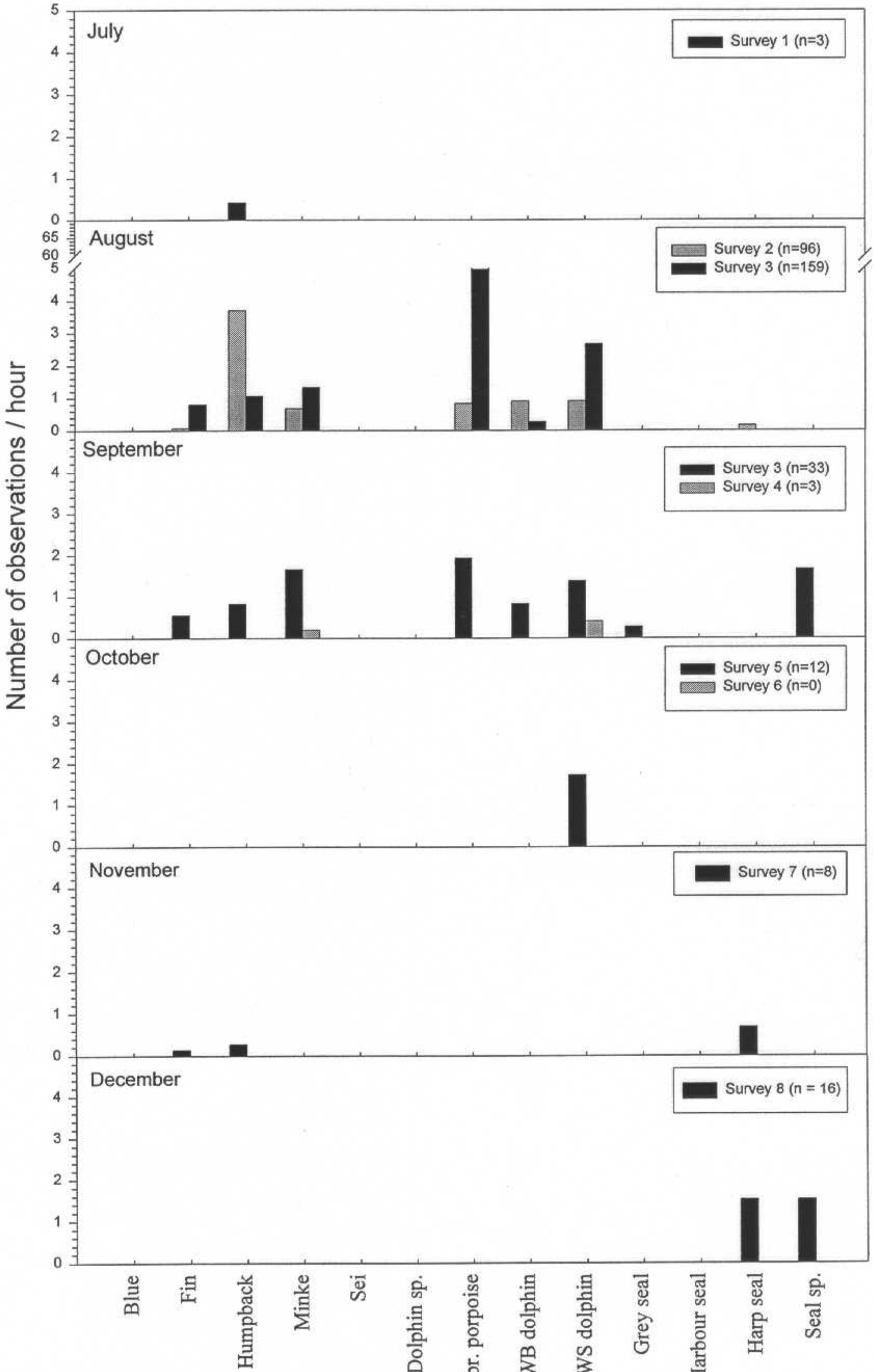
Transect	Boat Survey (all weather)			Aerial Survey (Beaufort 1 & 2)		
	2	3	4	2	3	4
14	0	3.05	9.15	0	0	0
15	0	7.04	10.6	0	0	0
16	2.75	16.5	13.7	0	2.19	0
17	9.09	3.64	1.82	0	3.12	0
18	11.7	0	2.93	--	0	0

Minkes are most abundant during August and September, encompassing over 98% of total observations. Just a single sighting was recorded after September (Figure 6.11). These data correspond well with historical observations (Section 6.1.1), which suggests that minkes were common from May to August, with greatest numbers in July and August. The historical records also show that minkes were more common than humpbacks in September, which also agrees with our data from 1998. Peak abundance likely corresponds to the arrival of capelin to the area.

It appears as if the aerial observers saw overall far fewer minke whales than the boat observers. Of the transects covered by the boat in surveys 2, 3, and 4, the boat saw minke whales on 12 of 15 combinations of transect and survey, the aerial survey saw minkes on only 2 (Table 6.3). This result is not surprising, as the short, discrete surfacing of minke whales makes them a poor subject for aerial surveys. The visible number estimates attained from the boat survey are therefore likely more accurate.

The distribution of all minke observations during the baseline survey in 1998 is illustrated in Figure 6.12. There appear to be more minkes on the Labrador side of the Strait, which supports the apparent historical trend (Figure 6.4). Also, minkes seem to be concentrated in the most narrow section of the Strait, between L'Anse Amour and Blanc Sablon, on the Labrador/Quebec side.

Figure 6.11 Mean Number of Sightings of Marine Mammals in the Strait of Belle Isle (Aerial Survey)



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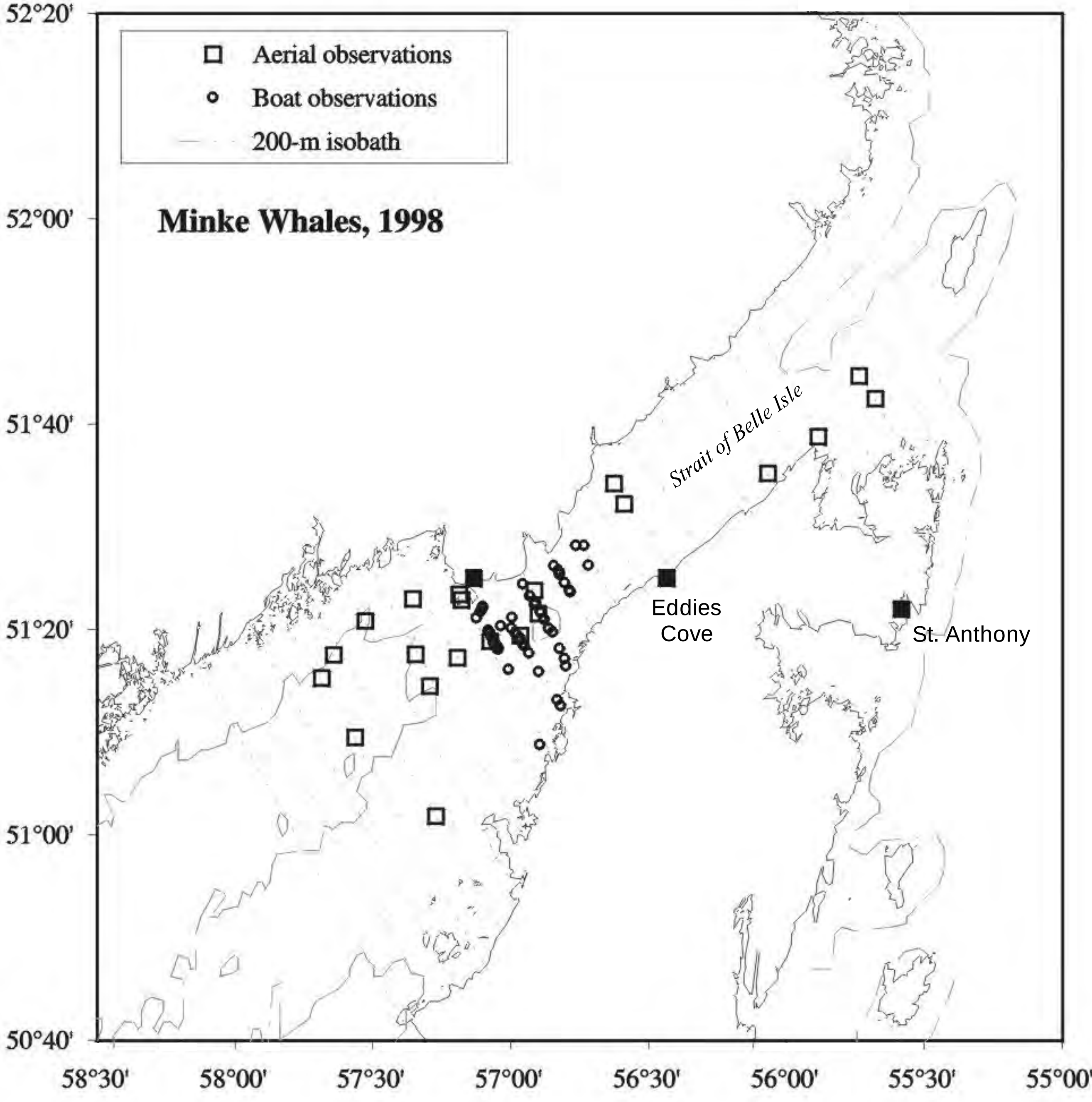

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FIGURE 6.12

DISTRIBUTION OF MINKE WHALE OBSERVATIONS

6.3.1.3 Fin Whale

The distribution of fin whale sightings was mostly in the northeastern Gulf, apparently associated with the 200 m depth contour, but one sighting was also made near Cape Bauld. In the Strait, fin whales were relatively infrequent during our surveys, as the historical observations indicate. They were most abundant in August (Figures 6.10 and 6.11), near the west end of the 1998 study area (Figure 6.13). During the summers of 1995 and 1996, the fin whale was the most abundant of the large whales on the north shore of the Gulf (Kingsley and Reeves 1998). The fin whale is designated as vulnerable by COSEWIC (1998).

6.3.1.4 Long-Finned Pilot (Pothead) Whale

The pilot whale is common in Newfoundland waters during the summer and may remain up to late autumn (Sergeant and Fisher 1957). The distribution of pilot whales is closely correlated with that of the squid (*Illex illecebrosus*), the primary prey of the pilot whale. The times of arrival and disappearance of the squid appear to be determined mainly by water temperatures (preferred range being 5 to 15^{o}C) and hence the distribution of the pilot whale is related to hydrographical conditions (Sergeant and Fisher 1957). Pilot whales are known to summer in the coastal waters of southern Labrador and in the Gulf of St. Lawrence; they move offshore outside the Continental Shelf in winter (Sergeant and Fisher 1957).

The only sightings of pilot whales during the 1998 surveys were incidental, or between transects. There were five pilot whales spotted by the boat crew between transects 17 and 18 on August 5.

6.3.1.5 Humpback Whale

For humpback whales, the aerial survey observers recorded encounter rates of the same order of magnitude as the boat survey during Survey 2, but surprisingly saw very few in Survey 3, despite favorable wind conditions. It seemed for both platforms as though relatively rough seas were not much of a barrier to seeing humpback whales (Table 6.4). Forty to sixty humpbacks in the area during the summer seems reasonable (Figure 6.2). There is evidence that significant numbers of humpbacks are in this area during the summer. Marine mammal observers on the research vessel *Alfred Needler* once had over 70 humpbacks in sight at one time in the Strait of Belle Isle.

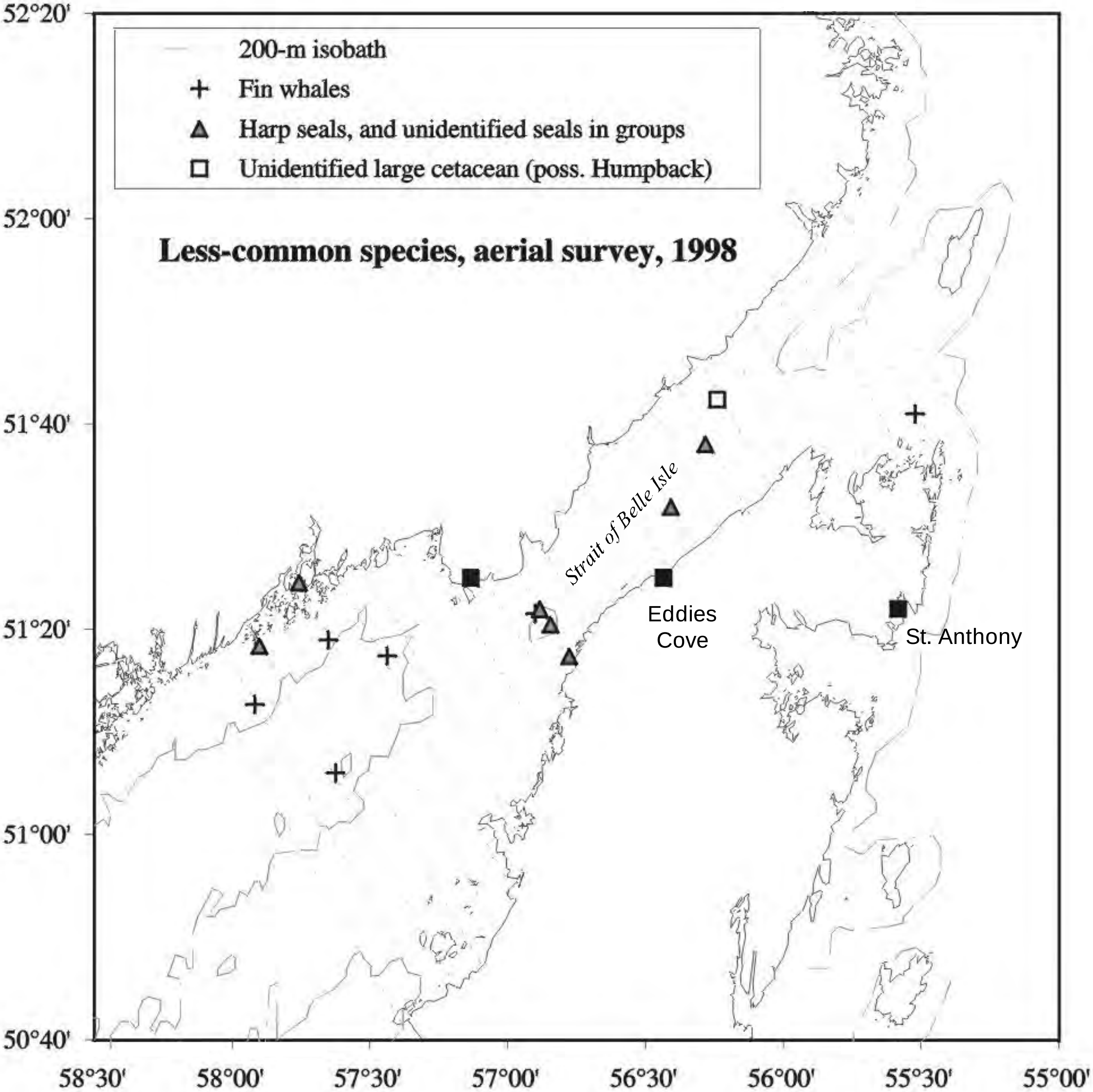

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FIGURE 6.13

DISTRIBUTION OF LESS COMMON SPECIES OBSERVATIONS

Table 6.4 Encounter Rates (per 100 Km) for Humpback Whales in Aerial and Boat Surveys of the Belle Isle Strait Narrows

Transect	Boat Survey (all weather)			Aerial Survey (Beaufort 1 & 2)		
	2	3	4	2	3	4
14	6.1	6.1	0	8.73	6.55	0
15	3.52	7.04	0	4.65	0	0
16	24.7	24.7	8.24	5.48	0	0
17	5.45	1.82	1.82	2.34	0	0
18	4.4	2.93	2.93	--	0	0

One-sided ESW for boat survey was estimated at 7.28 m, for aerial survey 552 m.

From July to November, humpbacks were most abundant in August, when 85% of our humpback observations were recorded. Relative abundances sharply decreased after September (Figures 6.10 and 6.11). Historically however, humpbacks appear to be common from May to August, with greatest numbers observed from June to July (Table 6.1). There appear to be two areas of particular importance for humpbacks, east of Cape Onion toward Belle Isle, and from Pinware to Blanc Sablon (Figure 6.14).

6.3.1.6 Harbour Porpoise

There were almost no data to compare sighting rates for harbour porpoise between the two platforms, as only the Beaufort 1 aerial survey data were used, and only one of the aerial transects covered by the boat survey was flown in sea state 1. This was Transect 18 in Survey 3, and the encounter rate for porpoises during the aerial survey was 12 and for the boat survey, 2.93 per 100 km (Figure 6.15). As the aerial ESW (173 m) was about twice the boat ESW (93.3 m), the aerial density estimate ended up about twice that for the boat survey (Table 6.2).

Results from the boat survey indicate that harbour porpoise disappear at the beginning of October. Large by-catches of this species have been observed in the north-eastern Gulf in mid-September, and it is hypothesised that porpoises move eastward along the north shore in late summer in preparation for leaving the Gulf.

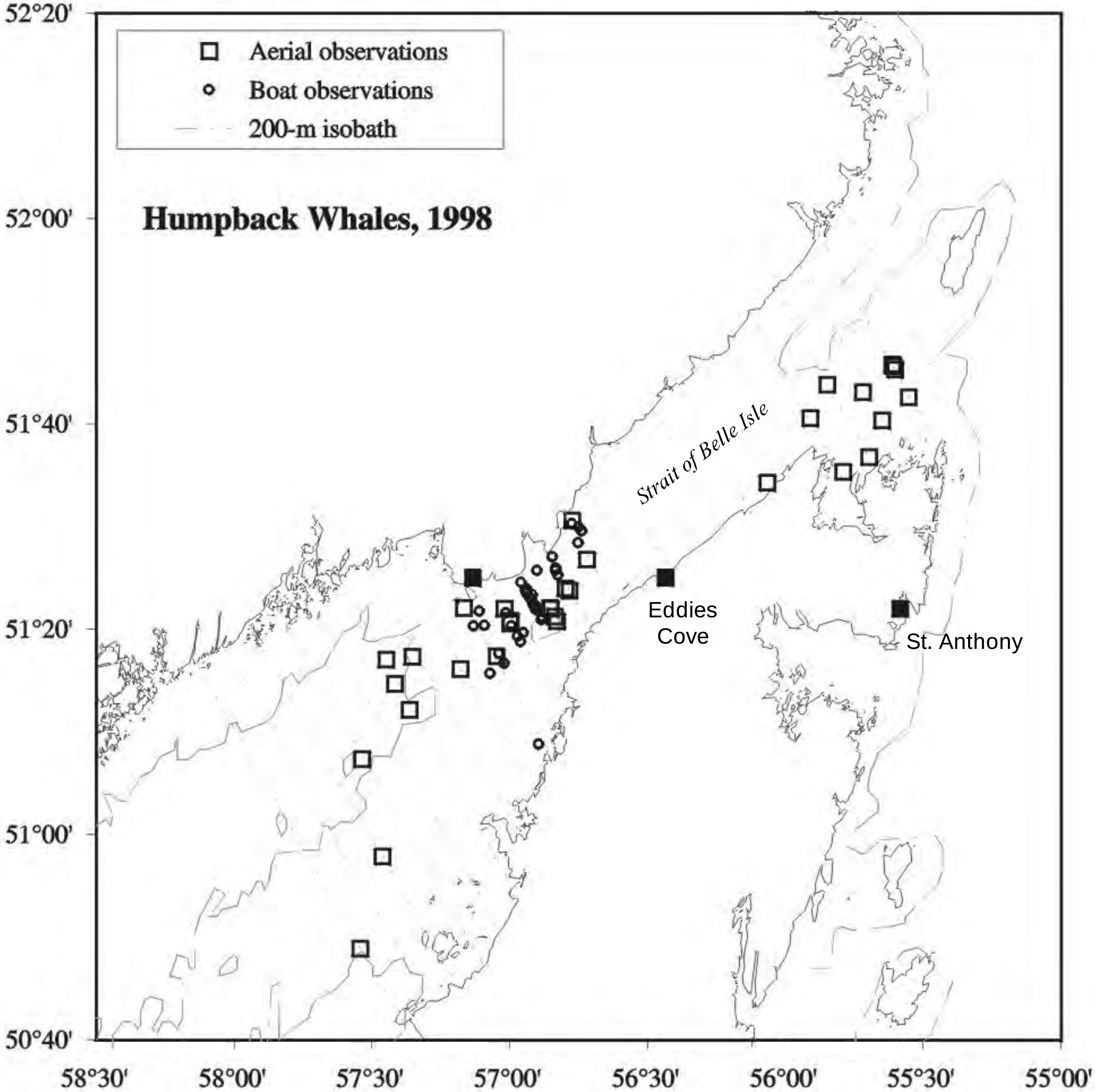

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FIGURE 6.14

DISTRIBUTION OF HUMPBACK WHALE OBSERVATIONS

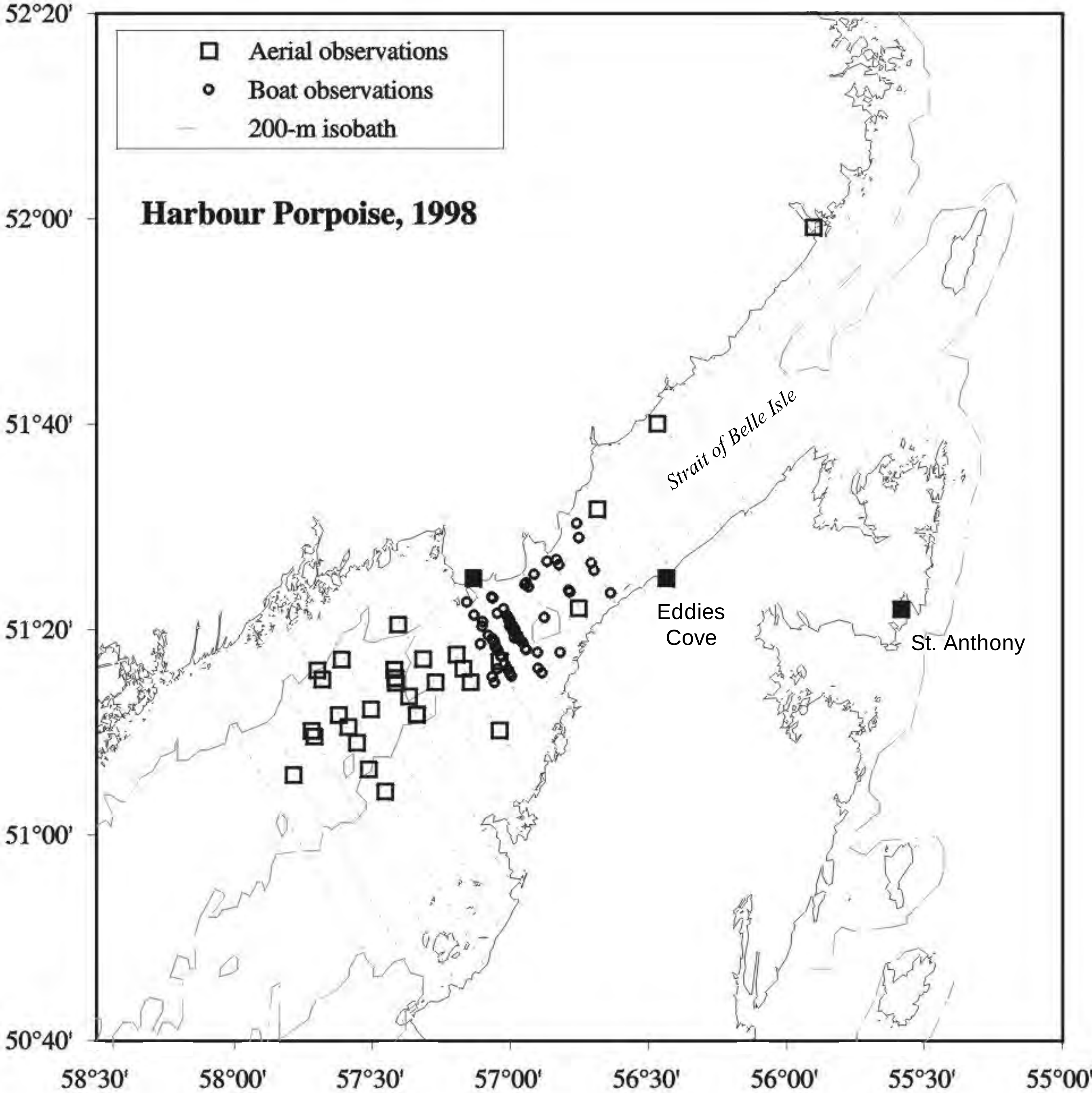

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FIGURE 6.15

DISTRIBUTION OF HARBOR PORPOISE OBSERVATIONS

The estimated numbers of harbour porpoise on aerial survey seem large (Table 6.2), compared with estimates for only 12,000 to 25,000 visible for the entire Gulf (Kingsley and Reeves 1998). However, this estimate assumes that densities measured in sea state 1 are applied to parts of the study area where these conditions never occurred. If porpoise densities are lower in areas that usually have rougher water, the estimate is too high. If this density estimate were applied only to the north-eastern Gulf (i.e., the south-western part of the study area), up to and including transect 17, the estimate of visible numbers would be only about 3,200. High rates of by-catch have been observed in the north-east Gulf during the fall, indicating that there may be high densities at that time.

6.3.1.7 Atlantic White-sided Dolphin

There is evidence to suggest that numbers of white-sided dolphin can vary widely from year to year. Estimates on the Gulf of St. Lawrence population from 1995 were approximately 12,000 animals, in 1996 only about 500 animals (Kingsley and Reeves, 1998). The white-sided dolphin was observed during the aerial surveys in August, September and October, with peak abundance in August (Figures 6.10 and 6.11). There were too few observations to determine any pattern of distribution (Figure 6.16). The Atlantic white-sided dolphin is designated as not at risk under COSEWIC (1998).

6.3.1.8 White-beaked Dolphin

A population estimate for white-beaked dolphins off the Labrador coast is about 3,500 (Alling and Whitehead 1987). This species was designated as not at risk by COSEWIC (1998). The white-beaked dolphin was the second most abundant species during the boat surveys, after the harbour porpoise, in August, September and October (Figure 6.10). Their pattern of distribution, like most other mammal species, seems to favour the Labrador side of the Strait (Figure 6.16).

Mean visible numbers of white-beaked dolphins in the boat survey area are just below 1,000 (Table 6.2). Kingsley and Reeves (1998) estimated an average of about 2,500 in the entire northern Gulf, but observed that this species was mostly seen in the extreme north-east and in the Strait of Belle Isle. White-beaked dolphins are conspicuous in being abundant as late as the end of October.

6.3.1.9 Harp Seal

The total population has been estimated in 1996 at 4.9 million (Hammill and Stenson 1997). Pup production in 1994 was estimated for the northern Gulf of St. Lawrence at approximately 58,000, an indication that the harp seal population is growing at approximately 5% per year (Lacoste 1997).

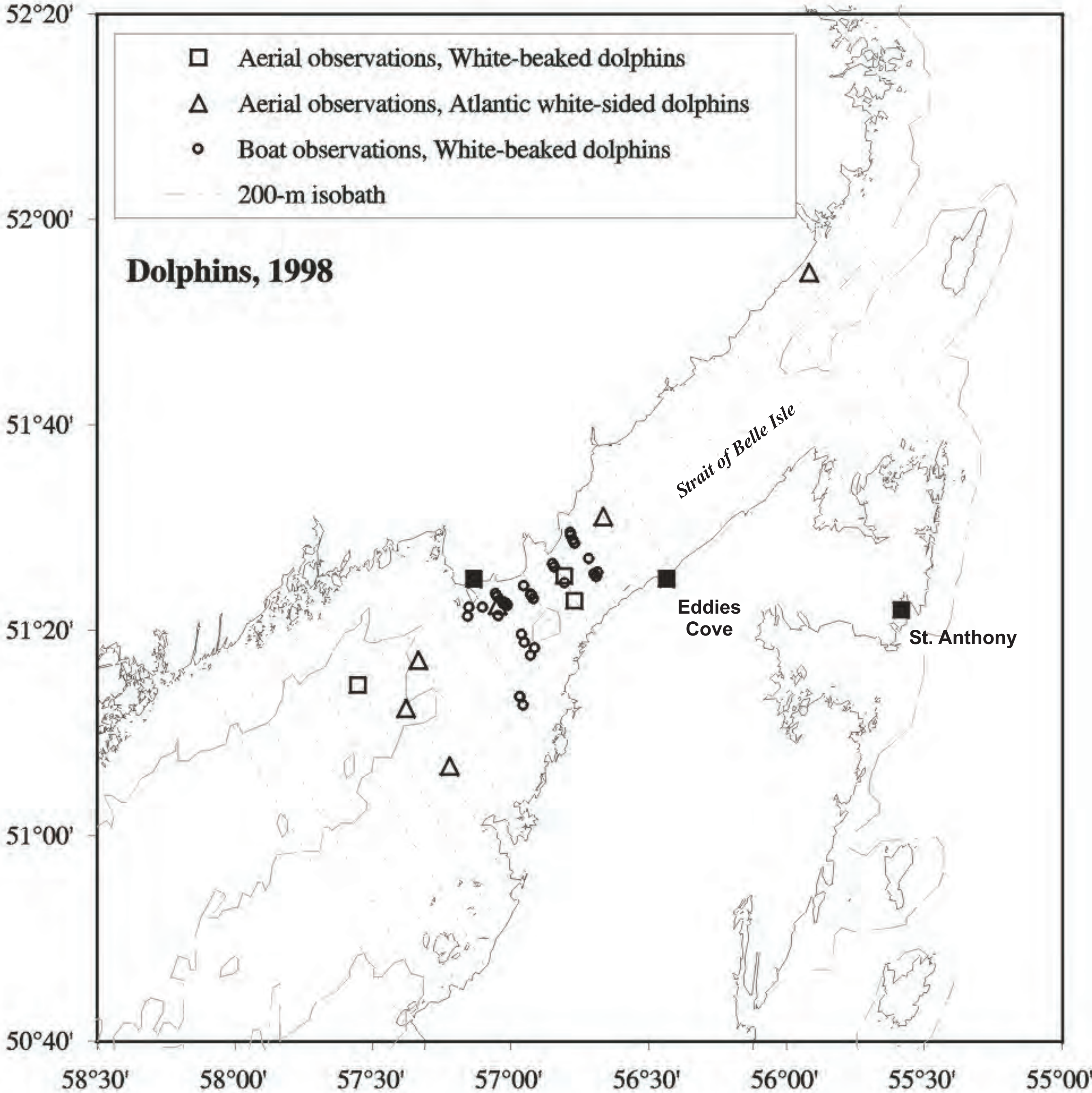

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FIGURE 6.16

DISTRIBUTION OF DOLPHIN OBSERVATIONS

The 1998 surveys identified few harp seals before November, with increasing densities thereafter (Figures 6.10 and 6.11). These individuals are likely the early migrants making their way to the breeding grounds on the Magdalen Islands. Numbers in the Strait would be expected to increase exponentially over the winter.

6.3.1.10 Grey Seal

The population of grey seals (*Halichoerus grypus*)in Atlantic Canada was estimated in 1996 at approximately 184,000. The Gulf component of the population was estimated at about 60,000 and is predicted to be increasing at approximately 6.8% per year (Hammill and Stenson 1997). Grey seals occurred in low numbers in the study area during the September, October and November surveys (Figures 6.10 and 6.11).

6.3.2 Seabirds

The total number of each species seen for each survey is presented in Table 6.5. Survey effort was not the same for all survey periods, so the number of each species seen/hour was calculated, in order to make results comparable across all survey periods. The number of each species seen/hour for each survey period is presented in Table 6.6; and Figure 6.17

A total of 29 seabird species were seen during all the seabird surveys. The total number of species seen for each of the surveys was quite consistent. However, species composition and abundance varied greatly between surveys. The five most abundant species for each survey are presented in Table 6.7. When considering all surveys together, there were a total of 10 species that comprise the top five species for each survey. Herring Gull (*Larus argentatus*) was the only species present in the five most abundant species for all four surveys, indicating a great deal of variability even among the most abundant species. Sooty Shearwater (*Puffinus griseus*) shows the greatest level of variability. It was the most abundant species for the August survey (Survey 1), when its abundance exceeded that of any other species seen on any of the surveys (Table 6.6; Figure 6.17). However, it was not seen at all on the late October survey (Survey 4) (Table 6.5; Figure 6.17). Common Eider (*Somataria mollisima*) was seen in very small numbers on Survey 1 (Table 6.6; Figure 6.17), and was not seen again until the late October survey, when it was the third most abundant species (Table 6.7).

Table 6.5 Total Number for All Species Seen on Each Seabird Survey

Species	Abbr.	Survey 1	Survey 2	Survey 3	Survey 4
		Aug. 29 – 30	Sept. 15 – 18	Oct. 7	Oct. 27 - 29
Common Loon	COLO	3	3	2	
Red-throated Loon	RTLO	3	5	4	3
Northern Fulmar	NOFU	17	291	66	40
Manx Shearwater	MASH	7	1		
Sooty Shearwater	SOSH	2387	53	67	
Leach's Storm Petrel	LSPE	2	2		
Parasitic Jaeger	PAJA	2			
Pomarine Jaeger	POJA	20	17		
Jaeger Sp.	JASP	7	4	2	
Northern Gannet	NOGA	25	84	16	3
Common Eider	COEI	8		5	232
White-winged Scoter	WWSC		1		1
Surf Scoter	SUSC		33		
Scoter Sp.	SRSP		2		
Oldsquaw	OLDS		1	4	4
Greater Black-backed Gull	GBBG	325	74	28	22
Herring Gull	HEGU	903	305	68	44
Iceland Gull	ICGU				5
Black-legged Kittiwake	BLKI	779	3173	842	16
Common Tern	COTE	13			
Arctic Tern	ARTE	13	15		
Tern Sp.	TESP	13	10	2	
Black Guillemot	BLGU		29	5	20
Atlantic Puffin	ATPU	1896	367	36	255
Razorbill	RAZO	26	16	6	128
Razorbill/Murre	RZMU				220
Common Murre*	COMU*	91	65	214	15
Thick-billed Murre*	TBMU*	2		3	26
Murre Sp.*	MUSP*	168	2	22	2
Total Murre Sp.**	TOMU**	261	67	39	43
Dovekie	DOVE			842	489
Red Phallarope	REPH		7	4	
Sanderling	SAND	1			
Greater Yellow Legs	GRYE		2		
Boreal Chickadee	BOCH			62	
Total Number of Species		**24**	**26**	**22**	**19**

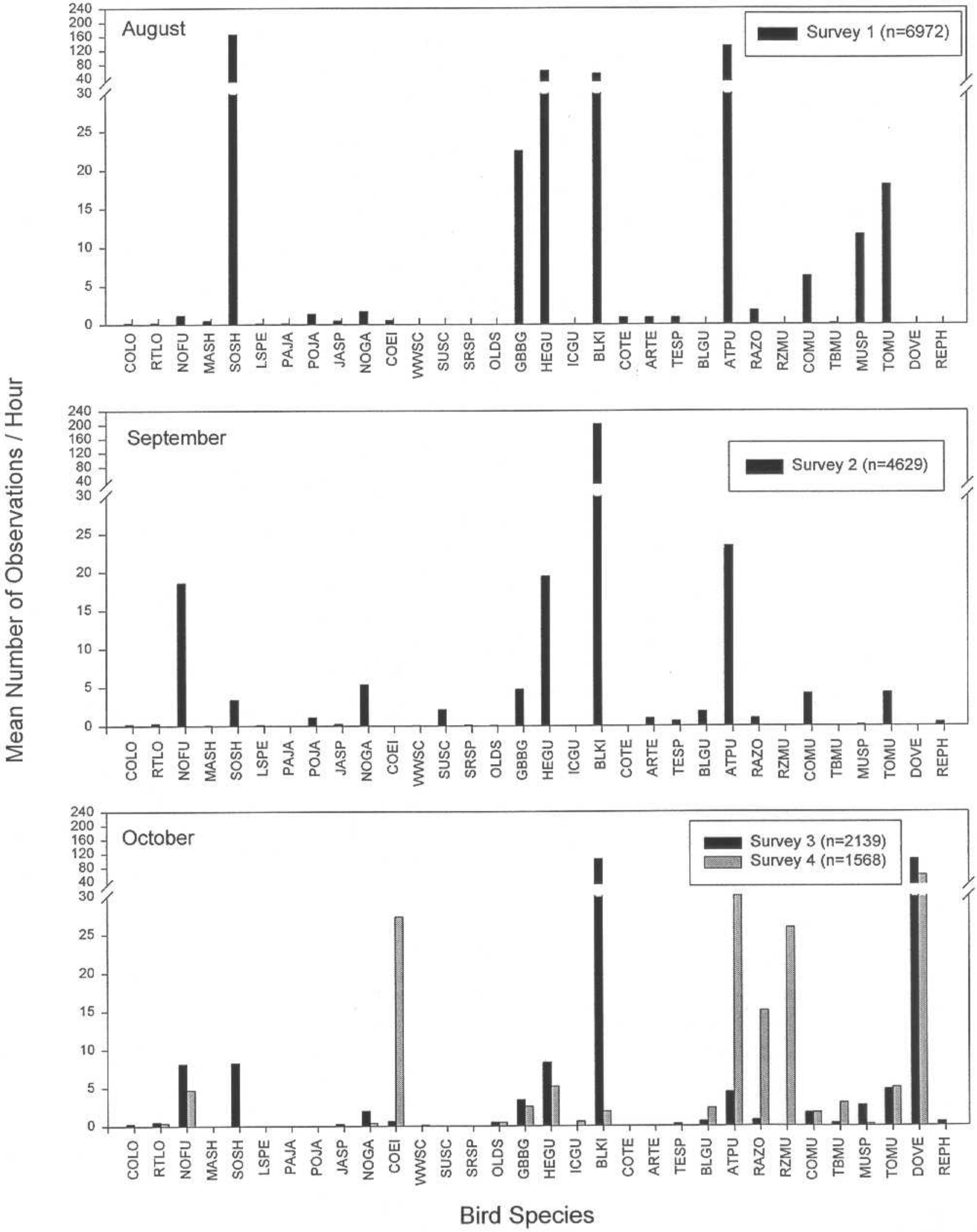
*Indicates Murre species
**Summation of Murre species

Table 6.6 Total Number of All Species Seen per Hour on Each Seabird Survey

Species	Abbr.	Survey 1	Survey 2	Survey 3	Survey 4
		Aug. 29 – 30	Sept. 15 – 18	Oct. 7	Oct. 27 - 29
Common Loon	COLO	0.21	0.19	0.25	0.00
Red-throated Loon	RTLO	0.21	0.32	0.49	0.35
Northern Fulmar	NOFU	1.18	18.57	8.11	4.71
Manx Shearwater	MASH	0.49	0.06	0.00	0.00
Sooty Shearwater	SOSH	165.76	3.38	8.24	0.00
Leach's Storm Petrel	LSPE	0.14	0.13	0.00	0.00
Parasitic Jaeger	PAJA	0.14	0.00	0.00	0.00
Pomarine Jaeger	POJA	1.39	1.09	0.00	0.00
Jaeger Sp.	JASP	0.49	0.26	0.25	0.00
Northern Gannet	NOGA	1.74	5.36	1.97	0.35
Common Eider	COEI	0.56	0.00	0.61	27.29
White-winged Scoter	WWSC	0.00	0.06	0.00	0.12
Surf Scoter	SUSC	0.00	2.11	0.00	0.00
Scoter Sp.	SRSP	0.00	0.13	0.00	0.00
Oldsquaw	OLDS	0.00	0.06	0.49	0.47
Greater Black-backed Gull	GBBG	22.57	4.72	3.44	2.59
Herring Gull	HEGU	62.71	19.47	8.36	5.18
Iceland Gull	ICGU	0.00	0.00	0.00	0.59
Black-legged Kittiwake	BLKI	54.10	202.53	103.52	1.88
Common Tern	COTE	0.90	0.00	0.00	0.00
Arctic Tern	ARTE	0.90	0.96	0.00	0.00
Tern Sp.	TESP	0.90	0.64	0.25	0.00
Black Guillemot	BLGU	0.00	1.85	0.61	2.35
Atlantic Puffin	ATPU	131.67	23.43	4.43	30.00
Razorbill	RAZO	1.81	1.02	0.74	15.06
Razorbill/Murre	RZMU	0.00	0.00	0.00	25.88
Common Murre*	COMU*	6.32	4.15	1.72	1.76
Thick-billed Murre*	TBMU*	.14	0.00	0.37	3.06
Murre Sp.*	MUSP*	11.67	0.13	2.70	0.24
Total Murre Sp.**	TOMU**	18.13	4.28	4.80	5.06
Dovekie	DOVE	0.00	0.00	103.52	57.53
Red Phallarope	REPH	0.00	0.45	0.49	0.00
Sanderling	SAND	0.07	0.00	0.00	0.00
Greater Yellow Legs	GRYE	0.00	0.13	0.00	0.00
Boreal Chickadee	BOCH	0.00	0.00	7.62	0.00

*Indicates Murre species
**Summation of Murre species

Figure 6.17 Mean Number of Seabird Sightings in the Strait of Belle Isle (Boat Survey)



P:\1998\JWEL\1203\draft\total_sightings.jnb

Table 6.7 The Five Most Abundant Species for Each Seabird Survey, in Order of Decreasing Abundance

Abundance	Survey 1 (Aug 29-30)		Survey 2 (Sept 15 – 18)		Survey 3 (Oct 7)		Survey 4 (Oct 27-29)	
	Species	Obs/hours	Species	Obs/hours	Species	Obs/hours	Species	Obs/hours
1	SOSH	165.76	BLKI	202.53	BLKI	103.52	DOVE	57.53
2	ATPU	131.67	ATPU	23.43	DOVE	103.52	ATPU	30.00
3	HEGU	62.71	HEGU	19.47	HEGU	8.36	COEI	27.29
4	BLKI	54.10	NOFU	18.57	SOSH	8.24	RAZO	15.06
5	GBBG	22.57	NOGA	5.36	NOFU	8.11	HEGU	5.18

As would be expected, species that breed in the area in relatively large numbers (e.g., the Brador Bay Seabird Sanctuary near L'anse au Claire and other parts of southern Labrador and the Quebec north shore) are most abundant in the August survey. These species include Greater Black-backed Gulls (*Larus marinus*), Herring Gulls, Atlantic Puffin (*Fratercula arctica*), and Common Murre (*Uria aalge*). Razorbills (*Alca torda*) also breed in the area in relatively small numbers, and are represented throughout all surveys. Razorbill numbers increase markedly in the late October survey (Survey 4) (Table 6.6; Figure 6.17). Leach's Storm Petrel which has a long breeding season, was present into the September survey.

The following is an account of the most common and/or the most ecologically important seabird species observed during the 1998 surveys.

6.3.2.1 Procellariidae

Northern Fulmar

The Northern Fulmar (*Fulmarus glacialis*) is circumpolar. In the western Atlantic, it breeds in colonies on Ellesmere and Baffin Islands. A few small colonies have been found in south east Labrador and eastern Newfoundland. It is a common bird at sea off Newfoundland year-round. Sub-adult birds summer commonly at sea off Newfoundland (Brown et al. 1975). It is fairly common in the Strait of Belle Isle during all periods of open water. Northern Fulmars feed mostly on zooplankton.

Sooty Shearwater

The Sooty Shearwater (*Puffinus griseus*) breeds in the southern hemisphere during the North American winter. It is highly pelagic and common in the north Atlantic from June to October. It is common in the Strait of Belle Isle from June to September, and less common in October. The Sooty Shearwater feeds on zooplankton and small fish near the surface of the water.

6.3.2.2 Hydrobatidae

Leach's Storm-Petrel

The Leach's Storm-Petrel (*Oceanodroma leucorhoa*) breeds in the north Pacific Ocean and north Atlantic Ocean. In the Atlantic Ocean, it breeds in the British Isles, Iceland, Greenland, Newfoundland and south to Massachusetts (Godfrey 1986). They breed on islands around the coast of Newfoundland and southeast Labrador. The center of population is the Avalon Peninsula, which contains several very large breeding colonies, including the largest in the world, 3,360,000 pairs on Baccalieu Island (Cairns et al. 1986). Leach's Storm-Petrels are highly pelagic. Their diet consists of zooplankton caught at the surface of the water. The winter range is poorly known but is south of Canadian waters. Leach's Storm-Petrels are present in small numbers in the Strait of Belle Isle from June to September.

6.3.2.3 Sulidae

Northern Gannet

The Northern Gannet (*Morus bassanus*) breeds locally in the north Atlantic: British Isles, Iceland, Newfoundland and Quebec (Gulf of St. Lawrence) (Godfrey 1986). The closest colonies to Strait of Belle Isle are Funk Island, Newfoundland and Anticosti Island, Quebec. In the western Atlantic, Northern Gannets winter at sea from Virginia south to Florida.

Northern Gannets are fairly common in the Strait of Belle Isle from June to October. Many of these are sub-adult birds. They feed on fish such as mackerel, herring and capelin by diving from the air into the water.

6.3.2.4 Anatidae

Common Eider

The Common Eider (*Somateria mollissima*) breeds throughout much of coastal North Atlantic. In the western Atlantic, it breeds from Ellesmere Island south to Maine. Large numbers breed on the coast of Labrador. Many northern birds migrate in the autumn to the southern limit of the breeding range. In the Strait of Belle Isle, Common Eider is a common migrant in spring (April and May) and autumn (October to December). Common Eiders dive for mollusks, crustaceans and other invertebrates.

6.3.2.5 Laridae

Pomarine Jaeger

There are three species of jaeger in the world. They breed in the Arctic and subarctic regions of the northern hemisphere and winter at sea roughly at latitude 35^{o} N and southward (Godfrey 1986). All three species migrate through Newfoundland waters in spring and autumn. Pomarine Jaeger *(Stercorarius pomarinus)* was the only species recorded during the surveys.

They migrate southward through Newfoundland waters from August to October. Pomarine Jaegers are kleptoparasitic, (i.e., they rob other birds of their prey). The Black-legged Kittiwake (*Rissa tridactyla*) is the favorite target of Pomarine Jaegers. Generally, jaegers are far less abundant than their prey species.

Black-legged Kittiwake

The Black-legged Kittiwake *(Rissa tridactyla*) is circumpolar. In eastern Canada, it breeds on islands and coastal cliffs in the high Arctic south to the Gulf of St. Lawrence (Godfrey 1986). They winter at sea as far north as there is open water and south to latitude 35^{o}. Kittiwakes are numerous year-round at sea off the Newfoundland and Labrador coast in ice-free conditions (Brown et al. 1975). They feed on a small fish and a large variety of invertebrates near the surface of the water. They are common, feeding and migrating through the Strait of Belle Isle, often congregating where strong tides bring food items to the surface.

6.3.2.6 Alcidae

Dovekie

The Dovekie (*Alle alle*) breeds in Greenland west to Spitsbergen. A small population breeds in Canada in eastern Baffin Island (Nettleship and Birkhead 1985). With an estimated 12,000,000 pairs, mostly in the Thule region of Greenland, it is the most numerous alcid and possibly the most numerous seabird in the Atlantic Ocean. It winters from the low Arctic south to the Scotian Shelf and Gulf of Maine (Nettleship and Birkhead 1985).

They occur in the Strait of Belle Isle as a migrant, remaining until extensive ice coverage forces them farther south. Dovekie is the only Atlantic alcid to feed primarily on zooplankton (Nettleship and Birkhead 1985). They can be very abundant around the coast of Newfoundland in fall and winter.

Common Murre

The Common Murre (*Uria aalge*) has a circumpolar breeding range. In the western Atlantic, 95% of the population breeds in colonies on islands or coastal cliffs from the mid-Labrador coast south to eastern Newfoundland. They winter off shore from Newfoundland south to Georges Bank.

Common Murres are fairly common in the Strait of Belle Isle during summer and fall. There is a breeding colony near Blanc Sablon. The diet is principally small fish which they dive for from the surface of the water.

Thick-billed Murre

The Thick-billed Murre (*Uria lomvia*) is circumpolar. In the western Atlantic, it breeds from the high Arctic (Ellesmere Island) south to Cape St. Mary's, Newfoundland (Godfrey 1986). The eastern Arctic holds 95% of the eastern Canadian breeding population. Small numbers breed in the Gulf of St. Lawrence. They winter at sea from the Arctic south to Nova Scotia and uncommonly to the mid-Atlantic States (Godfrey 1986).

In the Strait of Belle Isle, they are uncommon during the summer months. Thick-billed Murres become numerous in coastal Newfoundland when migrants from the north appear, starting in October. They can be a common winter bird wherever there is open water. This is the bird traditionally referred to as 'turr' by Newfoundlanders. The diet is mainly small fish (Nettleship and Birkhead 1985).

Razorbill

The Razorbill (*Alca torda*) breeds only in the north Atlantic from northern Russia, Iceland, Greenland, Labrador, Newfoundland and south in small numbers to Maine (Godfrey 1986). The total population estimated at 700,000 pairs, with the center of abundance being Iceland. Only 15,000 pairs breed in North America, with 70% of those breeding in eastern Labrador (Nettleship and Birkhead 1985). Small numbers breed near Blanc Sablon, Quebec. In North America, they winter from southern Newfoundland south to North Carolina (Godfrey 1986).

In the Strait of Belle Isle, Razorbills are present in small numbers during the summer. The Labrador breeding birds appear to use the Strait of Belle Isle as a migration corridor to wintering grounds farther south as was indicated by a few hundred flying south on the late October survey. The diet of Razorbills consists of small fish and crustaceans (Nettleship and Birkhead 1985).

Black Guillemot

The breeding range of Black Guillemot (*Cepphus grylle*) is almost circumpolar, centered in the north Atlantic and northern Russia. In eastern North America, it breeds from southern Ellesmere Island to coastal Maine. It breeds in small colonies on exposed rocky coasts and islands. Although relatively ubiquitous throughout its large range, the total north Atlantic breeding population, estimated at 266,000 pairs, makes it the least common Atlantic Ocean alcid (Nettleship and Birkhead 1985). It winters within its breeding range as far north as there is open water. Black Guillemots have a wider range of food items than the other alcids, choosing various small fish and invertebrates (Nettleship andBirkhead 1985). Black Guillemots prefer shallow coastal waters more than the other alcids. In the Strait of Belle Isle, it is fairly common near the shoreline year-round, as long as there is open water.

Atlantic Puffin

The Atlantic Puffin (*Fratercula arctica*) breeding range is from northern Russia west to Iceland, Greenland and North America. In North America, they breed on coastal cliffs and islands from mid-Labrador south to Maine (Godfrey 1986). Most of the Canadian population breeds in southeast Newfoundland. In North America, the Atlantic Puffin winters at sea from southern Newfoundland southward to Massachusetts (Nettleship and Birkhead 1985).

There is a breeding colony of puffins near Blanc Sablon totalling over 7,200 breeding pairs. Puffins are regularly seen in the Strait of Belle Isle from May to November. Numbers are probably enhanced by birds migrating to and from the mid-Labrador coast during spring and autumn. Atlantic Puffins feed primarily on fish that they catch by diving from the surface of the water.

7.0 DISCUSSION AND CONCLUSION

7.1 Marine Mammals

7.1.1 Blue Whale

The blue whale averages between 23 to 32 m in length and weighs 80 to 130 tonnes. They usually travel in small groups of three to four individuals. According to the most recent estimate, the population of blue whales in the western Northwest Atlantic is believed to be between 500 to 1,000 animals (Seton et al. 1992). The blue whale is designated as vulnerable by COSEWIC (1998).

In the summer, their distribution extends from Iceland to the Gulf of St. Lawrence and Newfoundland (Sears et al. 1987). The north shore of the Gulf of St. Lawrence, from the estuary to the Strait of Belle Isle, is recognized as an area of relatively frequent blue whale sightings during the spring, summer and fall (Mansfield 1985). However, blue whales are infrequently reported in the literature, as they were during our survey in 1998. Areas of upwelling and high plankton productivity attract blue whales because they feed exclusively on euphausiids (krill) (Gaskin 1976). During March and April, they frequent the southwest coast of Newfoundland and the Gulf of St. Lawrence to feed on krill. The winter range of the blue whale is not well understood, but it is believed to move south, towards the equator (Mansfield 1985) and perhaps offshore (Seton et al. 1992), but there may be some overwintering in the Gulf of St. Lawrence.

7.1.2 Minke Whale

Minke whales grow to a maximum of 10.2 m long and on average weigh 600 to 900 kg. The global population of minkes is estimated at approximately 300,000 animals. They are commonly spotted nearshore, rarely more than 169 km from land (Fahey 1996). They often enter estuaries, bays and inlets during the summer to feed. They are know to be curious creatures, approaching anchored boats and wharfs. Minkes usually travel singly or in small groups of two to four animals. They show a high degree of site fidelity and residency, and occupy distinct ranges.

Diet analysis conducted in the 1960s, during commercial whaling in Trinity Bay, showed that capelin (*Mallotus villosus*) is the dominant food item for minke whales in Newfoundland waters (Sergeant 1963). Cod was the next most abundant prey item, with salmon, squid, herring and plankton each comprising a small portion of the diet. Minkes were most abundant in August 1998, when the capelin fishery in the area was at its peak. Inshore/offshore movements in response to capelin abundance have been documented (see Marques 1996).

In Newfoundland waters, a migration northward, along the east coast peaks in June and July, with a peak return southward, during October and November (Sergeant 1963). A survey of the Gulf of St. Lawrence in 1995 and 1996 reported approximately 1,000 minkes, of which 75% occurred on the north shore of the Gulf in high densities (Kingsley and Reeves 1998). The 1998 boat survey estimate of 200 minkes in the survey area during August and September is realistic.

7.1.3 Fin Whale

There may be two discrete fin whale populations in the western North Atlantic, one in Nova Scotia and one in Newfoundland/Labrador. Fin whales in the Gulf of St. Lawrence may be a part of the Nova Scotia stock (Mitchell 1974). There are separate population estimates reported for each of these groups. The Newfoundland/Labrador group was estimated at 1,900 animals, the Gulf of St. Lawrence group at 340 animals in the 1960s, and the Nova Scotia group at 430 individuals (see Meredith and Campbell 1988). It has been suggested that the Nova Scotia stock moves south during the winter and the Newfoundland stock moves to an area off Nova Scotia (see Meredith and Campbell 1988). The fin whale was relatively infrequent in 1998, comprising just 1.27 percent of 1998 mammal observations. However, Kingsley and Reeves (1998) report the fin whale as relatively abundant on the north shore of Quebec. The fin whale is designated as vulnerable by COSEWIC (1998).

The fin whale is second only to the blue whale in size, reaching 24 m in length and weighing approximately 45 tonnes. The fin whale is widely distributed in the north Atlantic, in areas of high productivity. Winter distributions of the fin whales as well as their calving and breeding grounds are largely unknown, but they do undergo a seasonal north-south migration. Winter records of fin whales have been reported as far south as North Carolina, Florida and the Gulf of Mexico. They are usually solitary animals, but male, female and calf may travel together. Larger groups have been spotted feeding on schooling fish (Gambell 1985). The fin whale in Newfoundland and Labrador prey mostly on capelin and herring.

7.1.4 Long-Finned Pilot (Pothead) Whale

An aerial survey conducted in the coastal and offshore waters of eastern Newfoundland and southeastern Labrador estimated the pilot whale population at about 13, 200 (Hay 1982). This species is designated as not at risk under COSEWIC (1998).

One group of six pilot whales was seen on the 1998 boat survey, in relatively shallow water close to Blanc Sablon. This is somewhat unexpected, as this species is considered to be strongly associated with the warmer waters in the southeastern Gulf, as well as normally frequently rather deep water. In Newfoundland waters it has been thought to be associated with squid (*Illex illecebrosus*), but off the northeastern coast of the United States it has been found in association with mackerel (*Scomber scombrus*).

7.1.5 Humpback Whale

The humpback whale is a stocky baleen whale that rarely exceeds 15 m in length and 32 tonnes in weight (Hay 1985). Humpback whales are common during the summer months on the southeast shoal of the Grand Banks, off eastern Newfoundland and southern Labrador, on Fyllas Bank off West Greenland and in the southern gulf and estuary of the St. Lawrence. The lower north shore of Quebec and the Strait of Belle Isle are known as areas of relatively high humpback densities during the summer (Kingsley and Reeves, 1998). The survey in 1998 estimated 60 humpbacks in the aerial survey study area during the summer months, whereas the boat survey resulted in an estimate of 40 humpbacks during August and September. This narrow portion of the Strait appears to be of preferred area for humpbacks.

In the summer, the distribution of humpback whales is principally determined by prey distributions; prey includes crustacean zooplankton (i.e., euphausiids), herring (Clupeidae), sand lance (*Ammodytes* sp.), capelin and other small fish and squid (Whitehead 1987). Capelin is the major food for humpbacks off Newfoundland but krill, herring and squid are also taken at various times; preferred summer feeding grounds may change week by week and year by year (Whitehead 1987). Within a particular feeding or breeding ground, individual humpbacks may travel more than 100 km during a season or may stay resident in a certain place for an extended period of time (weeks or months). There is also evidence for humpbacks returning to the same feeding area year after year (see Kingsley and Reeves, 1998). Although other species of whales, such as the fin and minke, use the same prey as the humpback, there is no evidence that the presence of these other species disturb humpback whale feeding (Whitehead 1987).

The North Atlantic population of humpback whales is estimated at about 7,700 whales, with approximately 4,900 males and 2,800 females (Palsbøll et al. 1997). This population is designated as vulnerable by COSEWIC (1998).

7.1.6 Harbour Porpoise

The harbour porpoise is the smallest of the cold-water marine whales and is found along northern temperate coasts. It is generally regarded as a common species but is becoming less common in several major portions of its range (Gaskin 1992a). It is suggested that there are three separate populations of harbour porpoises in eastern Canadian waters, located in: 1) eastern Newfoundland; 2) the Gulf of St. Lawrence; and 3) the Gulf of Maine/Bay of Fundy (Palka et at. 1996). The division between the Newfoundland population and the other two is thought to be the most discrete based on summer distribution patterns. In addition, recent studies of regional differences in organochlorine and heavy metal contaminants revealed significant differences between the three populations, thus supporting the discrete population hypothesis (Palka et al. 1996).

During the spring, the Newfoundland population is distributed in the coastal shelf waters of Labrador and along the eastern and southeastern coast of Newfoundland. In the summer, harbour porpoises occur in Baffin Bay and in the deeper waters of the Labrador Sea. The offshore boundaries of the spring and summer distributions are unknown, as are the wintering grounds (Palka et al. 1996). The habitat of harbour porpoise is generally within waters of about 5 to 16^{o}C and in depths of greater than 10 m. It tends to be found in areas of significant coastal fronts or topographically generated upwellings. In a distributional sense, the harbour porpoise is closely tied to the major pelagic schooling fish which comprise the bulk of its diet. Capelin and herring have been found to be the most important prey items in terms of frequency of occurrence and mass and caloric contribution to the diet (Fontaine et al. 1994). Harbour porpoise also feed on redfish, hake, cod and other small demersal fishes. A large incidental catch of harbour porpoise by commercial fisheries has been documented in the northern Gulf of St. Lawrence but its impact on the population is unknown due to insufficient information available on population size.

The harbour porpoise is designated as threatened by COSEWIC (1998). Recent estimates of between 12,000 and 21,000 harbour porpoises have been reported in the Gulf of St. Lawrence population. This Gulf population is likely the one appearing in our survey from Blanc Sablon westwards, near the end of August (Figures 6.10 and 6.11). In fact, 83% of harbour porpoise observations came from this area in August.

7.1.7 Atlantic White-sided Dolphin

The Atlantic white-sided dolphin, a medium-sized cetacean, is one of two species of dolphins found in the cool waters of the North Atlantic ocean. They usually travel in loosely associated groups of 5 to 25 individuals. This dolphin is generally observed in waters of the inner region of the coastal shelf; the distribution is wide-ranging and includes southeastern Newfoundland and southern Labrador. Young dolphins appear to remain with breeding herds till about two years of age, after which they may lead solitary lives or form into loose groups (Sergeant et al. 1980).

The white-sided dolphin feeds primarily on pelagic schooling fish in the upper part of the euphotic zone and the major prey are sand lance, squid, herring and silver hake. Distribution in the spring and summer appears to be related to the availability of prey species and for this reason, the white-sided dolphin is largely confined to areas of the coastal shelf where abundant schooling fish or squid occur (Gaskin 1992b). The distribution of this dolphin has also been related to areas where water temperatures and salinities are low, although this may be coincidental to environmental factors that concentrate preferred prey (Selzer and Payne 1988).

The white-sided dolphin was too infrequently observed during the 1998 surveys to accurately estimate the population size. Estimates on the Gulf of St. Lawrence population range from 500 to 12,000 animals (Kingsley and Reeves 1998).

7.1.8 White-beaked Dolphin

The white-beaked dolphin is also a common dolphin species in the north Atlantic, occurring in closely associated pods. White-beaked dolphins feed on squid, octopus, cod, herring, capelin and sometimes on benthic crustaceans (Leatherwood et al. 1976). It has a more northerly distribution than does the white-sided dolphin, regularly occurring from Davis Strait to Nova Scotia. The white-beaked dolphin is primarily an offshore migratory species, but is most common in water less than 100 m deep (Kingsley and Reeves 1998). The peak southern migration time for this species off the Labrador coast is August and September (Alling and Whitehead 1987). The peak abundance during the 1998 surveys was during August and September, possibly reflecting this southern migration.

7.1.9 Harp Seal

The harp seal is the most abundant of the four seal species found in Atlantic Canada. The northwest Atlantic population of harp seals is usually subdivided into two components: 1) the Newfoundland component, which breeds off northeast Newfoundland and southern Labrador; and 2) the Gulf component, which breeds in the southern, and occasionally the northern, Gulf of St. Lawrence (Lacoste 1997). Harp seals are highly migratory and these two components of the population overlap in their distribution during the non-breeding season while summering in the Canadian Arctic and/or west Greenland. Seals from both areas move southward along the coast of Labrador during the fall or early winter. Upon reaching the Strait of Belle Isle, one component of the population moves into the Gulf of St. Lawrence while the rest of the seals remain off the east coast of Newfoundland (Hammill and Stenson 1997). In the Gulf, harp seals whelp near the Magdalen Islands and in the northern Gulf in late February or early March. Following mating in late March, the seals disperse and move into the northern Gulf to moult in April and May. After moulting, seals begin a northern migration and return to the Arctic for the summer months (Lacoste 1997). Harp seals were not abundant during the 1998 surveys but their numbers would be expected to increase considerably throughout the winter and again in the spring.

The harp seal has been found to be the most important predator in the northern Gulf region, accounting for 68 to 98% of cod, herring and redfish consumed (Hammill and Stenson 1997). Other prey species include capelin, Greenland halibut, squid, euphausiids and small crustacea (Wallace and Lavigne 1992).

7.1.10 Grey Seal

This species is recognized as the second most important consumer of fishes in the northern Gulf of St. Lawrence, the harp seal being the primary consumer. Important prey of the grey seal include cod, herring, capelin, mackerel, redfish and flounder (Beck 1983; Hammill and Stenson 1997).

The breeding season for the grey seal is from mid-December to early February and the two major breeding grounds in Canada are Northumberland Strait and St. George's Bay. Seals leave the breeding grounds by late February and March. There is no well-defined migration pattern or time but some seals do enter the Gulf of St. Lawrence and take up residence along the Quebec north shore (Beck 1983). Grey seals were infrequent during the 1998 surveys in September, October and November.

7.1.11 Temporal Summary of Mammal Distributions

All species became scarcer in later summer and fall. Both survey platforms showed humpback and minke whales decreasing in mid-September. Both these species may be in the area to feed on capelin, which usually peak in the area in late July or August.

The humpback and minke whales appear to leave the area the earliest, followed by porpoise and then white-beaked dolphins. Porpoises are probably year-round feeders, but have such thin blubber that they may be intolerant of low water temperatures. The white-sided and white-beaked dolphins are probably also year-round feeders and are resident in the north Atlantic. However, their principal prey species, mackerel or other pelagic schooling fishes, have limited tolerance for cold water.

The most interesting feature of the data on other species is the small number of sightings of seals. Most of the seals seen were harp seals, and although a few were encountered in August, they were mostly seen late in the program in November and December, possibly early migrants from the Arctic. There were very few sightings of grey or harbour seals.

7.1.12 Spatial Summary of Mammal Distributions

There were frequent sightings of humpback whales in an area north of Pistolet Bay and the northern tip of the Northern Peninsula, roughly the south-eastern halves of transects 3–6 (See Figure 5.1). A few minke whales were also sighted in this area. Apart from this area, there were few sightings of any marine mammals anywhere east of transect 14. The sea state on average was worse in the eastern part of the study area, which may have contributed to this observed distribution pattern either by reducing visibility of those animals that were in this area, or by inducing smaller species to favour calmer waters. However, it seemed that this trend was also confirmed within the boat-survey study area, where more observations tended to occur on the more south-westerly transects.

There appears to be an area of concentration of marine mammals in the north-eastern Gulf and extending into the Belle Isle Strait narrows as far as about transect 17 or 16. The aerial survey results showed a consistent pattern of sightings for humpback whales, minke whales and porpoises, all of which seemed to be associated with water 200 m deep or deeper in the extreme north-eastern Gulf. There were relatively few sightings south of the 200-m isobath on transects 19–26.

Within the survey area covered by boat and aerial surveys (Transects 14-18), sightings seemed to be more concentrated on the Labrador side. It is not known if this may be due to calmer waters on the Labrador side of the Straits as the sea state data were ordinarily summarized by transect. This area appeared highly productive in that flocks of many species were observed feeding and there was fishing activity in the area throughout the summer and fall.

7.2 Seabirds

Seabird populations are highly variable, both temporally and spatially. The Strait of Belle Isle and surrounding area is used for breeding, feeding and migration by many species throughout the year. Species abundance and composition is affected not only by season, but also by local weather conditions. Storm events can create upwellings that bring benthic prey to the surface, and can create ideal feeding conditions for several days. Prevailing winds also influence the distribution of pelagic species. These variables affect seabird distribution and abundance in the Strait of Belle Isle. Seabird distribution in the study area for each survey are presented in Figure 7.1a-d.

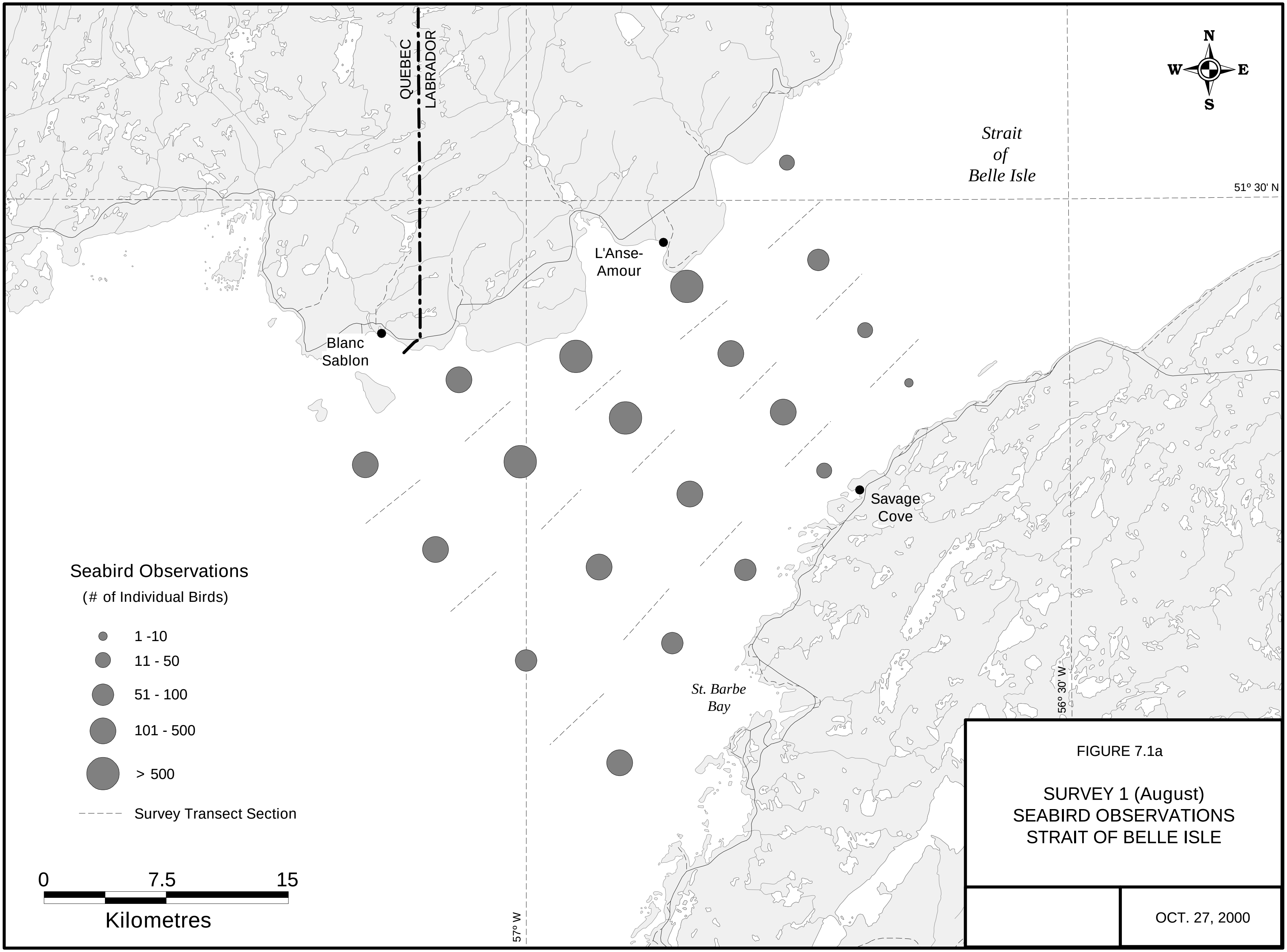


FIGURE 7.1a

SURVEY 1 (August)
SEABIRD OBSERVATIONS
STRAIT OF BELLE ISLE

OCT. 27, 2000

1203-16.WOR 01NOV00

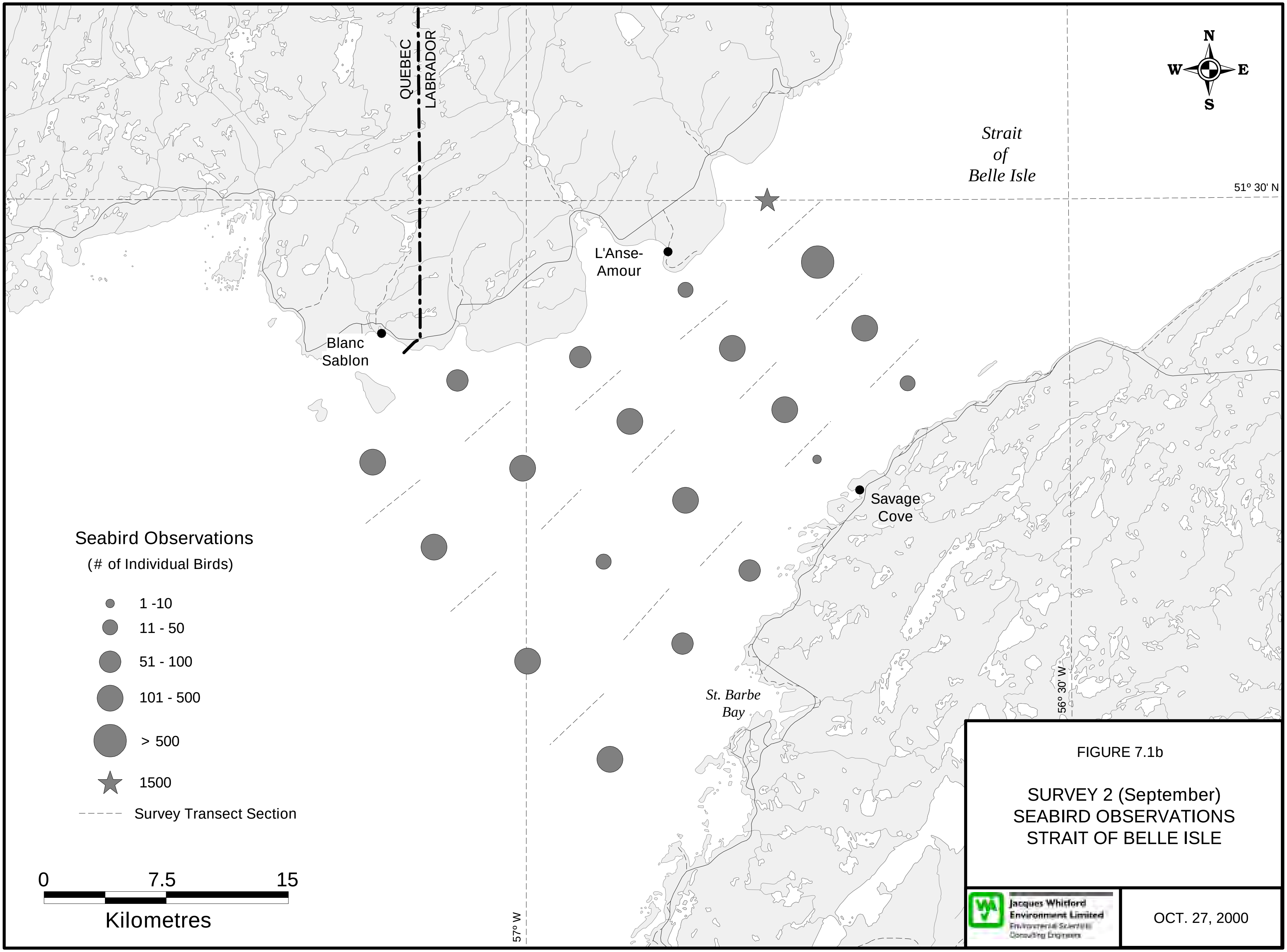


FIGURE 7.1b

SURVEY 2 (September)
SEABIRD OBSERVATIONS
STRAIT OF BELLE ISLE

1203-18.WOR 01NOV00

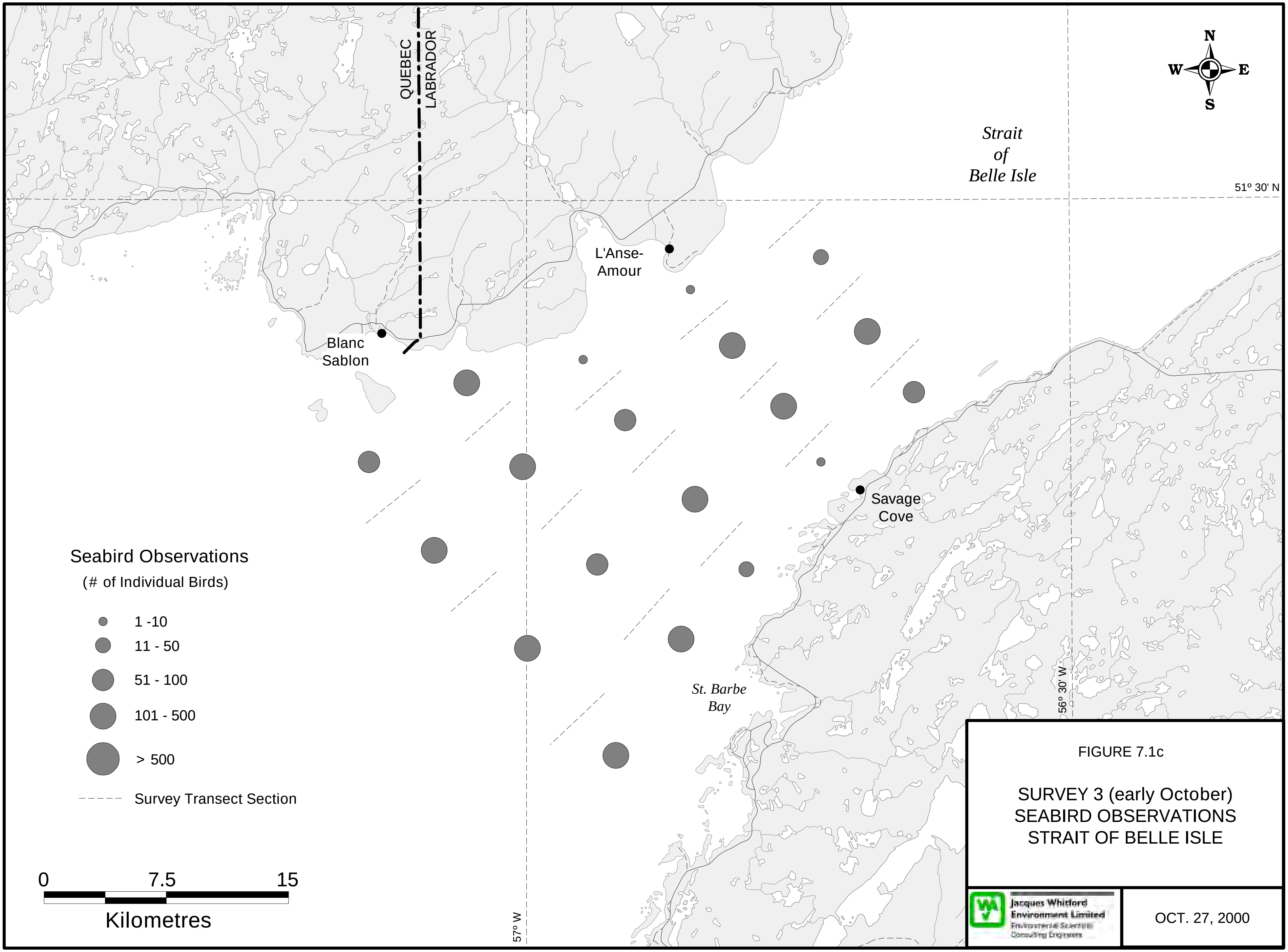


FIGURE 7.1c

SURVEY 3 (early October)
SEABIRD OBSERVATIONS
STRAIT OF BELLE ISLE

1203-17.WOR 01NOV00

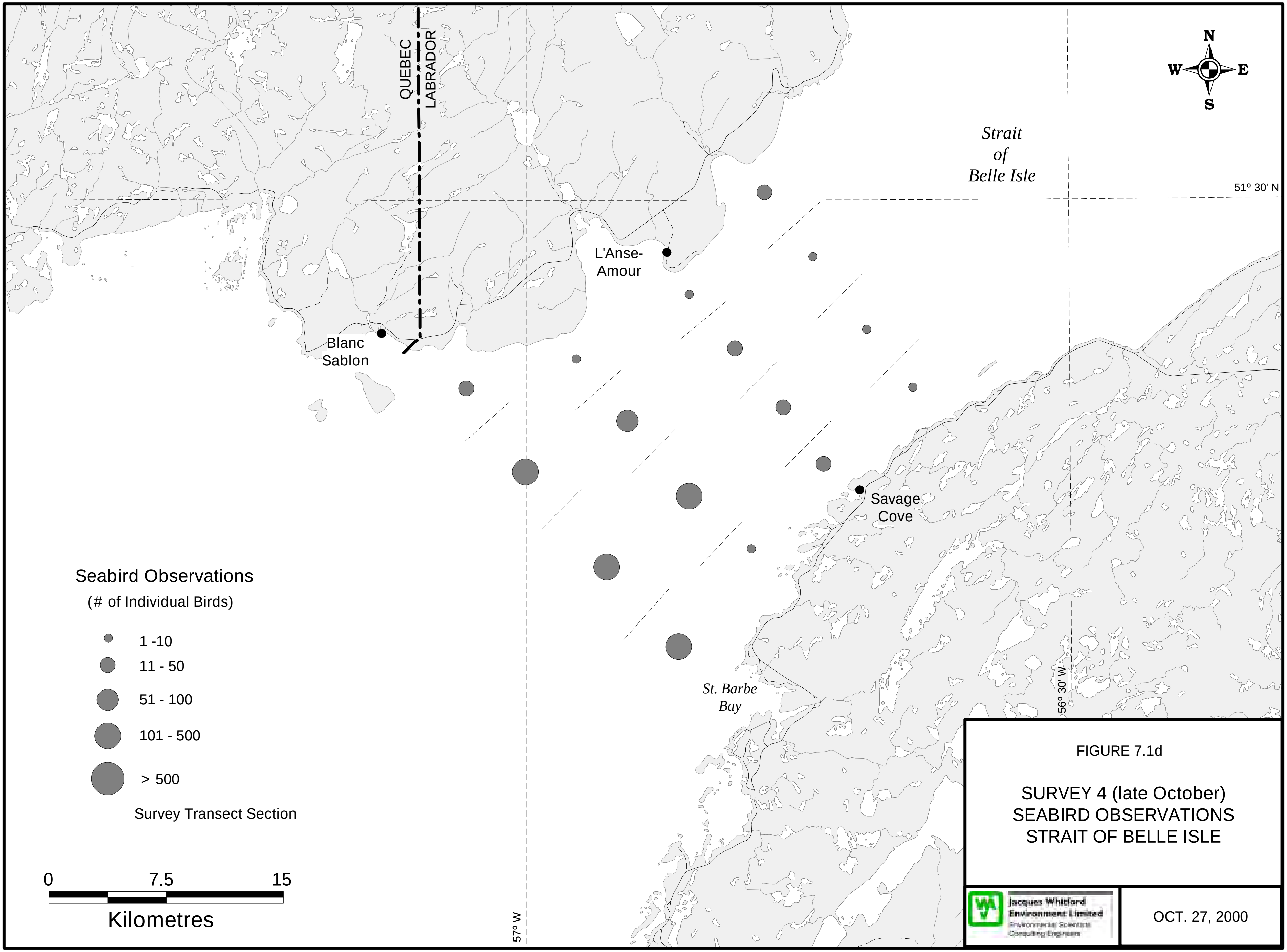


FIGURE 7.1d

SURVEY 4 (late October)
SEABIRD OBSERVATIONS
STRAIT OF BELLE ISLE

1203-19.WOR 01NOV00

7.2.1 Temporal Distribution

The August survey was predominated by locally breeding species: Atlantic Puffin; Herring Gull; Black-legged Kittiwake; and Greater Black-backed Gull. These species, with the exception of Black-legged Kittiwake, all breed in the Brador Bay Seabird Sanctuary, near Blanc Sablon. (G. Chapdelaine, pers. comm.). The Brador Bay Seabird Sanctuary is particularly important for its Atlantic Puffin colony. In late August, this species would still be nesting and rearing young. Other breeding species would have fledged young, and be starting to disperse. All of these species breed in other locations along the Quebec North Shore, and would likely feed in the Strait of Belle Isle. Sooty Shearwater, the most abundant species during the August survey, is the only one that does not breed in the area. It breeds in the southern hemisphere during the North American winter. It is highly pelagic and common in the north Atlantic from June to October. It is common in the Strait of Belle Isle from June to September, and less common in October. It was seen on all but the last survey in August. Sooty Shearwaters seen in the August survey were noted to be flying predominantly east, or feeding in riptides. The distribution of this species is greatly influenced by prevailing or storm winds. It is likely that the large numbers seen on this survey were due to strong westerly winds preceding the survey.

The September survey was dominated by post-breeding Black-legged Kittiwakes that congregated in the Strait of Belle Isle to feed. This would be expected, as they are commonly found feeding and migrating through the Strait of Belle Isle, often congregating where strong tides bring food items to the surface. Kittiwakes are numerous year-round at sea off the Newfoundland and Labrador coast in ice-free conditions (Brown et al. 1975).

Although Northern Fulmars were present in all surveys, they were particularly numerous during the September survey. Fulmars breed in small numbers along southern Labrador. Like Sooty Shearwaters, Fulmars are pelagic, feed primarily on zooplankton, and their distribution is influenced greatly by local weather conditions. The large numbers likely reflect a local weather event.

There was a clear shift in the dominant species in the October surveys. New species have emerged in large numbers, and species that were previously present in small numbers, increased. This represents a shift from the predominance of breeding populations to migrating populations from other breeding grounds.

Dovekies were not present at all in the first two surveys, but were among the most abundant species in the two October surveys. The Dovekies breed in Greenland west to Spitsbergen. A small population breeds in Canada in eastern Baffin Island (Nettleship and Birkhead 1985). With an estimated 12,000,000 pairs, mostly in the Thule region of Greenland, it is the most numerous alcid and possibly the most numerous seabird in the Atlantic Ocean. It winters from the low Arctic south to the Scotian Shelf and Gulf of Maine (Nettleship and Birkhead 1985). They occur in the Strait of Belle Isle as a migrant, remaining until extensive ice coverage forces them farther south.

Razorbills breed at the Brador Bay Seabird Sanctuary, and in other areas of the Quebec North Shore (G. Chapdelaine, pers. comm.), and are present on all surveys in small numbers. However, they are present in large numbers in the final October survey. Large numbers breed at St. Mary's Island in the Gulf of St. Lawrence. Many of the breeders migrate through the Strait of Belle Isle en route to wintering grounds in the Bay of Fundy and coastal Massachusetts.

Another large colony of Razorbills is located on the Gannet Island, located northeast of Cartwright, Labrador. Migratory birds from this population could also be using the Strait of Belle Isle as a migratory corridor to winter feeding areas.

Common Eider numbers also increase dramatically in the late October survey. Large numbers breed on the coast of Labrador. Many northern breeding eiders migrate in the autumn to the southern limit of the breeding range. It is a common autumn migrant in the Strait of Belle Isle, from October to December.

7.2.2 Spatial Distribution

During the August survey, when breeding species predominate, the greatest concentrations of seabirds occur near the Labrador coast, between L'anse Amour and Blanc Sablon. When raising young, there is a great deal of effort exerted in food procurement for raising young. For this reason, it is likely that the area where the birds are concentrating is an area of high productivity. Possible oceanographic features that would contribute to these conditions are discussed in Section 4.3.

The September and early October surveys show no clear pattern in seabird distribution. This time period includes late puffin breeding activity, migration into the area by some species, as well as short-term influxes of pelagic species from weather events. Feeding is not the primary reason for being in the area for some species. Since several species are present in the Strait of Belle Isle at the same time, but for different reasons, it is not surprising that no clear pattern of distribution emerges.

The late October survey indicates a pattern of distribution, with numbers decreasing away from the Gulf of St. Lawrence end of the Strait. The reason for this pattern is not clear.

7.3 Conclusion

The objectives of the marine mammal and seabird survey in the Strait of Belle Isle were met in that:

1) the relative abundance and distribution of species present during the ice-free season in 1998 was identified;
2) a literature/data review of previous mammal sightings was documented; and
3) a literature search on the effects of underwater construction noise on marine mammals was conducted and summarized.

The data collected and summarized during this survey can therefore contribute to the baseline data requirements of an environmental assessment and future follow-up monitoring, if required.

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APPENDIX A

Data Sheets

AERIAL SURVEY OBSERVATION SHEET

Marine Mammal Survey in the Strait of Belle Isle
JWEL Project 1203

DATE	TRANSECT NO.	OBSERVER	RIGHT/LEFT
START TIME	END TIME	ALTITUDE	
START POSITION	END POSITION	HEADING 320°; 140°	

WAY POINT	OBS. TIME	SPECIES	COUNT	OBS. ANGLE	CONDITIONS (IE. WIND, GLARE, SEA STATE)

BOAT-BASED SURVEY OBSERVATION SHEET

Marine Mammal Survey in the Strait of Belle Isle
JWEL Project 1203

WIND DIRECTION/SPEED:

BEAUFORT SCALE: **VISIBILITY:** **SKY:**

DATE	TRANSECT NO.	OBSERVER	RIGHT/LEFT
START TIME	END TIME	ALTITUDE	
START POSITION	END POSITION	HEADING 320^{o}; 140^{o}	

WAY POINT	SIGHTING BOARD	OBS. TIME	OBS. ANGLE	SPECIES (ad/juv.)	COUNT	COMMENTS

Page ____/____

Straits of Belle Isle Seabirds

Newfoundland and Labrador Hydro - 1203-1531

Date:_________________ **Transect #**:_______ **Bearing**:_______ **Ship Speed** (*knots*) _______

	START	END
Position	N51° . ´,W ° . ´	N51° . ´,W ° . ´
Way Point #		
Time		
Visibility		
Weather	*Sky* *Wind (knots)* *Temp (°C)*	*Sky* *Wind (knots)* *Temp (°C)*
Observer: **Bruce Mactavish**		

Page ____/____

Date: ______/______/ 98 ______ Transect: ________________ Bearing: ___________

Start Position: N 51° . ´, W ° . ´			Way Point #:
Species	Number	Comments	

Start Position: N 51° . ´, W ° . ´			Way Point #:
Species	Number	Comments	

APPENDIX B

Historical Data References

Historical Data References

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Labrador–Island Transmission Link

Strait of Belle Isle:
Ambient Noise and Marine Mammal Survey

Prepared for:

Nalcor Energy
Hydro Place, 500 Columbus Drive, PO Box 12800
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Project 001107-001
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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 *Ambient Noise and Marine Mammal Survey* was completed to collect and present information on ambient noise and marine mammals in the Strait of Belle Isle (SOBI).

In 2010, acoustic data were recorded at three locations along or near the two identified cable crossing corridors across the SOBI: (1) off Flower's Cove, Newfoundland; (2) near the middle of the SOBI; and (3) near L'Anse Amour, Labrador. Acoustic recorders were deployed and they recorded sounds at the three locations from June to August and from September to December 2010.

Analysis of acoustic data confirmed the presence of several marine mammal species during the recording periods. Humpback whales (*Megaptera novaeangliae*), killer whales (*Orcinus orca*), and dolphins (most likely *Lagenorhynchus albirostris* and *L. acutus*) accounted for the majority of the biological sounds. Humpback whales and dolphins were present in all recordings. The main detection period for the humpback whales and dolphins was before 10 November. Killer whales were present at all three locales but became scarce at the beginning of August, and were not detected during the September to December recording period. The greatest number of detections for these species occurred at the station near the middle of the Strait, followed closely by the Labrador Station. The Newfoundland location recorded considerably less biological acoustic activity. Blue whales (*Balaenoptera musculus*) and a sei whale (*Balaenoptera borealis*) were detected during the June to August recording period. The blue whales were detected at the Newfoundland Station recorder and the sei whale was detected at the Middle Station. Fin whales (*Balaenoptera physalus*) were detected most days of the September to December recording period, and sporadically during the June to August recording period. Additional biological activity was recorded but could not be identified, although many are presumed to be from fish. No pinnipeds were definitively identified in either deployment period.

Analysis of the ambient data indicated that marine noise levels in the SOBI are well within the normal limits of prevailing ocean noise. Below 100 Hz real and pseudo-noise from tidal flow dominate the measured noise. Above 100 Hz local vessel traffic is the dominant noise source when present. Noise measured from the recorder in the middle of the Strait was 5 dB higher during the October to December recording period, likely due to storm activity.

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 INTRODUCTION

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.

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 EA of the Project, this *Strait of Belle Isle: Ambient Noise and Marine Mammal Survey* was conducted to measure and document ambient (baseline) sound levels in the marine environment of the Strait of Belle Isle (SOBI), for use in the eventual environmental effects analyses.

The sound data collected as part of this marine survey were also analyzed to detect marine mammal vocalizations in the area during the survey period, as further environmental baseline information for use in the EA.

1.1 Project Overview

The proposed Labrador–Island Transmission Link involves the construction and operation of transmission infrastructure within and between Labrador and the Island of Newfoundland. Nalcor Energy is proposing to establish an HVdc transmission system extending from Central Labrador to the Island's Avalon Peninsula.

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

- an ac-dc converter station in Central Labrador, on the lower Churchill River adjacent to the Lower Churchill Hydroelectric Generation Project;
- an HVdc transmission line extending 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 approximately 60 m wide, and consist of single galvanized steel lattice towers;
- cable crossings of the Strait of Belle Isle with associated infrastructure, including cables placed under and on 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 SOBI cable crossings, as well as various alternative corridor segments in particular areas (Figure 1.1). 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 EA of the Project will also identify and evaluate alternative means of carrying out the Project that are technically and economically feasible. In conjunction and concurrent with the EA process, Nalcor Energy will be continuing with its technical and environmental analyses of the corridors, 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 was to determine the ambient underwater noise environment of the Strait of Belle Isle for eventual use in the EIS. Additionally, the acoustic recordings were analyzed for the presence of marine mammal calls to evaluate the acoustic occurrence of cetaceans and pinnipeds in the Strait of Belle Isle during the ice-free period. The Study Area included the Strait of Belle Isle, approximately between Forteau Point/Point Amour and Mistaken Cove/Yankee Point (Figure 1.1).

Figure 1.1 Proposed Strait of Belle Isle Submarine Cable Crossing Corridors

2.0 METHODS

2.1 Location and Study Design

The study area surrounds the proposed SOBI submarine cable crossings. The objectives of the acoustic monitoring were to determine: (1) the ambient noise in the SOBI; and (2) the usage of the SOBI by marine mammals during the ice-free period.

The marine mammals of primary interest are large cetaceans such as blue, fin, humpback, and killer whales. These mammals can be detected at ranges of tens to hundreds of kilometres from the recorders, depending on the noise and sound propagation conditions (Širović *et al.* 2007). Other mammals of interest include pinniped and dolphin species, which are detectable by the recorders at shorter ranges due to their lower source levels and higher frequencies which do not propagate as far. Based on the 20 km width of the SOBI, three recording locations were considered appropriate, with recording stations evenly spaced across the Strait. The sampling rate for the study was intended to be 16 kHz, which provides a usable frequency bandwidth of 10 Hz to 7500 Hz. This frequency range captures all acoustic energy from shipping, construction activities, as well as calls from seals as well as blue, fin, minke, humpback, sei, right, and killer whales. The lower end of dolphin whistles is detectable in this band as well. To better capture the full range of dolphin whistles, a recording sampling rate of 32 kHz is more suitable. The higher sampling rate would capture the upper range of humpback and killer whale calls.

The initial survey period was intended to be late June to September 2010. Toward the end of summer, Nalcor Energy also opted for a second deployment from October to December 2010 to monitor the SOBI in the fall. The sampling rate for the June–September deployment was inadvertently reset to 32 kHz due to a software error. This provided better dolphin, humpback, and killer whale data, at the expense of a shorter recording period (June to mid-August). The second recording period was performed at 16 kHz sampling rate.

The exact deployment locations were chosen in consultation with local fishers, to ensure the recorder locations were as well suited as possible for the study objectives, but also safe from long line and scallop trawling activity. The selected sites have particularly rocky bottoms that fishers often try to avoid.

In this report the three recording stations are referred to as 'Labrador', 'Middle', and 'Newfoundland'. The Labrador recorder was located in the bay between L'Anse Amour and Forteau Point, the Middle recorder was located near the middle of the Strait (about 1 km south of one of the corridors), and the Newfoundland recorder was located near Flower's Cove, along one of the proposed corridors.

2.2 Acoustic Monitoring Equipment

Underwater acoustic monitoring was performed with Autonomous Underwater Recorders for Acoustic Listening Model 2 (AURALs, Multi-Electronique Ltd.) recorders. The AURAL is powered by 64 D-cell industrial alkaline batteries. Data were recorded in 30 min files on a 320 GB IDE hard-disc drive at 16-bits per sample. The recorders were configured for 22 dB of gain (voltage level amplified by 22 dB or a factor of 12.6). The AURALs were set to record continuously at a rate of 32,768 samples per second during the first deployment and 16,384 samples per second during the second deployment, providing useable frequency ranges of 5 to 16,384 Hz and 5 to 8,192 Hz, respectively. Each AURAL was fitted with an HTI-96-MIN precision, low-noise, omnidirectional hydrophone (High Tech Inc.) with -201 dB re 1 V/µPa sensitivity (without preamp).

Each recorder was mounted to a float frame with a xenon flasher/radio beacon (Novatech ST-400B6, Cobham Tracking & Locating Ltd.). The float frame assembly was weighted to the seabed with a 45 kg anchor weight (recycled mooring chain), attached via dual acoustic releases for Deployment 1 (Model 111, InterOcean Systems; Figure 2.1) and a single acoustic release for the Deployment 2.

Figure 2.1 AURAL Recorder (white) on a float frame with dual acoustic releases (yellow) before deployment at the Newfoundland Station.

2.3 Recorder Deployment and Retrieval

Acoustic data were collected over two deployments in 2010. For Deployment 1, three recorders were deployed 19 June 2010, from the *Freda M,* captained by Jarvis Walsh, from Flower's Cove NL. The deployment locations (Table 2.1, Figure 2.2) were chosen in consultation with the vessel operator and crew to ensure they were well suited for the study objectives while avoiding potential interaction with long-line and scallop-trawling activity.

The Deployment 1 recorders were retrieved 30 September 2010 from the *Freda M*. Upon review of the data, it was determined that the recorders had reset unexpectedly during shipment to a sample rate of 32 kHz from the desired rate of 16 kHz. As a result, data collection ended (when the hard-drive reached capacity) between 31 July and 19 August (Table 2.1), rather than in late September. As previously stated, the improved bandwidth did, however, provide better dolphin, humpback, and killer whale data.

Table 2.1 Deployment 1 Locations, June to August 2010. Location, distance to each shore and period of operation for the three recorders deployed 20 June 2010 in the Strait of Belle Isle.

Recorder Station	Latitude (N)	Longitude (W)	Depth (m)	Distance to Nfld (km)	Distance to Labrador (km)	Deployment	Recording End	Retrieval
Newfoundland	51°19.739′	56°45.729′	32	2.2	16.0	20 Jun	31 Jul	30 Sep
Middle	51°21.003′	56°52.950′	116	10.1	10.7	20 Jun	19 Aug	30 Sep
Labrador	51°27.890′	56°53.300′	51	20.0	0.6	20 Jun	18 Aug	30 Sep

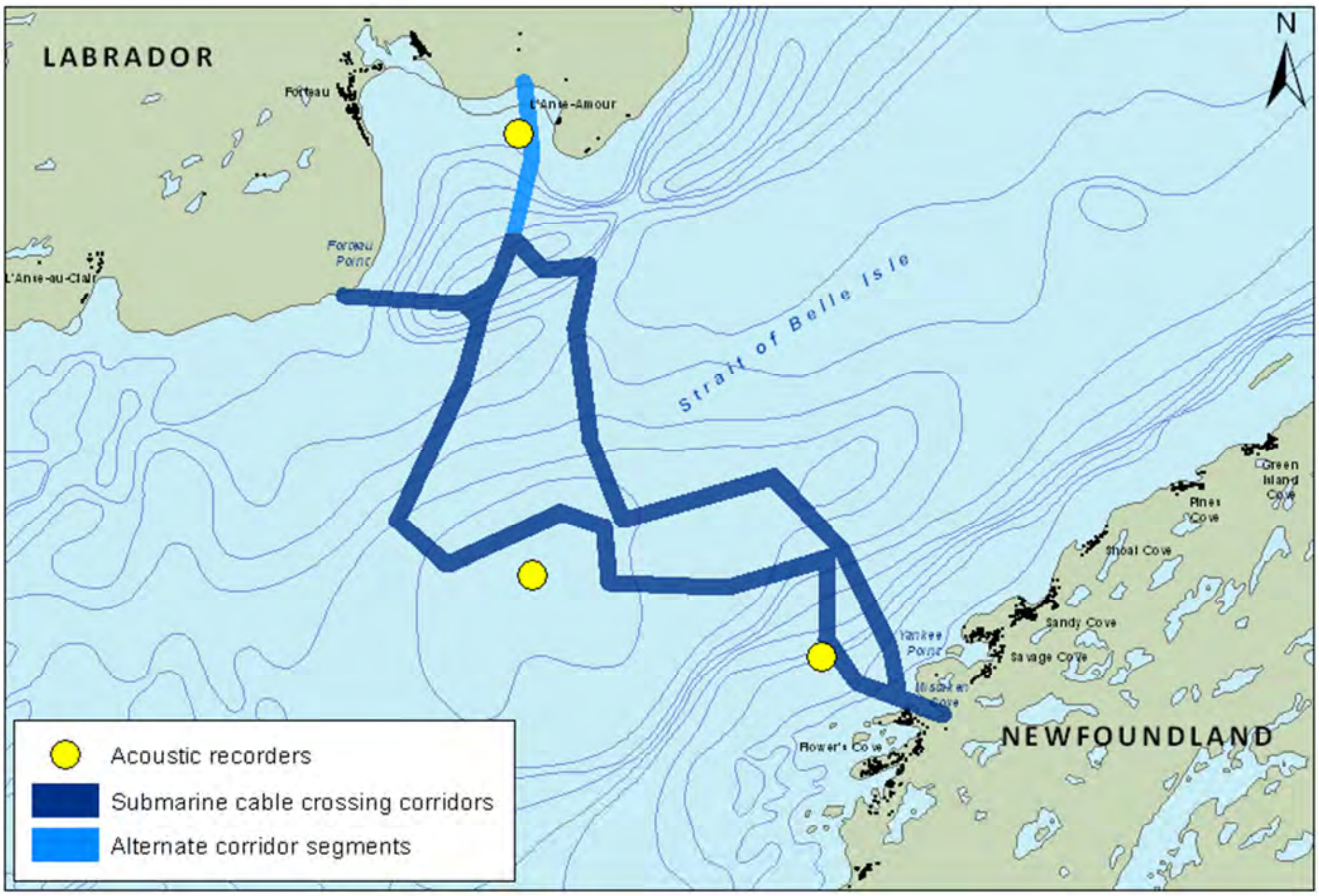


Figure 2.2 Acoustic Recorder Locations for the June to August and September to December 2010 deployment periods in the Strait of Belle Isle. Each station was instrumented in both periods.

For Deployment 2, three recorders were deployed 30 September 2010 at the Deployment 1 locations (Table 2.2, see Figure 2.2). The recorders were configured and tested on location before deployment. Due to equipment availability, the recorders were deployed with a single acoustic release.

Retrieval activities occurred over three days (13 to 15 December 2010) with assistance of the *M/V Labrador Venture* from L'Anse-Amour, captained by Lloyd Normore. Only the Middle recorder was retrieved, as the acoustic releases on the Labrador and Newfoundland recorders did not release. Many attempts over three days to retrieve the Newfoundland and Labrador recorders, using grapple gear and fish-finder sonar, were unsuccessful. A possible transpond ping was received from the Newfoundland recorder and the unit was visible on the fish finder. A return trip is planned for June 2011 to retrieve the Newfoundland and Labrador recorders using a side-scan sonar.

Table 2.2 Deployment 2 Locations, September to December 2010. Location, distance to each shore and period of operation for the three recorders deployed 30 September 2010 in the Strait of Belle Isle.

Recorder Station	Latitude (N)	Longitude (W)	Depth (m)	Distance to Nfld (km)	Distance to Labrador (km)	Deployment	Recording End	Retrieval
Newfoundland	51°19.470′	56°45.920′	32	2.2	16.0	30 Sep	*	*
Middle	51°21.020′	56°53.040′	116	10.1	10.7	30 Sep	11 Dec	13 Dec
Labrador	51°27.510′	56°53.290′	51	20	0.6	30 Sep	*	*

* Retrieval to be re-attempted in June 2011.

2.4 Data Analysis

The acoustic data recorded at the three stations in the SOBI was analyzed by both manual analysis and JASCO's automated detection/classification software suite. A total of 5% of the data from each station was analyzed manually by two trained analysts to identify marine mammal calls and classify them by species and call type. This was achieved through visual examination of spectrograms, combined with auditory (listening) review. All data acquired during both surveys were analyzed with JASCO's automated data processing suite to: (1) compute ambient noise levels; (2) detect marine mammal vocalizations and identify by species; and (3) detect boating and shipping vessel noise.

2.4.1 **Manual Analysis**

Manual data analysis was conducted on 5% of the data recorded on all recorders (except those not yet retrieved) to establish acoustic occurrence of each species during both survey periods. Acoustic data were recorded continuously during both surveys. For each recorder throughout each survey period, manual analysis was performed on 90 s segments sampled every 30-min (*i.e.*, the first 90 s of each 30-min audio file). In total, for each day (1440 min) of recording, 72 min were manually analyzed, which equates to 5% of the dataset. The annotation of one call per species per sample provided an estimate of the acoustic occurrence of each species within the entire dataset. Additionally, the first and middle samples of each day were fully annotated (*i.e.*, all marine mammal calls were annotated). These fully-annotated samples were used to assess the performance of the detector by comparing the number of manual and automated detections (see Appendix A).

In case of doubt regarding species identification within a sample, the source file of the sample was examined for the presence of more easily identifiable calls. The manual analysis was performed with a custom software tool (*SpectroPlotter*) allowing standardized annotations and consistency of approach between analysts. Calls were identified by species and call type (Table 2.3).

The lead analyst reviewed a subset of annotations from the other analyst to ensure accurate species classification of vocalizations. Emphasis was placed on verifying annotations for which a classification risk was identified (*e.g.*, possible confusion between killer whale and *Lagenorhynchus* sp.) as well as notable or suspicious annotations (*i.e.*, annotations referring to species not commonly in the area). Owing to the large number of "unknown" annotations (see Table 3.1), the review focused on those that were tentatively identified to a species for days with no confirmed manual detections of that species to ensure all detection days were compiled.

The manual annotations were used to determine the acoustic occurrence of each species throughout the operational period of each recorder. A species was considered present on a day if at least one call was detected on at least one sample for that day. This analysis is not intended to yield the relative abundance of species.

2.4.2 **Automated Data Analysis**

JASCO's automated acoustic analysis software suite was used to: (1) compute ambient sound levels, (2) detect marine mammal calls, and (3) detect anthropogenic and shipping events within the acoustic data, as described in the following sections.

Ambient Noise

Ambient sound levels at each recording station were examined to document baseline underwater sound conditions during each survey period. Ambient noise at each of these stations was analyzed by Hamming-windowed fast Fourier transforms (FFTs) with 1-Hz resolution and 50% window overlap. 120 FFTs performed this way were averaged to yield 1-min average spectra.

Ambient sound levels at each recording station are presented as:

1. Broadband and approximate-decade-band sound pressure levels (SPLs) over time for the frequency bands:

    - 10 Hz to 16 kHz or 10 Hz to 8 kHz (broadband SPL, Deployment 1 and 2, respectively),
    - 10 Hz to 100 Hz,
    - 100 Hz to 1 kHz, and
    - 1 kHz to 10 kHz or 1 kHz to 8 kHz (decade-band SPLs, Deployment 1 and 2, respectively).

2. Spectrograms of the 1-min average spectra computed as described above. These plots show the distribution of sound energy in both time and frequency.

3. Spectral level percentiles: Histograms of each frequency bin for all 1-min data from each recorder were computed. The 5th, 25th, 50th, 75th, and 95th percentiles are plotted. The 95th percentile curve describes the frequency dependent levels exceeded by 5% of the 1-min averages. Equivalently, 95% of the 1-min spectral levels are below the 95th percentile curve. The 95^{th} percentile represents the quietest noise state that can be expected to occur. The 5^{th} percentile typically represents the noise level associated with occasional loud events such as nearby shipping or extreme weather.

The 50th percentile (median of 1-min spectral averages) can be compared to the well-known Wenz ambient noise curves shown in Figure 2.3. The Wenz curves show the variability of ambient spectral levels as a function of frequency based on measurements worldwide over a range of weather, vessel traffic, and geologic conditions. The Wenz curve data are general and are used for approximate comparison only. The limits of prevailing noise from the Wenz curves are overlaid as dashed lines on the percentile spectral levels for comparison.

Table 2.3 Marine Mammal Call Types Annotated During Manual Analysis.

Species	Call Type	Description
Humpback Whale	Moans	LF FM calls, may have harmonic structure (Thompson *et al.* 1986, Dunlop *et al.* 2007).
	Cries	HF FM calls, usually without harmonics, may have multiple inflexion points (Thompson *et al.* 1986, Dunlop *et al.* 2007).
	Grunts/Snorts/ Wops	Grunting sounds, peak frequency usually below 500 Hz, often upsweeping at the end (Thompson *et al.* 1986, Dunlop *et al.* 2007).
	Growl/Purr/ Trill	LF purring sounds with marked harmonic structure (Thompson *et al.* 1986, Dunlop *et al.* 2007).
	Overlap	Overlapping calls produced concurrently by several humpbacks.
	Other	Humpback calls that do not match the above categories.
Minke Whale	Downsweep	Short downsweeping calls between 200 and 50 Hz (Edds-Walton 2000).
	Pulse Train	Series of pulses between 200 and 400 Hz, usually 40–60 s in duration (Mellinger *et al.* 2000).
	Other	Minke whale calls that do not match the above categories.
Fin Whale	Narrowband Downsweep	Pulse down-sweeping from 25 to 18 Hz, about 1 s long (Watkins 1981).
	Broadband Downsweep	Pulse down-sweeping from 50 Hz or higher to 18 Hz (Watkins 1981).
	Other	Fin whale calls that do not match the above categories.
Blue Whale	Infrasonic Downsweep	Downsweeping call between 18 and 15 Hz, 5–15 s in duration (Berchok *et al.* 2006).
	Infrasonic Monotonic	Flat call between 18 and 15 Hz, 5–20 s in duration (Berchok *et al.* 2006).
	Audible Downsweep	Downsweeping call between 90 and 30 Hz, about 2 s in duration (Berchok *et al.* 2006).
	Other	Blue whale calls that do not match the above categories.
Sei Whale	Downsweep	Downsweeping moan from 100 to 30 Hz, about 1.5 s in duration (Baumgartner *et al.* 2008).
	Other	Sei whale calls that do not match the above categories.
Killer Whale	Pulsed Calls	Characterized by harmonic structure. Fundamental frequency usually around 800–1000 Hz. Stereotyped calls often repeated within a sound file (Ford 1989).
	Clicks/Buzzing	Broadband clicking sounds, presumably for echolocation (Barrett-Lennard *et al.* 1996).
	Whistles	FM calls usually without harmonics (Ford 1989).
	Overlap	Overlapping calls produced concurrently by several animals.
	Other	Killer whale calls that do not match the above categories.
Lagenor-hynchus sp.	Whistles	FM calls, usually between 5 and 16 kHz, 0.05 to 1 s in duration (Rasmussen and Miller 2002).
	Clicks	Broadband clicking sounds, presumably for echolocation.
	Overlap	Overlapping calls produced concurrently by several animals.
	Other	Dolphin calls that do not match the above categories.
Harbour Seal	Roars	Roaring sounds with highest energy around 1.2 kHz, 7 to 10 s in duration (Van Parijs *et al.* 2002).
	Other	Harbour seal calls that do not match the above categories.
Harp Seal	Grunts/Other	Calls assigned to harp seals based on context.
Unknown	Grunts	Grunt-like calls, generally produced by unidentified seals.
	Undescribed	Biological sounds matching no call type listed above. Includes calls unclassifiable from context.

Notes: Abbreviations: FM, frequency-modulated; HF, high-frequency; and LF, low-frequency.

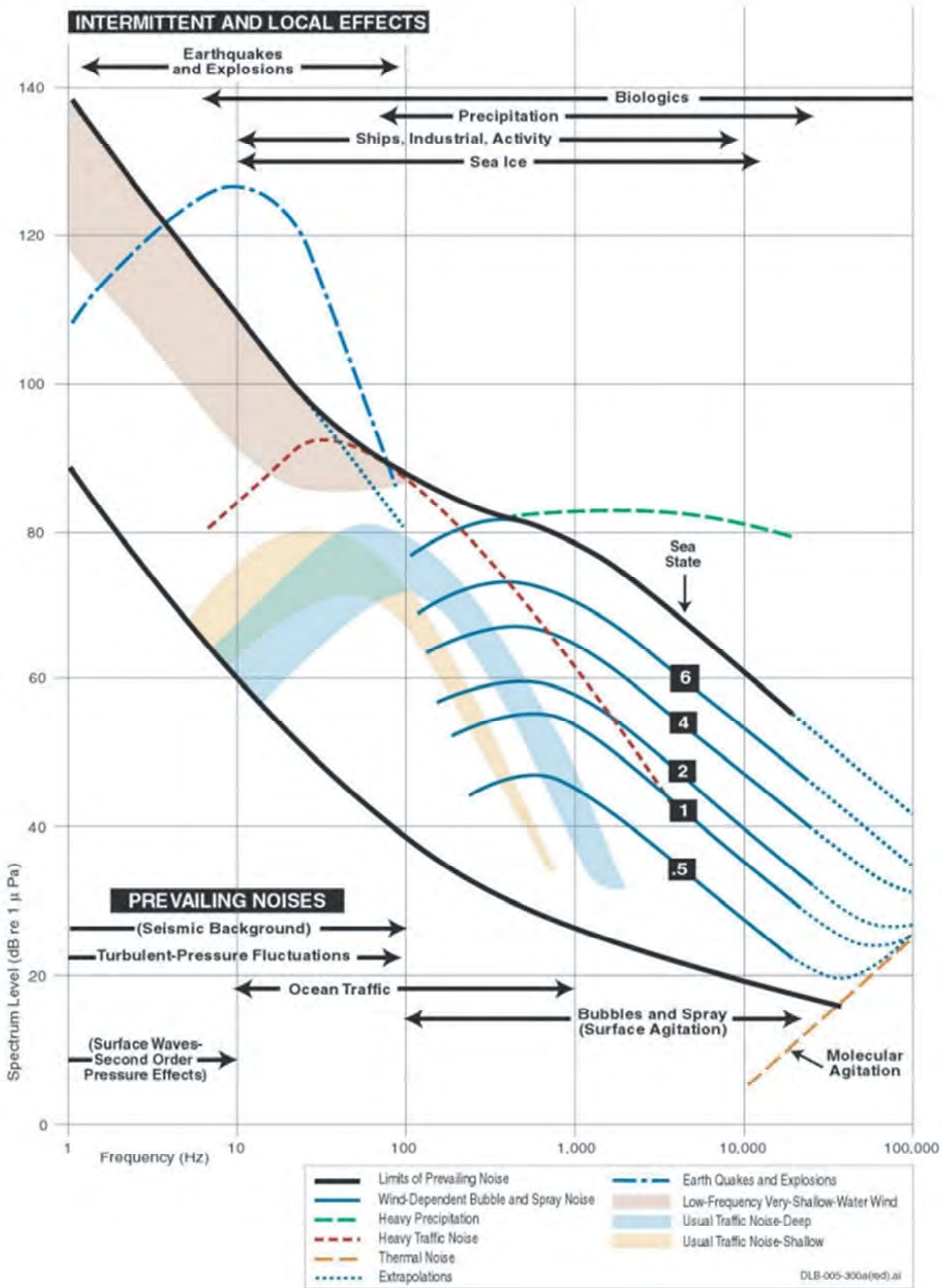


Figure 2.3 Wenz Curves of Ambient Noise in the Ocean. Pressure spectral density levels of marine ambient noise from weather, wind, geologic activity, and commercial shipping (Ocean Studies Board 2003 adapted from Wenz 1962). Thick lines indicate limits of prevailing noise.

Marine Life Call Detection

The automated detection of marine life calls consists of three stages: (1) short time Fourier analysis; (2) contour following with parameter extraction; and (3) contour sorting. The detection and sorting algorithms are designed for high probability of detection of vocalizations. The call sorter provides a means of computing call counts from large datasets where only a portion of the data can be analyzed manually in a reasonable timeframe. Evaluation of the sorter's performance as a classifier requires comparison against known correct classifications. Comparisons of the sorter outputs to the manual analysis results were used to generate precision and recall values (see Appendix A) for the detector/classifier, which in turn allowed us to obtain accurate estimates of call counts.

Short-Time Fourier Transform (Spectrogram) Analysis

The automated detection of acoustic events, such as marine life sounds, was performed via spectrogram in the time/frequency domain. The data are converted to a time/frequency representation using a short-time Fourier transform (STFT; Oppenheim and Schafer 1975). To detect transient calls by marine mammals, a short-time span is analyzed at each time step to investigate changes in frequency content as a function of time. The choice of STFT parameters affects the overall performance of the detector/sorter. The parameters available and their effects are described in Table 2.4. The effects of different STFT parameters on two types of signals are shown in Figure 2.4. The actual signal processing implementation uses a fast Fourier transform (FFT; Oppenheim and Schafer 1975).

Table 2.4 STFT Analysis Parameters.

Parameter	Definition	Effect of Increasing	Effect of Decreasing
Sample Rate (determined by data collection system)	Number of data samples acquired per second. Highest frequency that can be analyzed is one half the sample rate (the Nyquist frequency).	More demanding signal processing.	Less acoustic information since there is less frequency range represented. Faster to process.
Analysis Window Length	Total number of data points in the FFT. Set to a power of 2 for efficient FFT implementations.	Increases the frequency resolution, but decreases the time resolution. Frequency resolution is equal to 1/window length, *e.g.*, a 2-s long FFT has a resolution of 0.5 Hz. Longer is better for signals where the frequency changes slowly in time.	Better if the signal frequencies change rapidly in time.
Zero-Padding	If the number of actual data samples in the FFT is less than the FFT length, then remaining points are set to zero.	Increasing the zero padding allows the analysis to keep a high frequency resolution, but with better time resolution. This technique provides a better resolution, but does not improve the ability to discriminate two closely spaced tonal frequencies which would otherwise require more data and a longer FFT.	Some signals have constant frequencies for short durations, which are best represented by long FFTs with less actual data in the FFT.
Analysis Window Advance	The number of data points that the data flow advances with each FFT, *e.g.*, with a 2048-point FFT, we can advance by 25% or 512 data points.	Provides lower time resolution, speeds up the analysis, and makes each output more sharply defined. A 'window' function in time is normally applied before an FFT to reduce frequency sidelobes. As a result there should always be some overlap to ensure all data is represented.	Provides more output points when a signal is present, thereby improving detection and contour following. This increases processing time due to data redundancy.

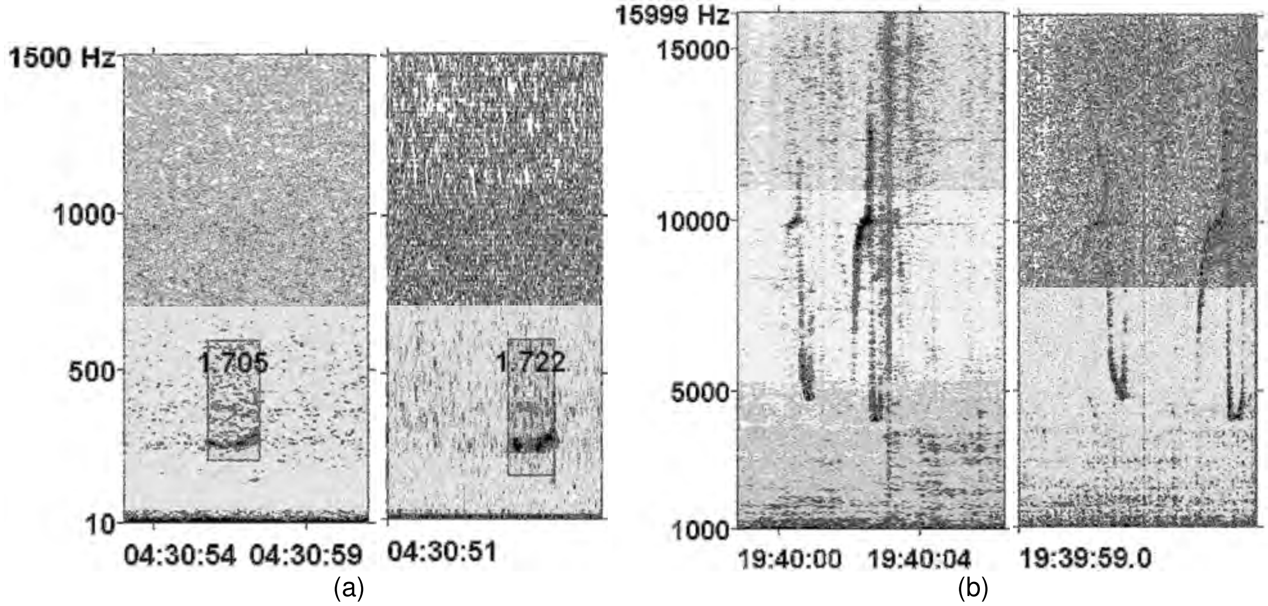


Figure 2.4 Effects of Different STFT Settings. (a) Humpback moan recorded at a sample rate of 32 kHz. Left panel of (a) was analyzed with a 0.25 s analysis window, and an advance of 0.0625 s. Right panel of (a) was analyzed with a 0.0625 s analysis window and 0.016 s advance. (b) A dolphin whistle processed with the same settings. The short settings are better suited to the rapidly changing dolphin whistle, while the longer settings are better suited to the slowly changing humpback moan.

The data were analyzed in a processing block of specific duration. As an example for discussion, assume a block size of 128 s. Assuming the sample rate is 16,384 Hz, and using an analysis FFT window size of 2048 pts (1/8 second) with window advance of 1024 pts, the processing block has 2047 time window steps (16 window step advances per second times 128 s per block). Detection of time-frequency cells with energy peaks must occur before the contour-following and sorting. For all time steps in the processing block, the data in each frequency bin are sorted and normalized by the median amplitude for that frequency bin. The normalized values are then compared to an empirically chosen detection threshold. The bins above the threshold are set to one and the bins below the threshold are set to zero. This is referred to as the contour data space, which is a binary 0/1 matrix. Typically the detection thresholds for the normalized data are four times the median value. This approach has been found to provide better performance for tonal and whistle events than a split-window mean normalization scheme or a simple energy threshold.

Contour Following and Parameter Extraction

This study implemented a simple yet robust contour-following algorithm that is a variation of the flood-fill algorithm (Nosal 2008). The contour data space is passed to a contour-follower algorithm that joins cells with detected energy. For each ‘test’ cell that is a ‘1’ in the contour space, the joining algorithm searches adjacent points that are also ‘1’. The merged cells create a contour of the vocalization. Figure 2.5 shows the contour ‘mask’ which are the adjacent cells that may be added to a contour. The contour joining algorithm moves from oldest data to newest and from lowest frequency to highest. Each detected time-frequency bin can be added to only one contour. This algorithm does not distinguish between different calls.

As shown in Figure 2.5, the starting cell for joining to the contour is the center white cell which must be a ‘1’ to initiate contour following. All green and blue cells are checked and those equal to 1 are added to the contour. The algorithm advances from left to right in time; therefore gray cells left of the test cell need not be checked. However, checking the far left cells may join broken contours. Note that a contour can be broken—a ‘1’ in the green cells is added to the contour even if all blue cells are ‘0’.

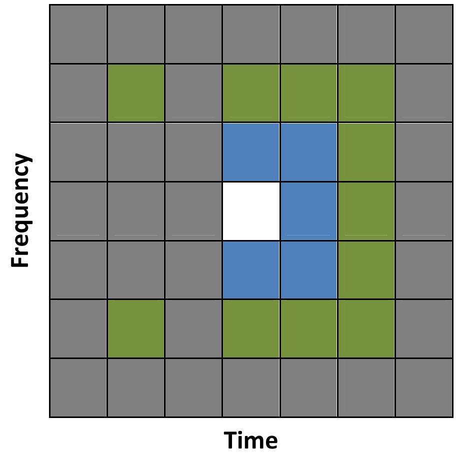


Figure 2.5 Contour-Follower Mask

Once a contour is complete, the following features are extracted:

- Start time,
- Duration,
- Minimum frequency, and
- Maximum frequency.

This algorithm is sensitive to noise generated by small pleasure craft or fishing vessels near a recorder, which can generate many contours that may be mistaken for marine life calls. Therefore, a boating detector is implemented in the contour follower to reduce false-positive detections. Boating is considered detected when at least five frequencies have detected contours for 5 s. Files with at least two detections of boating are omitted from further processing.

Contour Sorting

A 'contour-sorter' algorithm compares the extracted parameters against a defined set of call types. The best match, in terms of duration and bandwidth, is selected as the output type. The algorithm supports three types of contours:

- Regular Contours—output as a complete object from the contour follower, *e.g.*, simple downsweep calls and whistles.
- Multi-Component Contours—generally occupy several frequency bands at once, such as harmonics of a killer whale call, a humpback song, or sub-harmonics below 16 kHz produced by dolphin or beluga feeding buzzes.
- Multi-Time Component Contours—groups of related contours that are broken in time, *e.g.*, seal trills and groups of beluga, dolphin, or beaked whale whistles.

Call types are defined by the following parameters:

- Minimum frequency—often lower than the published lower frequency bound for the species and call type.
- Maximum frequency—either the maximum frequency expected for the call type, or the maximum frequency in the data, whichever is lower.

- Minimum duration—at least one STFT time slice.
- Maximum duration.
- Minimum bandwidth.
- Maximum bandwidth—not often used.
- MultiComponent (Boolean): for call types where contours should be grouped in frequency with some time overlap before applying the frequency, duration, and bandwidth constraints. Each contour that is added to the multi-component contour has the following constraints applied:
    - minComponentDuration—minimum duration for a contour to be added to the multi-component contour.
    - minComponentBW—minimum bandwidth for a contour to be added to the multi-component contour.
    - Minimum and maximum frequencies as per the global definition.
- MultiTimeComponent (Boolean): for call types where contours should be grouped in time before applying the frequency, duration, and bandwidth constraints. Each contour that is added to the multi-time-component contour has the following constraints applied:
    - minTimeComponentDuration—minimum duration for a contour to be added to the multi-time-component contour.
    - minTimeComponentBW—minimum bandwidth for a contour to be added to the multi-time-component contour.
    - Minimum and maximum frequencies as per the global definition.

Figure 2.6 shows a block diagram of the contour sorter algorithm. The algorithm consists of two loops. The outer loop iterates through the contour list. For each contour that has not yet been sorted, the contour's features are compared to each defined call type in the inner loop. If the call type is a multi-component or multi-time-component type, the contour list is searched for unsorted calls that meet the call association criteria. The total contour duration, minimum and maximum frequencies, and call bandwidth are compared to the call type definition. If the contour falls within the call type's bounds, then the bandwidth (BW_i) and duration (T_i) indices are computed:

$$BW_i = \frac{BW_{contour}}{BW_{call}} \quad T_i = \frac{T_{contour}}{T_{call}}$$

If either of these indices exceeds an empirically chosen threshold of 1.5 times the current best index, then the current best-match call type is updated. The 1.5 threshold for updating the best-match call type means that the algorithm prefers call types that are defined earlier. Therefore, if for a particular recording killer whales are more likely to occur than singing humpbacks, the killer whale call should be defined before that for humpbacks.

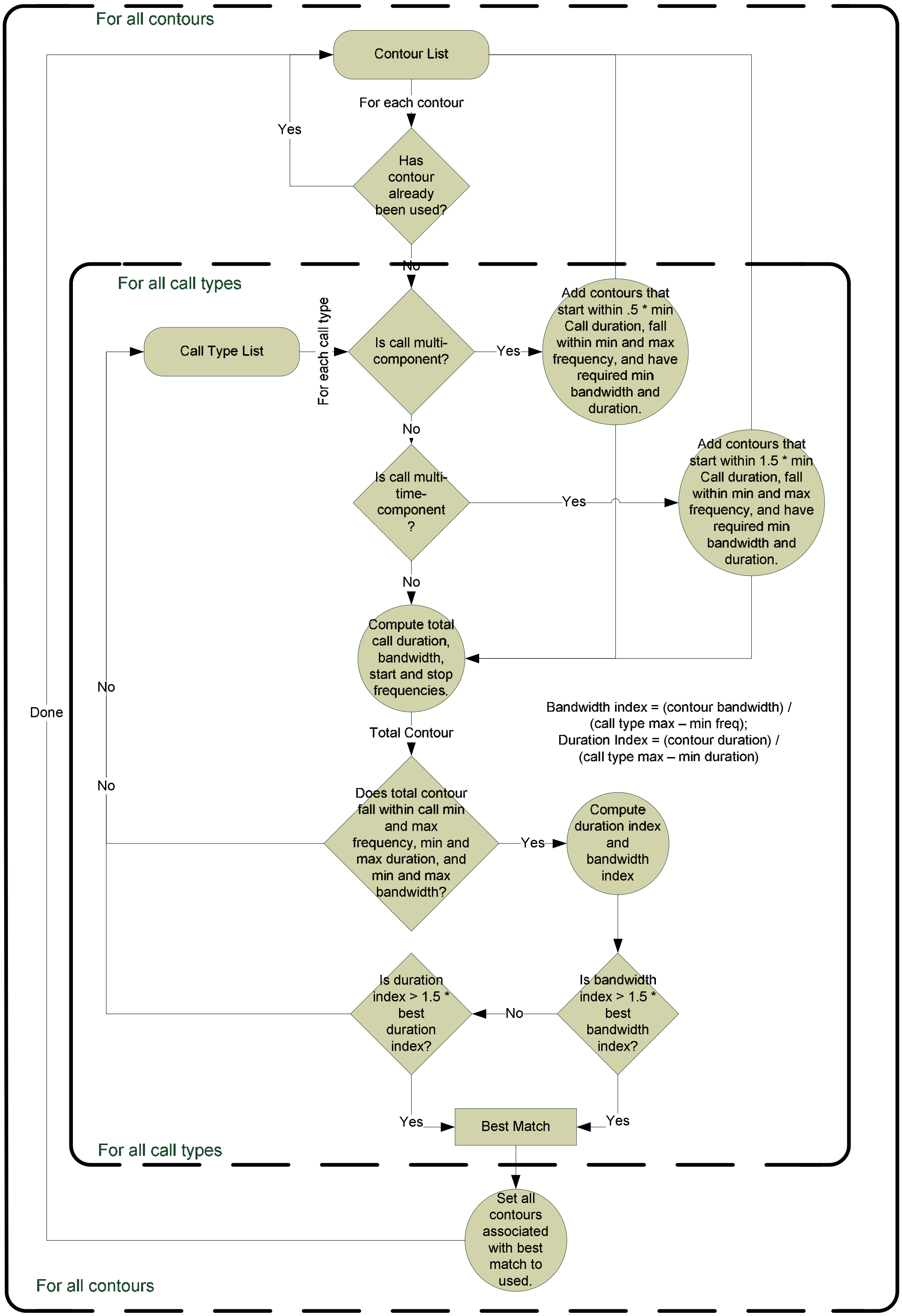


Figure 2.6 Contour Sorter Algorithm Block Diagram

Figure 2.7 is an example of all three types of contours applied to dolphin calls. Referring to Figure 2.7, the far left event in green is a feeding-buzz sub-harmonic detection that was assembled from discrete contours for each harmonic using the multi-component contour type. At middle right is a single whistle contour type, and at the far right is a group of whistles that was associated together using the multi-time-component call type definition. The purple box to the right shows an impulse that extends below the minimum defined frequency for dolphin calls. The purple box in the time series window at the middle of the display is a detection below 1000 Hz which is not visible in the spectrogram. The parameters for the STFT were a 2048-point analysis window with a 512-point advance.

The SOBI data analysis required two marine mammal data runs. The first data run searched for low-frequency calls from large mammals. The second data run searched for dolphin whistles. Table 2.5 and Table 2.6 show the parameters used for each detection run. These parameters are based on published duration and minimum and maximum frequency values for the most common calls of the species expected in the study area. These bands should therefore capture most vocalizations for these species.

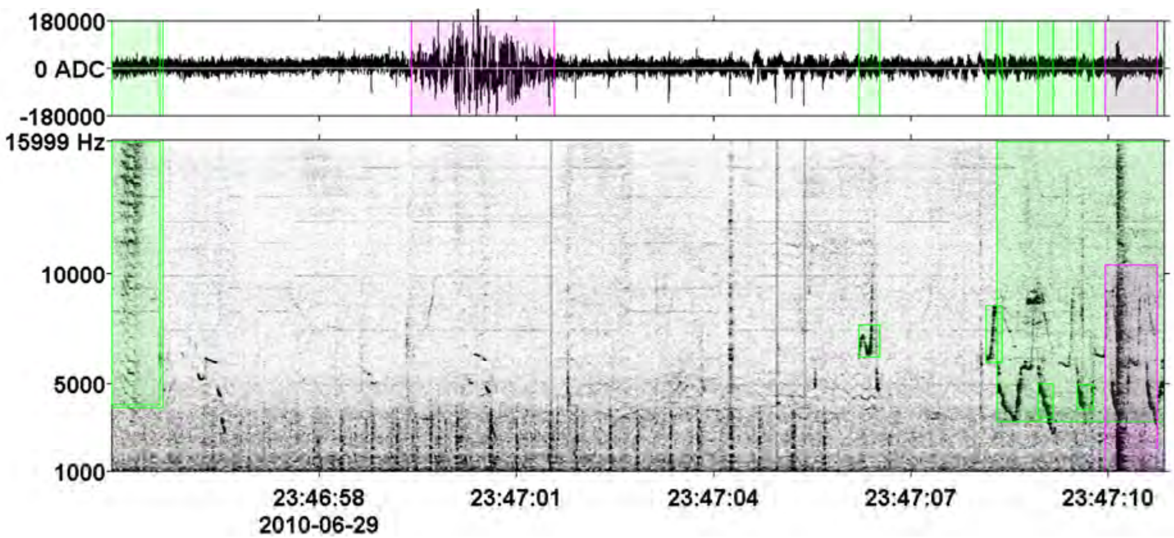


Figure 2.7 (Top) Time Series and (Bottom) Spectrogram of Examples of Three Types of Contours from the Sorter Output using SOBI-specific parameters.

Table 2.5 Automated Detection Parameters for Low-Frequency Marine Life Vocalizations (using 0.25-s FFTs with 0.25 s Real Data, 0.0625-s advance, and a detection threshold of 4) based on published values of call duration and minimum and maximum frequency.

Band	Frequency (Hz)	Duration (s)	Min. Bandwidth (Hz)	Species/Call Type
1	12–120	0.7–20	12	Blue whale (Berchok *et al.* 2006)
2	8–50	0.5–2	15	Fin whale (Watkins 1981)
3	30–180	0.4–2	50	Sei whale (Baumgartner *et al.* 2008)
4	100–10000	0.5–5.0	500	Humpback complex calls (multi-component) (Thompson *et al.* 1986, Dunlop *et al.* 2007)
5	300–7000	0.5–5.0	1000	Killer whale (multi-component) (Ford 1989)
6	100–1000	0.5–5.0	20	Humpback moan (Thompson *et al.* 1986, Dunlop *et al.* 2007)

Table 2.6 Automated Detection Parameters for Dolphin Whistles (using 0.064-s FFTs with 0.064 s real data, 0.016-s advance, and a detection threshold of 3) based on published values of call duration and minimum and maximum frequency. Dolphin species likely encountered are *Lagenorhynchus albirostris* and *L. acutus*.

Band	Frequency (Hz)	Duration (s)	Min. Bandwidth (Hz)	Species/Call Type
1	3000–16000	0.3–10	1000	Dolphin whistles (Rasmussen and Miller 2002)

Vessel Noise Detection

The vessel detector locates narrow tonal peaks characteristic of vessel motors, pumps, and gearing (Arveson and Vendittis 2000). A spectrogram of typical vessel noise is shown in Figure 2.11. The vessel detector generates spectra using a 2-s FFT with a Hamming window and 50% overlap. Sixty of these FFTs were averaged to create 1-min average spectra. The spectra between 1 Hz and 1000 Hz were normalized in frequency, using a split-window normalizer, and searched for narrowband peaks. A positive detection is indicated when a peak occurs in three out of four adjacent 1-min intervals. The detection confidence increases with the number of peaks detected. This technique is appropriate for large shipping vessel traffic only. It is inappropriate for fishing vessels and pleasure craft, which produce sound that varies in frequency due to speed changes and effects of bouncing on the waves.

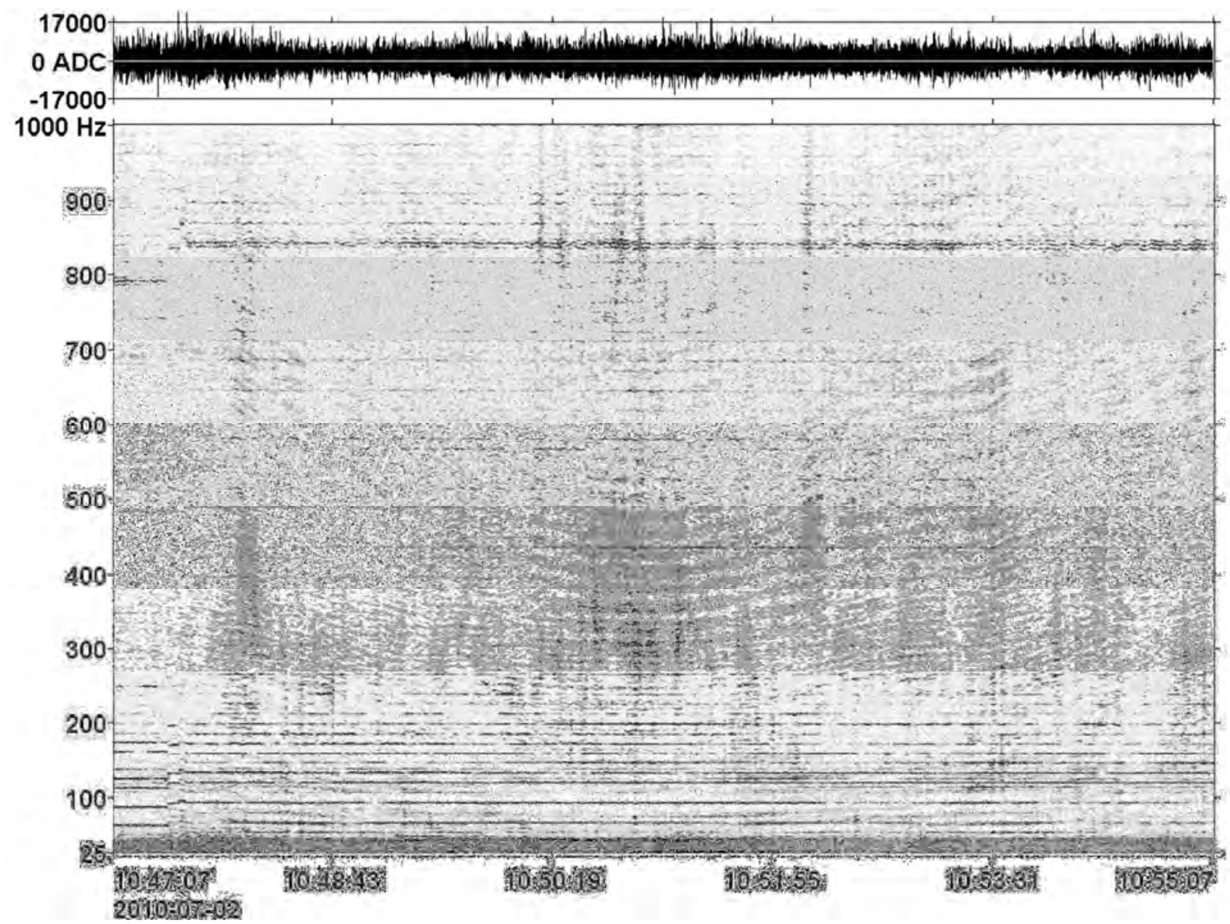


Figure 2.11 Spectrogram of Tonal Vessel Noise at the Middle Station, 2 July 2010 (2-s FFT, 2-s time window, 1.5 s overlap, Hamming window). Upward curved pattern is due to the Lloyd mirror effect. Changes in frequency of the tonals indicate changes in vessel engine speed or gearing.

2.4.3 Combining Automated and Manual Marine Mammal Detections

The performance of the automated detector was assessed individually for each species for all fully-manually-annotated samples. Detector performance was assessed by calculating the precision (*P*) and recall (*R*) metrics, which characterize the relationship between the given automated detector and the dataset. The precision can be seen as a measure of exactness (*i.e.*, how many detected calls were identified correctly), and the recall, of completeness (*i.e.*, how many calls within the data were actually detected). Table 2.7 summarizes the detector performance for each species. There were insufficiently many manual detections of blue and sei whale calls to calculate *P* and *R*.

Table 2.7 Performance of Automated Vocalization Detectors for Each Species. Insufficiently many blue and sei whale calls were detected manually to calculate *P* and *R.*

Species	Recall (%)	Precision (%)
Humpback whale	27	57
Fin whale	34	90
Killer whale	45	67
Dolphins	19	60

Species-specific call counts were plotted to depict the relative abundance of species among stations for each survey period. The number of vocalizations was estimated from the number of automated detections in the frequency bands listed in Table 2.5 and Table 2.6. Because the automated detections may include noise events (*i.e.*, false positives) and may not include all calls within the data (*i.e.*, false negatives), total call counts were estimated with the use of the *P* and *R* values. Provided that the data samples used to calculate *P* and *R* are a good representation of the entire dataset and that at least 100 calls were annotated for a given species, these values can be used to extrapolate the actual number of vocalizations within the data as the number of true detections plus the number of missed detections (see Appendix A for details).

Call count estimates were compiled based on manual classifications. If no call was manually detected for a species in a given file sample, then the automated vocalization count, if any, was zeroed for that file and species. For Deployment 1 (June to August), detection numbers were summed over 2-week periods, corrected and mapped. For Deployment 2 (October to December), the corrected detection numbers at the Middle Station were plotted as a continuous time series.

2.5 Study Team

Recorder deployments and retrievals were performed by Jeff MacDonnell, Eric Lumsden, and Julien Delarue. The manual analysis team consisted of Julien Delarue (lead analyst) and Frederic Paquet. Frederic Paquet analyzed data from the Newfoundland and Middle Stations for Deployment 1 and from the Middle Station during Deployment 2. Julien Delarue analyzed the data recorded at the Labrador Station during Deployment 1. Julien Delarue also aided Frederic Paquet in identifying unknown calls throughout the manual analysis.

Julien Delarue is JASCO’s lead marine biologist, with over seven years experience in acoustic identification of marine mammals in the Arctic, St. Lawrence River, and Gulf of Maine. Frederic Paquet is a marine mammal observer and tour guide, and has over 1000 h experience in marine mammal acoustic identification.

Data processing and ambient noise result extraction were performed by Bruce Martin and Jeff MacDonnell for Deployments 1 and 2.

3.0 RESULTS AND DISCUSSION

The ambient noise and marine mammal survey results are presented separately for each deployment period: Deployment 1, from June to August 2010; and Deployment 2, from September to December 2010. During Deployment 1, marine mammal detections included sounds of blue, fin, sei, humpback, and killer whales along with dolphin whistles (likely from white-beaked and/or white-sided dolphins). Humpback whales, killer whales, and dolphins were the most commonly detected species and were recorded throughout the study periods. Blue, fin, and sei whales were detected sporadically, likely indicating relatively low occurrence in the SOBI.

Ambient noise levels in the SOBI were 5 to 13 dB lower at the Labrador Station than at the other two stations for frequencies below 250 Hz. The sound levels at all stations were strongly affected by vessel traffic and tidal flow pseudo-noise. A lunar cycle can be observed in the tidal noise effect. Average ambient noise at the Middle Station was 5 dB higher during Deployment 2 than during Deployment 1, likely due to increased wind speeds observed during the fall.

3.1 Deployment 1: Recording Period June to August 2010

3.1.1 Detections of Marine Mammal Vocalizations, Biological Sounds, and Vessel Noise

A total of 2,890 sound events were annotated manually in the data from the first deployment, of which 1,910 were identified as marine mammal calls (Table 3.1). Humpback whale calls comprised the bulk of the identified sounds, followed by dolphin and killer whale calls. The Middle Station had the most annotated sounds, followed closely by Labrador. There was considerably less biological acoustic activity at the Newfoundland Station than at the other two stations, even when accounting for the shorter recording period at Newfoundland. Unknown sounds were primarily unidentified biological sounds (*e.g.*, fish or distant marine mammals) but may have included some non-biological sounds.

Table 3.1 Marine Mammal Calls Identified by Manual Analysis for each station and species. No other species were detected.

Species	Labrador	Middle	Newfoundland	Total
Blue whale	0	0	9	**9**
Fin whale	2	9	0	**11**
Sei whale	0	1	0	**1**
Humpback whale	521	427	56	**1004**
Killer whale	46	297	23	**366**
Dolphin	221	232	66	**519**
Unknown	365	448	167	**980**
Total	**1155**	**1414**	**321**	**2890**
Recording Days	**59**	**60**	**41**	

Blue Whale (*Balaenoptera musculus*)

Blue whale calls (Figure 3.1) were detected only on four days in July, at the Newfoundland Station. The short-term nature of these detections suggests that the detected animals were transiting through the Strait rather than foraging in the area. On 30 July several concurrent calls were recorded that differed in received sound level, suggesting that more than one blue whale was present near the Newfoundland recorder (Figure 3.2).

Blue whales have been sighted in the past on the Gulf of St. Lawrence side of the SOBI (Sears *et al.* 1991, Kingsley and Reeves 1998) but recent sightings are rare, primarily due to limited effort (Richard Sears, personal communication).

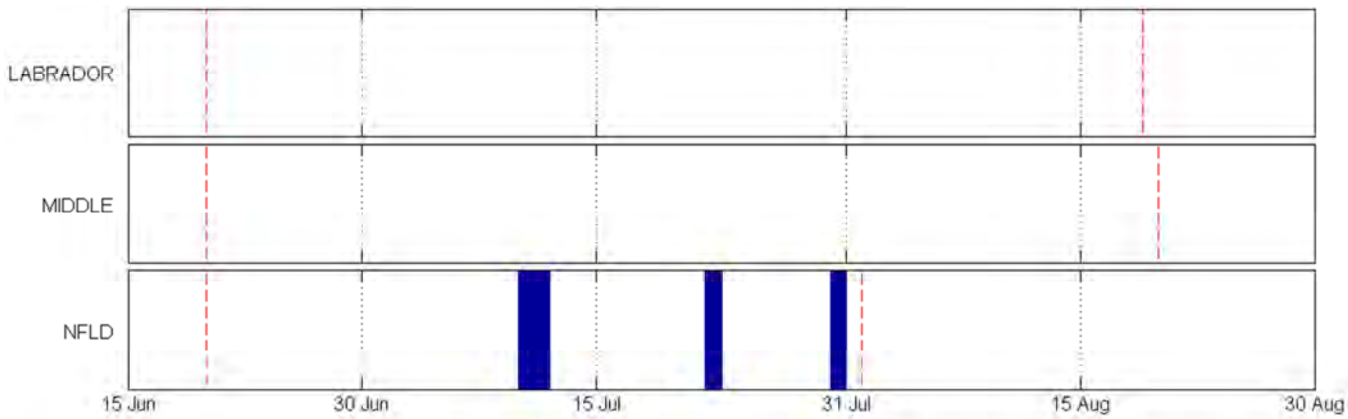


Figure 3.1 Occurrence of Manually Detected Blue Whale Calls in the SOBI between 20 June and 19 August 2010. No calls were detected at the Labrador and Middle Stations. Red dashed lines indicate recording start and end.

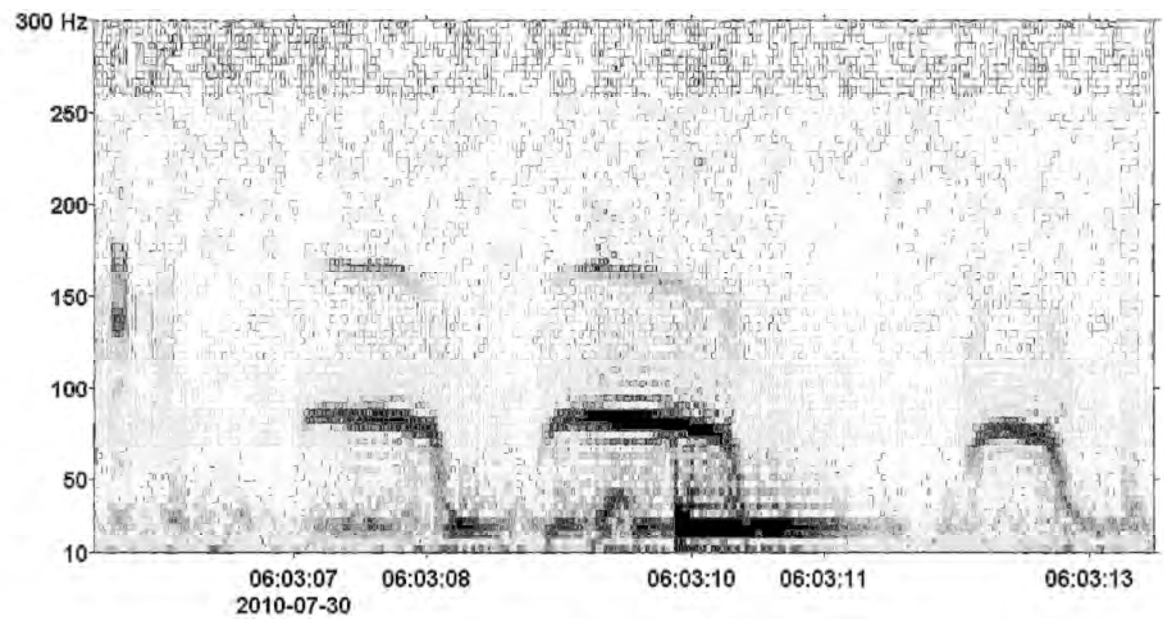


Figure 3.2 Spectrogram of Blue Whale Calls recorded 30 July 2010 at the Newfoundland Station (Hamming window, 4096-point FFT, 1024-point overlap).

Killer Whale (*Orcinus orca*)

Killer whale calls were detected at all three stations. The number of detection days ranged from four at the Newfoundland Station to 22 at the Middle Station (Figure 3.3). Killer whales were present consistently from late June to early July at the Middle Station, while detections were less regular after that. Estimated call counts were always highest at the Middle Station. Killer whales were not detected until 17 July at the Newfoundland Station. Following this date and until the end of its operational period, this station recorded the second highest call counts, except during the third period 21 July to 4 August (Figure 3.4), call counts at the Middle Station were usually an order of magnitude higher than at the other stations. The call counts at the Middle Station were relatively constant until 4 August and then abruptly decreased, possibly indicating a lower abundance of killer whales in the study area (Figure 3.4).

On several occasions, unique calls were detected at both the Labrador and Middle Stations, suggesting that the same animals may be the source of the detections occurring on the same day at these two stations. The detection of unique stereotyped pulsed calls (Ford 1989; Figure 3.5) on different days suggests that at least some pods or whales belonging to the same community occupied the area recurrently.

It is unclear whether the distinction between mammal- and fish-eating killer whales observed in the north eastern Pacific holds for north Atlantic killer whales. Several observed attacks of killer whales on minke whales in the Gulf of St. Lawrence (Wenzel and Sears 1988) suggest that at least some individuals and pods prey on marine mammals. More recently, killer whales were observed killing a minke whale in two separate occurrences off the coast of Newfoundland in summer 2010, in Trinity Bay and south of St. John's (CBC News 2010). The predictable aggregation of humpback whales in summer does not explain killer whale presence in the SOBI in summer. Indeed, although 15.6 and 17.8% of humpback whales sighted in the Gulf of St. Lawrence or off Newfoundland-Labrador, respectively, bear killer whale teeth marks attesting to a previous attack, few individuals acquire new scars after their first sighting on the feeding grounds (Mehta *et al.* 2007). This suggests the scars are acquired during travel from low-latitude breeding grounds to high-latitude feeding grounds when the animals are young (Mehta *et al.* 2007). The decrease in killer whale detections after 4 August while humpback whale call counts remained high (see following section) may indicate that the detected killer whales target other prey or there are other factors associated with the presence of killer whales in the SOBI.

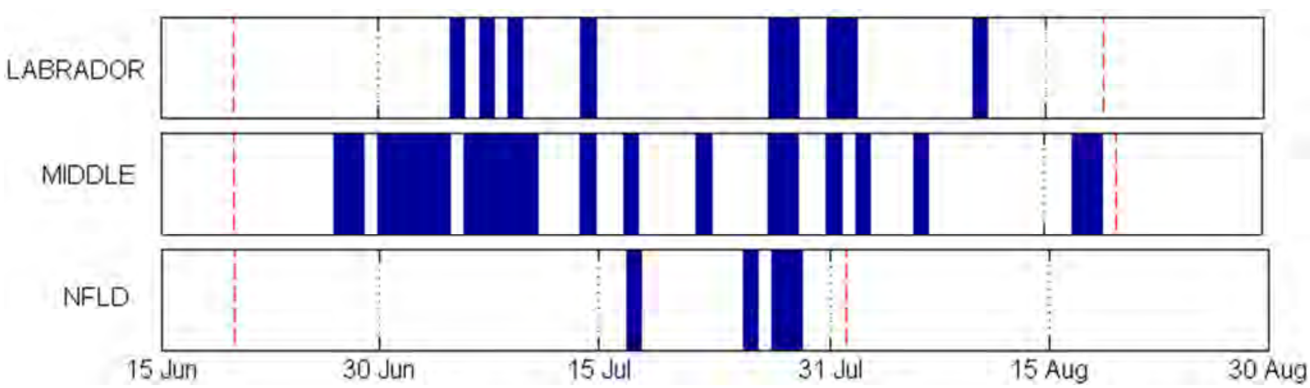


Figure 3.3 Occurrence of Manually Detected Killer Whale Calls in the SOBI between 20 June and 19 August 2010. Red dashed lines indicate recording start and end.

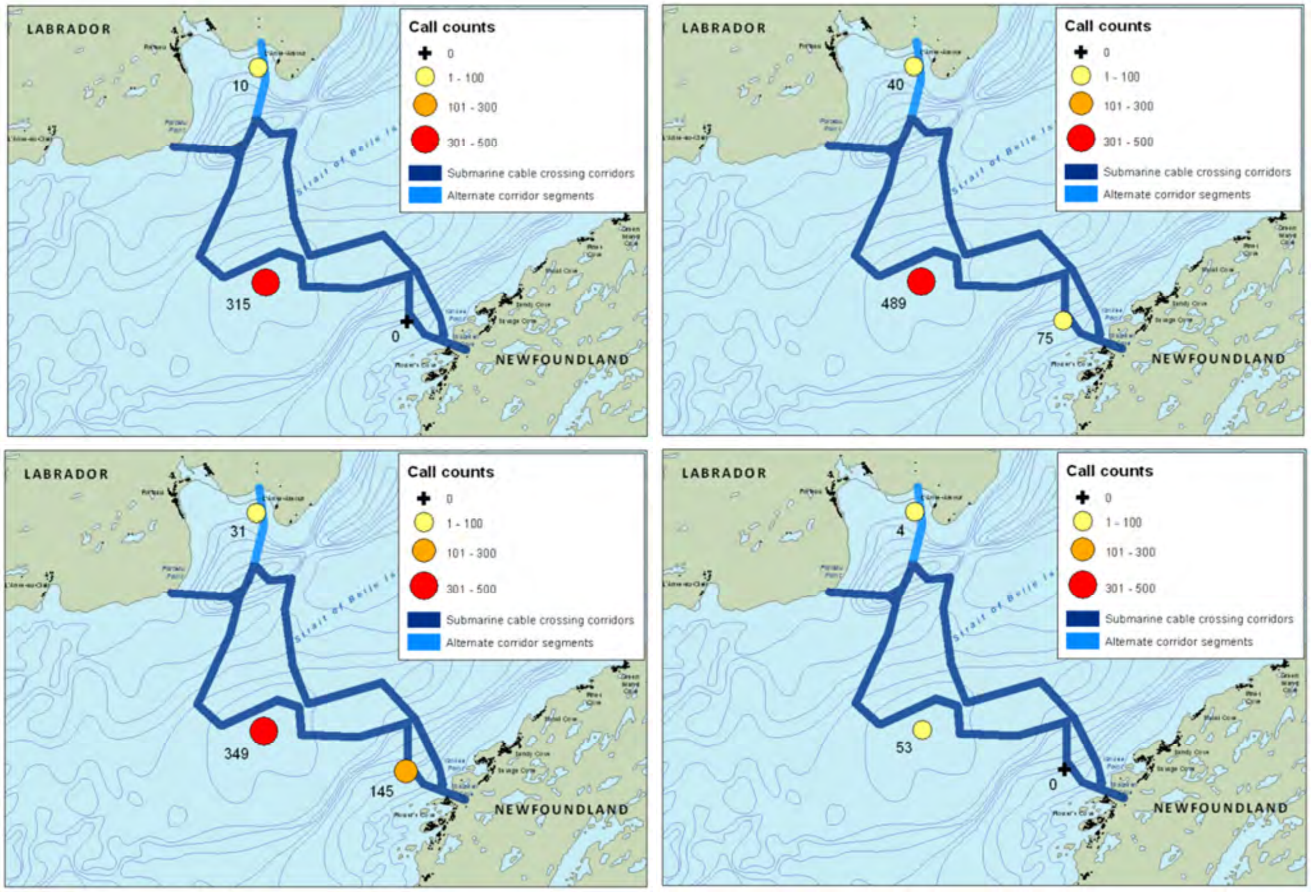


Figure 3.4 Killer Whale Call Counts. Each tile shows the sum of the call counts over two weeks: (Top left) 20 June to 5 July; (top right) 6 to 20 July; (bottom left) 21 July to 4 August; and (bottom right) 5 to 19 August 2010. The Newfoundland recorder stopped working 31 July.

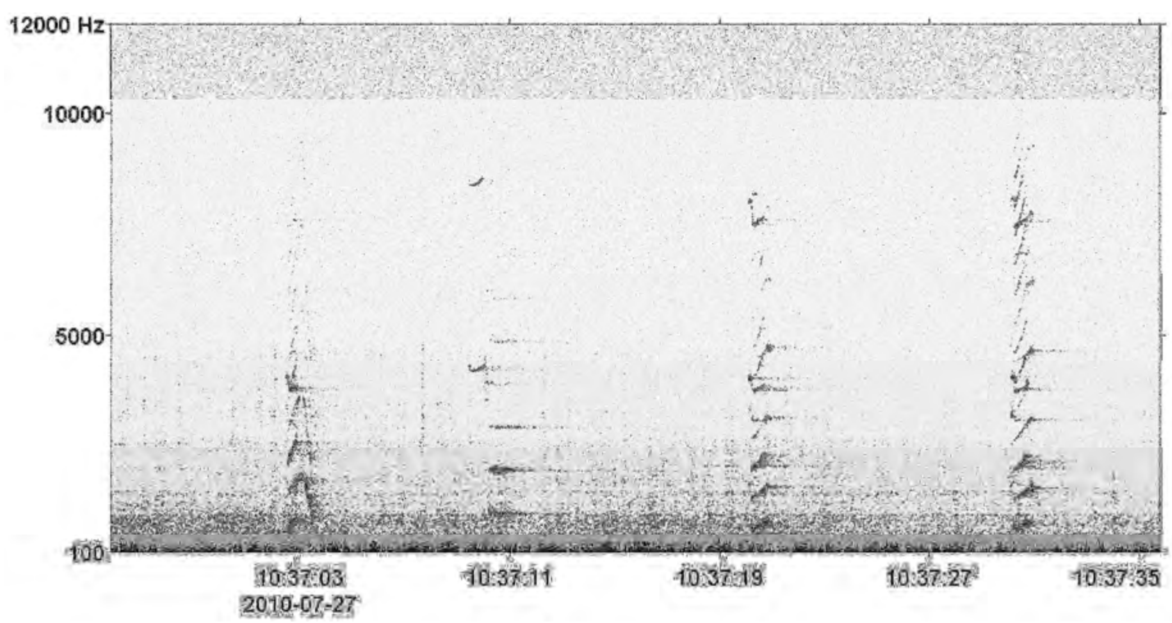


Figure 3.5 Spectrogram of Killer Whale Calls recorded 27 July 2010 at the Middle Station (Hamming window, 2048-point FFT, 512-point overlap).

Humpback Whale (*Megaptera novaeangliae*)

Humpback whales were the most commonly detected species and were present almost continuously throughout the first recording period. The number of detection days ranged from 21 at the Newfoundland Station to 45 at both the Labrador and Middle Stations. The maximum recording duration was 60 days at the Middle Station. Humpbacks were first detected on 22 June at the Newfoundland Station and 23 June at the Labrador and Middle Stations. Detections lasted until the end of recording at all three stations (Figure 3.6).

In addition to humpbacks being detected on half of the days at the Newfoundland Station (which is partially explained by the Newfoundland Station recording period being 19 days shorter than the other two stations), there were usually few detections per day, few calls per detection event, with detection events shorter and fainter in comparison to the other two stations. This indicates that the detected calls may often have been produced by distant whales and that humpback whales used this side of the SOBI less heavily during the recording period. This is confirmed by the observation that estimated call counts at the Newfoundland Station were always the lowest, and one to two orders of magnitude lower than the highest call counts (Figure 3.7). In three out of the four periods, the highest call counts were recorded at the Labrador Station, which is in agreement with the observations of typically larger aggregations on the Labrador side of the SOBI, where they prey on bait fish (Patricia Nash, personal communication). Despite a decrease in call counts in the third period, the occurrence of vocalizing humpback whales appears to have been relatively stable throughout the recording period July to August.

On a few occasions, humpbacks ceased vocalizing when killer whales were calling, but this would only have affected their detection probability for a few consecutive files. Figure 3.8 shows an example of humpback whale calls.

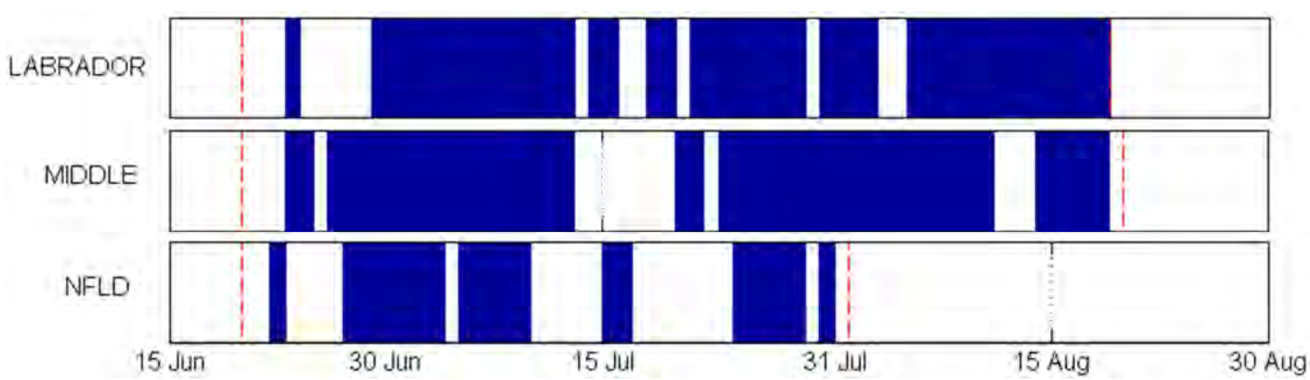


Figure 3.6 Occurrence of Manually Detected Humpback Whale Calls in the SOBI between 20 June and 19 August 2010. Red dashed lines indicate recording start and end.

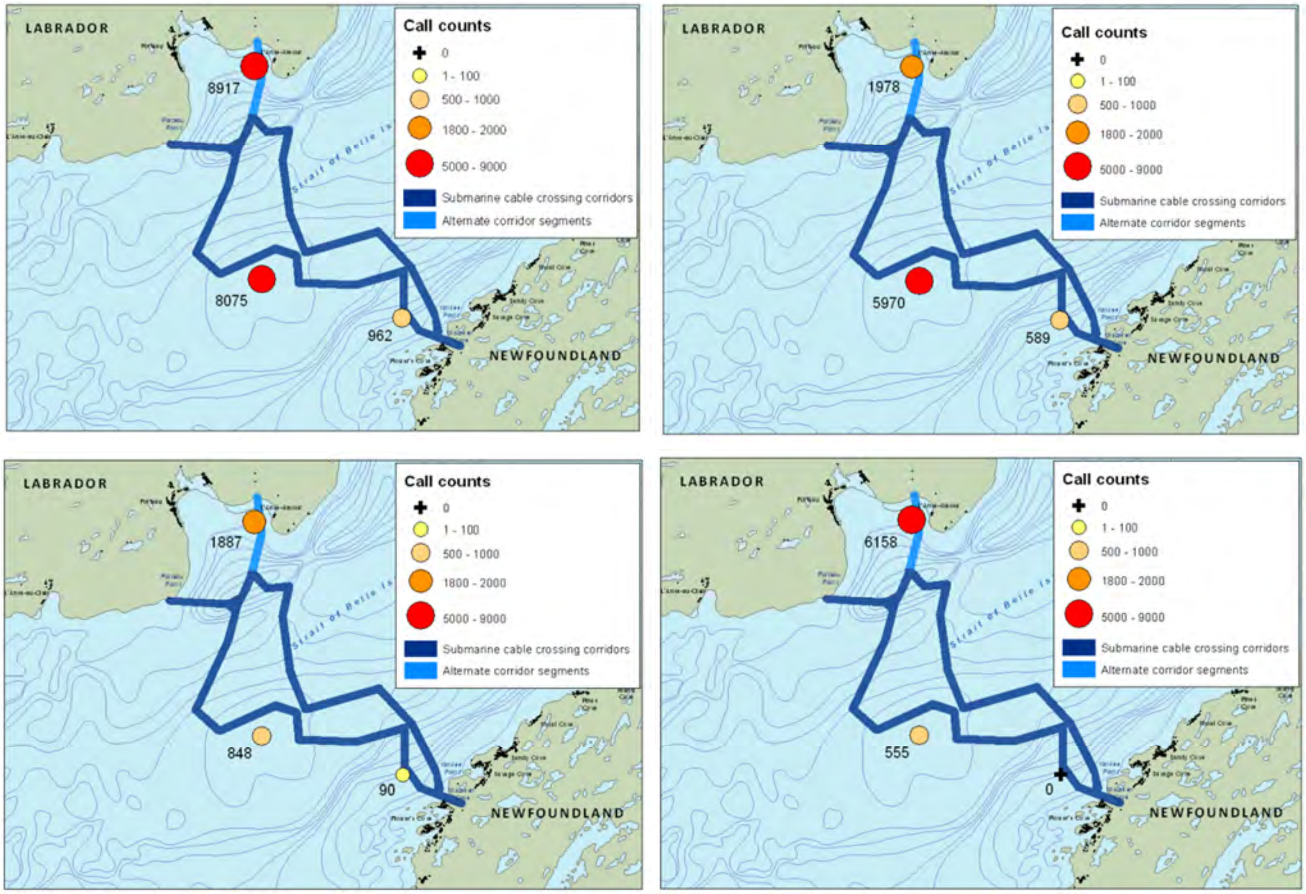


Figure 3.7 Humpback Whale Call Counts. Each tile shows the sum of the call counts over two weeks: (Top left) 20 June to 5 July; (top right) 6 to 20 July; (bottom left) 21 July to 4 August; and (bottom right) 5 to 19 August 2010. The Newfoundland recorder stopped working 31 July.

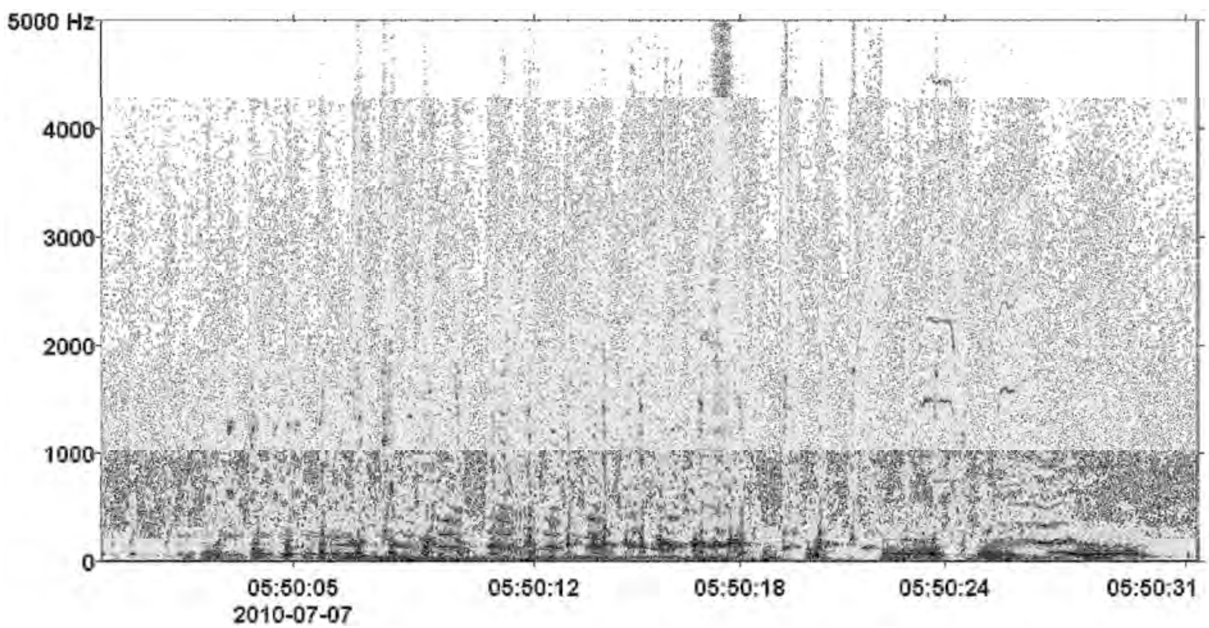


Figure 3.8 Spectrogram of Humpback Whale Calls recorded 7 July 2010 at the Middle Station (Hamming window, 2048-point FFT, 512-point overlap).

Dolphin (*Lagenorhynchus albirostris, L. acutus*)

Dolphin whistles were detected at all three stations. The first detections occurred 27 and 28 June at the Newfoundland and Middle Stations, respectively, and 15 July at the Labrador Station. Whistles were recorded sporadically until the end of the operational period of each recorder. The number of detection days ranged from nine at the Newfoundland Station to 18 at the Middle Station (Figure 3.9).

Estimated call counts were essentially null until 20 July at the Labrador Station. The highest call counts were recorded at the Newfoundland or the Middle Station during the first three periods, before increasing dramatically and shifting towards the Labrador Station in the last period. Call counts decreased and were relatively uniform at all stations during the second and third period (Figure 3.10).

The patterns of dolphin acoustic occurrence at all stations seem to oppose that of killer whales: dolphin call counts were highest at the Newfoundland Station early in the recording period when no killer whales were detected there; they decreased during the middle of the recording period when killer whales were most consistently detected at the Middle Station; finally dolphin whistle detections increased dramatically at the Labrador Station in the last detection period when killer whale call counts decreased abruptly throughout the SOBI (Figure 3.4, Figure 3.10). It is unclear if this reflects an adaptation (vocal or distributional) to predation by killer whales on dolphins or normal patterns habitat of use.

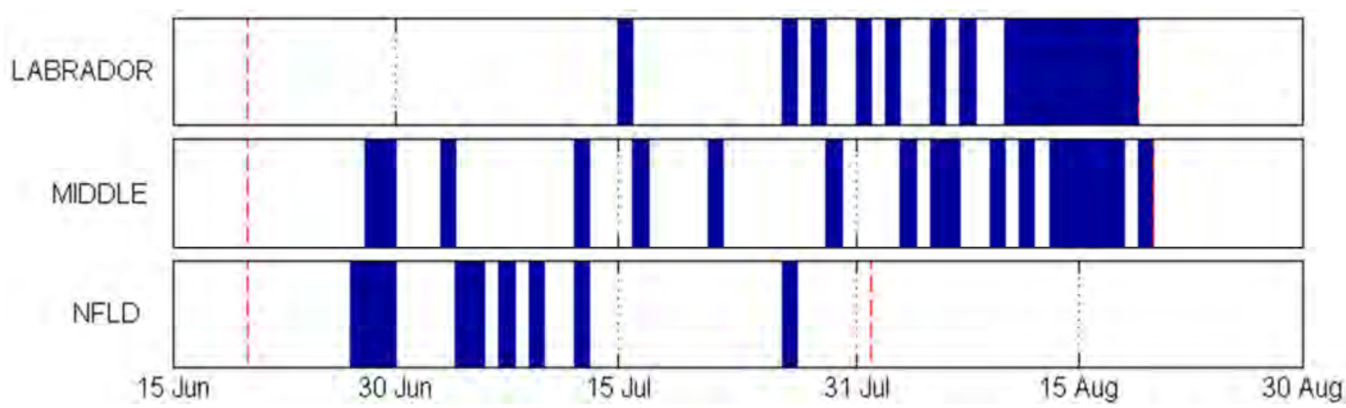


Figure 3.9 Occurrence of Manually Detected Dolphin Whistles in the SOBI between 20 June and 19 August 2010. Red dashed lines indicate recording start and end.

Most detected whistles were likely produced by white-beaked dolphins. This is the most commonly sighted dolphin species in this area (Kingsley and Reeves 1998). However, white-sided dolphins are also present in this area (Kingsley and Reeves 1998) and the temporal pattern of detections also matches the timing of their observation in the adjacent Gulf of St. Lawrence (MICS, unpublished data) where they typically appear from late July onwards. The lack of published call descriptions for both species and the similarity of their calls similarity makes distinguishing them challenging. A representative example of dolphin calls is shown in Figure 3.11.

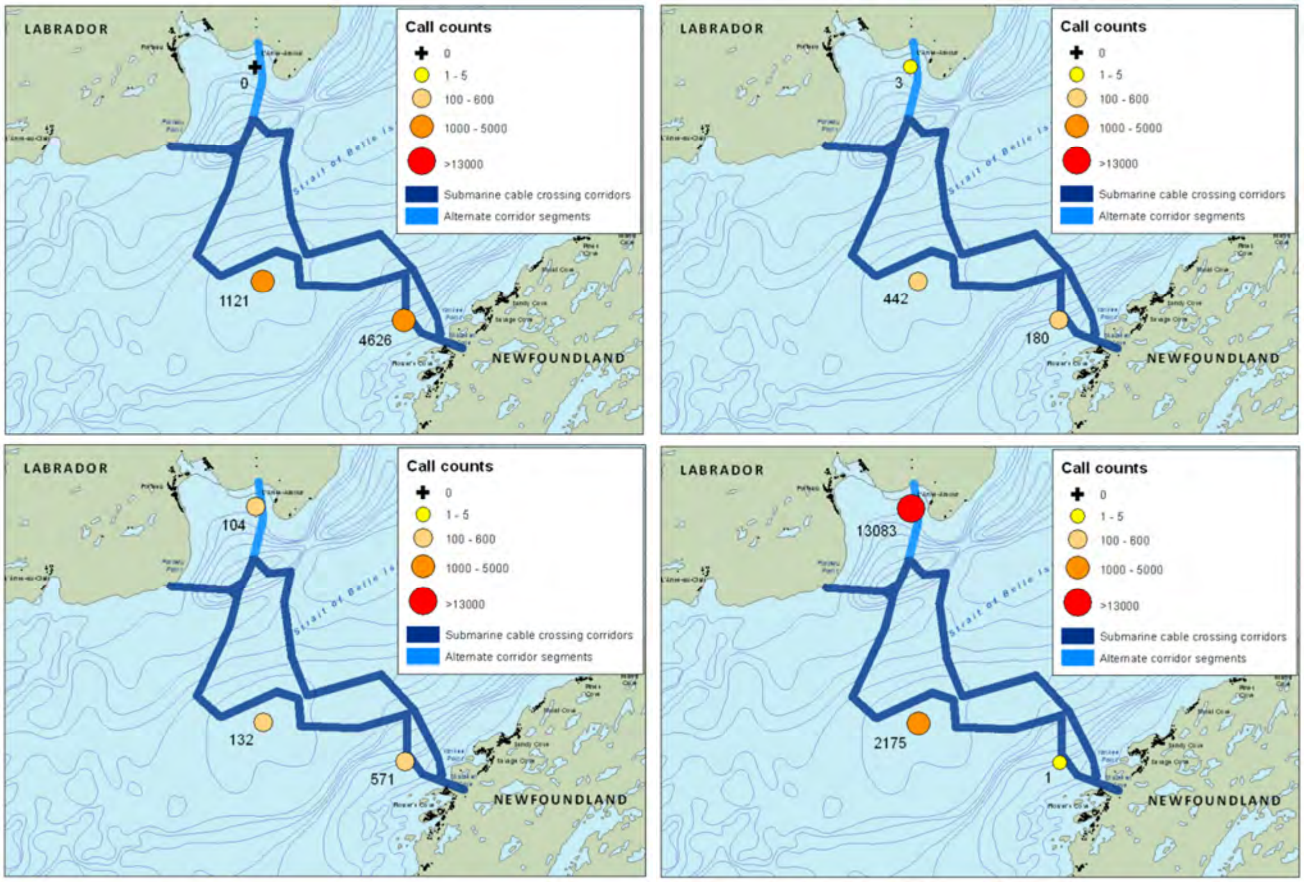


Figure 3.10 Dolphin Whistle Call Counts. Each tile shows the sum of the call counts for a two week period: (Top left) 20 June to 5 July; (top right) 6 to 20 July; (bottom left) 21 July to 4 August; and (bottom right) 5 to 19 August 2010. The Newfoundland recorder stopped working 31 July.

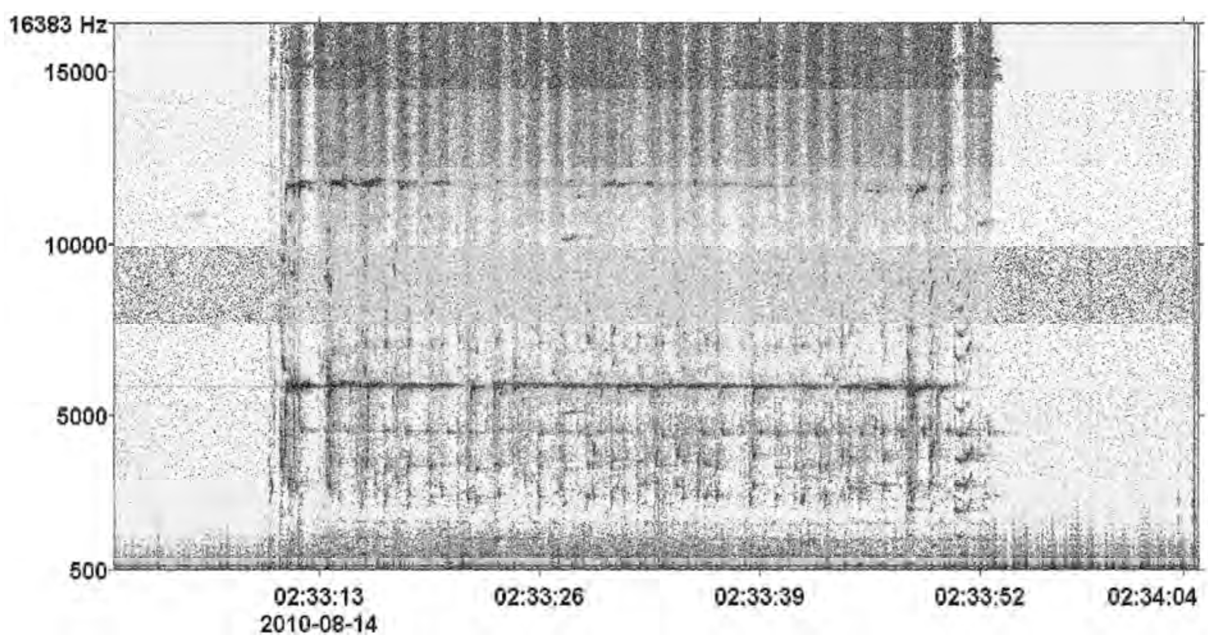


Figure 3.11 Spectrogram of Dolphin Whistles (likely white-beaked dolphins) recorded 14 August 2010 at the Middle Station (Hamming window, 2048-point FFT, 512-point overlap).

Fin Whale (*Balaenoptera physalus*)

Fin whale calls were detected manually once at the Labrador Station and six times at the Middle Station. Detections occurred from 1 July to 16 August 2010 (Figure 3.12). In summer they occur in or near the SOBI (Patricia Nash, personal communication) and aggregate in several areas of the Gulf of St. Lawrence (COSEWIC 2005). A sample fin whale call is shown in Figure 3.13.

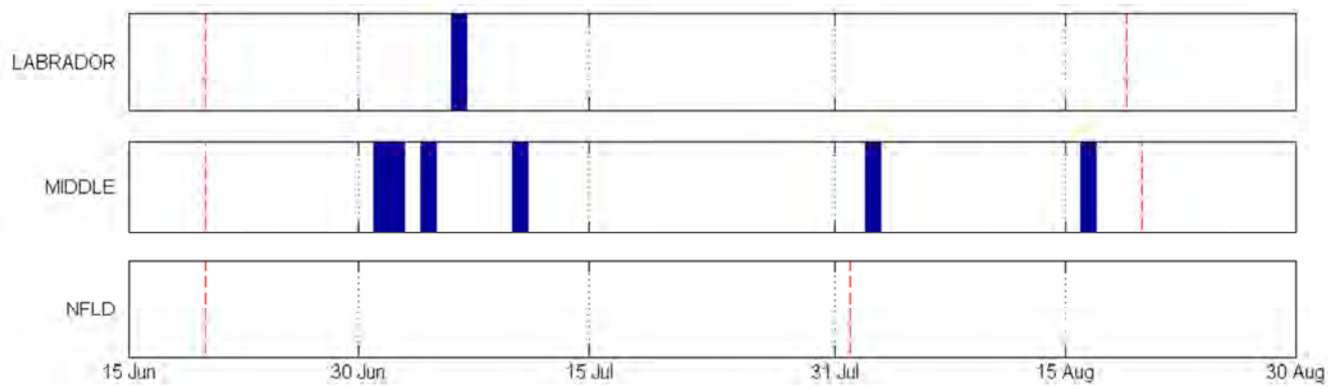


Figure 3.12 Occurrence of Manually Detected Fin Whale Calls in the SOBI between 20 June and 19 August 2010. There were no detections at the Newfoundland Station. Red dashed lines indicate recording start and end.

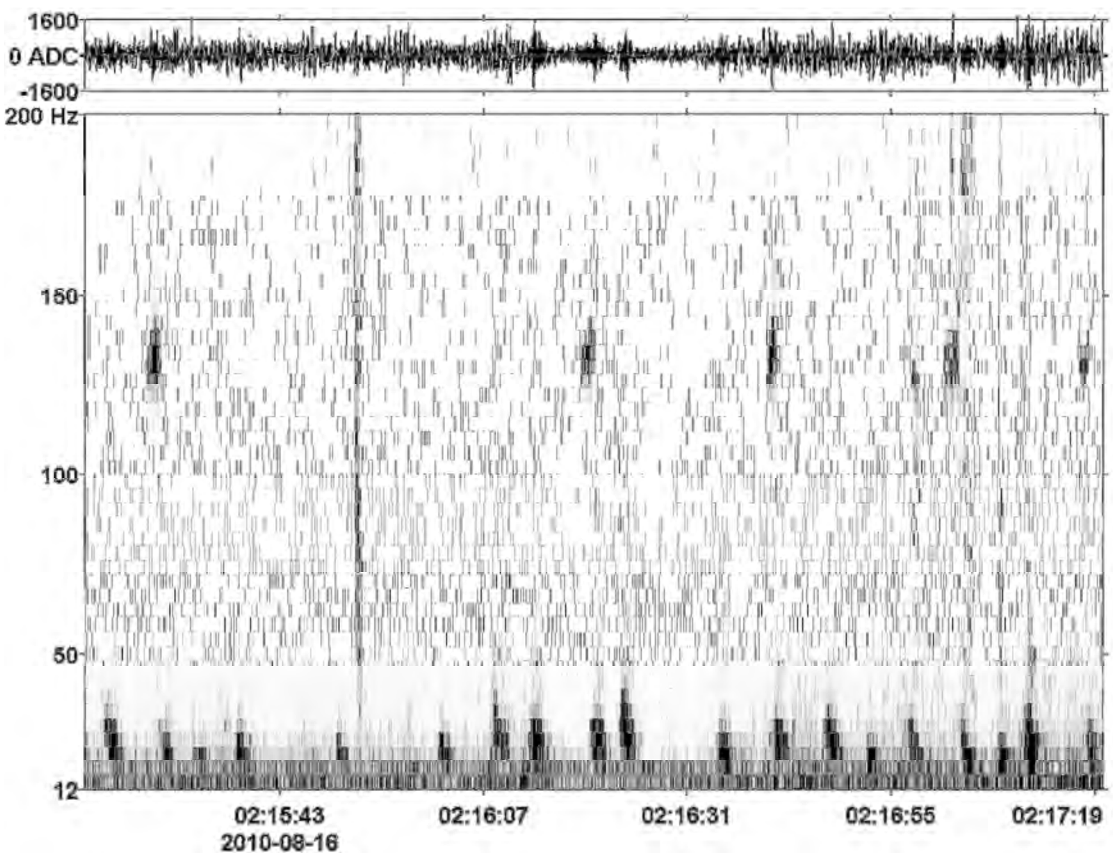


Figure 3.13 Spectrogram of Fin Whale Calls recorded 16 August 2010 at the Middle Station (Hamming window, 8192-point FFT, 512-point overlap). Both the 30–15 Hz downsweeps and 130–140 Hz upsweeps are typical of fin whales.

Sei Whale (*Balaenoptera borealis*)

Calls from one sei whale were detected at the Middle Station on 4 July. The three calls detected (Figure 3.14) were stereotyped downsweeps matching those recorded from sei whales off Massachusetts (Baumgartner *et al.* 2008). Sei whales are not known to occur in the Gulf of St. Lawrence (COSEWIC 2003). Olsen *et al.* (2009) have tracked sei whales in the Labrador Sea via satellite telemetry in spring, and sei whales have been sighted off West Greenland in summer (Heide-Jørgensen *et al.* 2007) so this isolated detection may come from an individual otherwise summering between Labrador and Greenland.

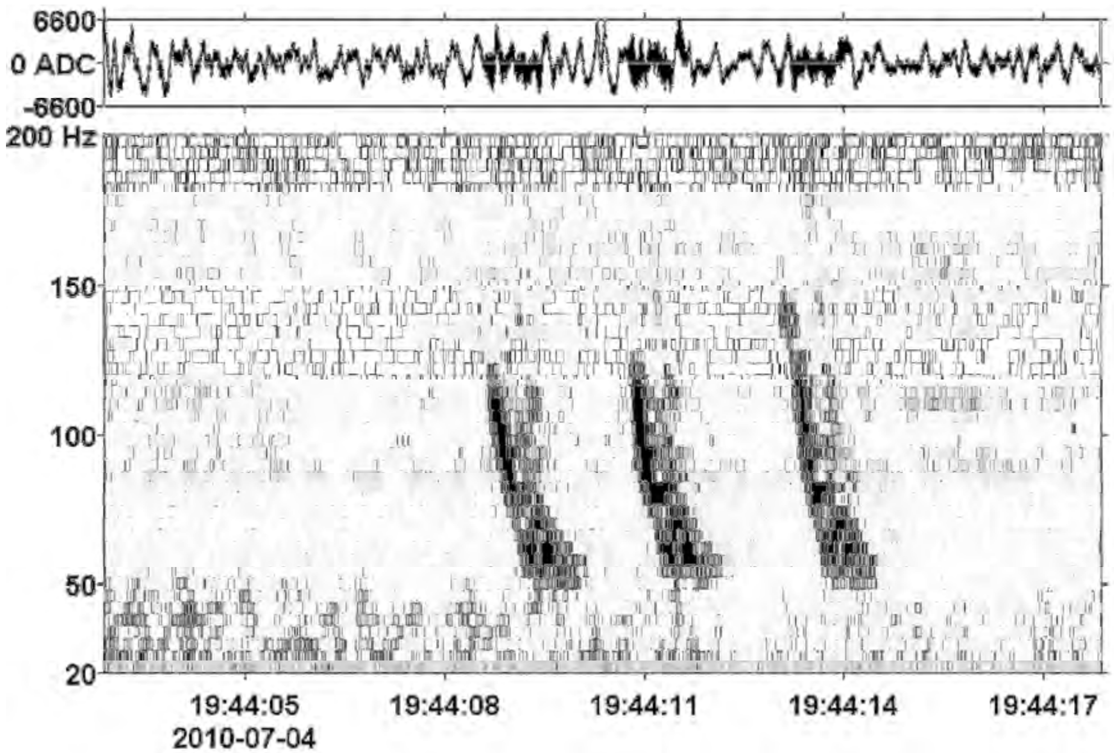


Figure 3.14 Spectrogram of Sei Whale Calls recorded on 4 July 2010 at the Middle Station (Hamming Window, 4096-Point FFT, 1024-Point Overlap).

Unidentified Biological Detections

Many calls of presumed biological origin were encountered whose source could not be identified. Some of these calls were likely produced by pinnipeds. Harp seals are a possible source since individuals are known to remain in the Gulf of St. Lawrence in June and early July (MICS, unpublished data), thus exiting through the SOBI while the recorders were operational. Hooded seals would likely have transited through the area before the recording period. Indeed, all hooded seals equipped with satellite tags that transited through the SOBI out of the Gulf of St. Lawrence did so in early May (Bajzak *et al.* 2009). Grey and harbour seals are rare in the SOBI (Robillard *et al.* 2005) and are unlikely the source of unknown calls.

Fish were also likely responsible for some low-frequency grunting sounds detected throughout the recording period. Gadoids (*e.g.*, cod, haddock) produce various sounds, usually associated with spawning, but also occurring outside of the spawning season (Hawkins and Rasmussen 1978).

Vessel Noise

Vessel noise detections for the SOBI recorders during Deployment 1 are shown in Figure 3.15. Marine life detections were suppressed for any files that had more than two 5-s vessel detections. The Labrador recorder was located near L'Anse-Amour, resulting in many vessel noise detections.

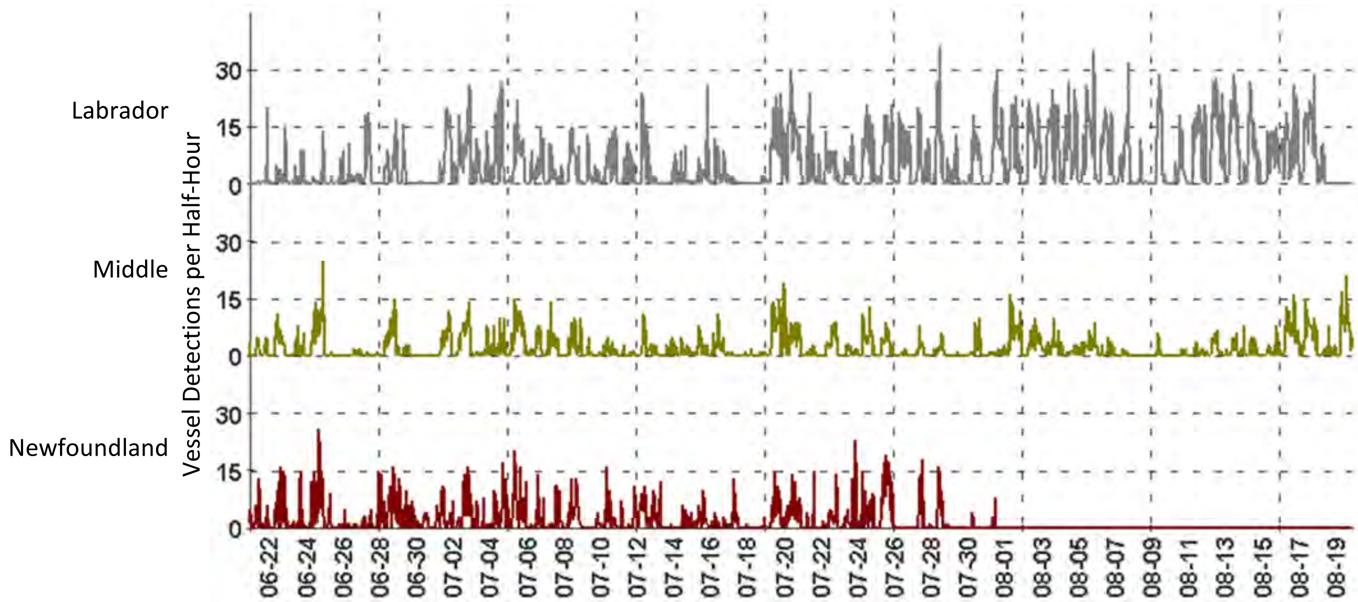


Figure 3.15 Vessel Noise Detections Per 30-min Recording, June to August 2010, in the Strait of Belle Isle.

3.1.2 Ambient Noise

Ambient sound levels for Deployment 1 (June to August 2010) are shown in Figure 3.16. Higher resolution versions of these plots are provided in Appendix B. As expected, all plots show that the lowest frequencies dominate the ambient noise levels. The percentile spectral level plots show that the bounds for the noise are within the Wenz curve limits of prevailing noise (see Figure 2.3). The band-level plots and spectrograms show regular events below 70 Hz that occur approximately twice per day. These events are attributed to real and pseudo-noise from tidal water flow around the hydrophones. The spectrograms and percentile spectral level plots show the flow noise peaks between 20 and 40 Hz, which is attributed to pseudo-noise from the mooring.

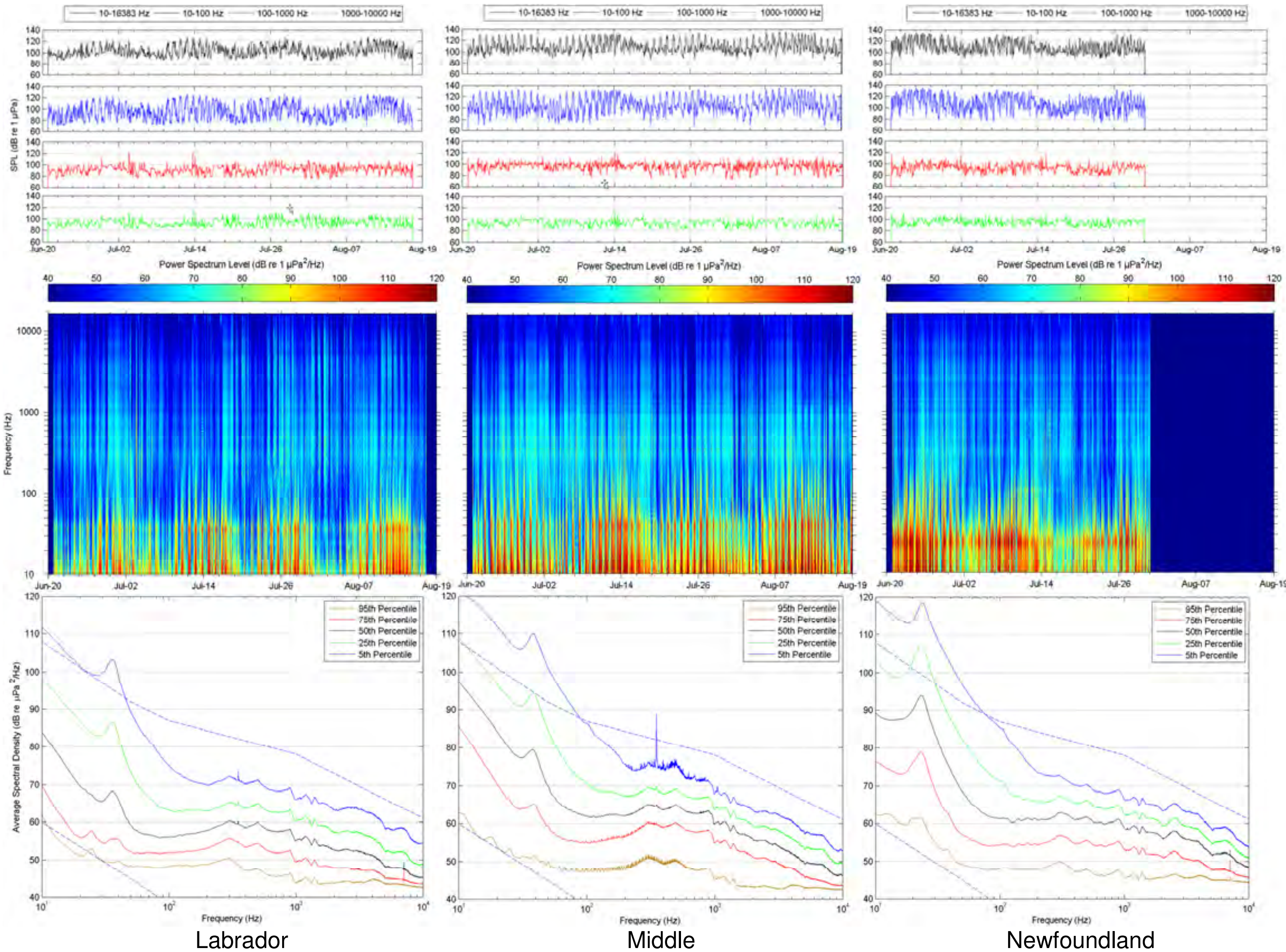


Figure 3.16 (Top) Decade-Band Sound Pressure Levels (SPL), (Middle) Spectrograms, and (Bottom) Percentile 1-min Average Spectral Densities of Underwater Noise at the Labrador, Middle, and Newfoundland Stations, June to August 2010.

Tidal Cycle and Ambient Noise Levels

The 10 to 100 Hz band SPLs (top of Figure 3.16) show that tidal noise has an amplitude modulation with a 14-day period. This is attributed to the lunar cycle of the tides. The lunar distance over the summer is shown in Figure 3.17, time aligned with the 10 to 100 Hz band SPLs for each station.

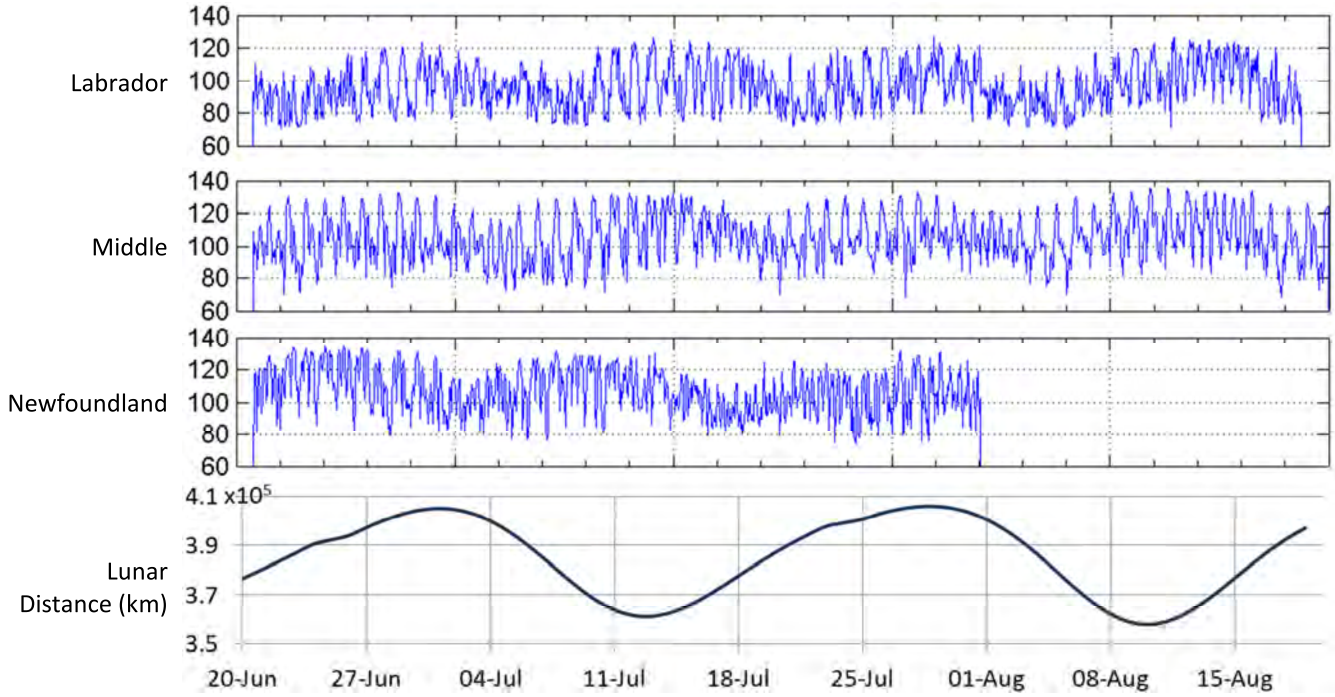


Figure 3.17 Sound Pressure Level (dB re 1 µPa) in the 10 to 100 Hz Band at each station compared to lunar distance during Deployment 1, June to August 2010. The tidal dependence of noise levels is generally minimal during neap tide at the quarter moon.

Marine Mammal Calls and Ambient Noise Levels

The spectrograms have a speckled pattern in the cyan colour range between 100 and 1000 Hz which is due to strong biologic activity having a discernible effect on noise levels (Figure 3.16). For instance, the events around 100 Hz in late July at the Labrador Station are due to humpback whale calls. Similarly the events between 500 and 1000 Hz at the Newfoundland Station in mid-July may be due to killer whale calls (Figure 3.16).

Vessel Noise and Ambient Noise Levels

Throughout the first recording period there are frequent vertical cyan spikes in the spectrograms (middle of Figure 3.16) that are attributed to rain and local vessel traffic. Rain is a broadband noise source with a bandwidth of 2000 to 10,000 Hz or higher.

Vessel traffic in the SOBI is mostly by small- to medium-sized fishing vessels and work boats. These vessels typically have diesel engines with revolutions per minute between 1200 and 3000, or fundamental frequencies of 200 to 500 Hz. These frequencies are then modulated upwards by the multi-bladed propellers and exhausts at or below the waterline. The propellers normally cavitate at all speeds on these vessels which results in a broadband noise effect. Figure 3.18 compares the vessel detections with SPLs in the 100 to 1000 Hz and 1000 to 10,000 Hz bands. Vessel noise is a dominant noise source above 100 Hz, especially above 1000 Hz.

The 5th percentile 1-min average spectral density level for the Middle Station shows a strong spike at 364 Hz. This is attributed to a local vessel making regular passes near the recorder, as shown in Figure 3.19.

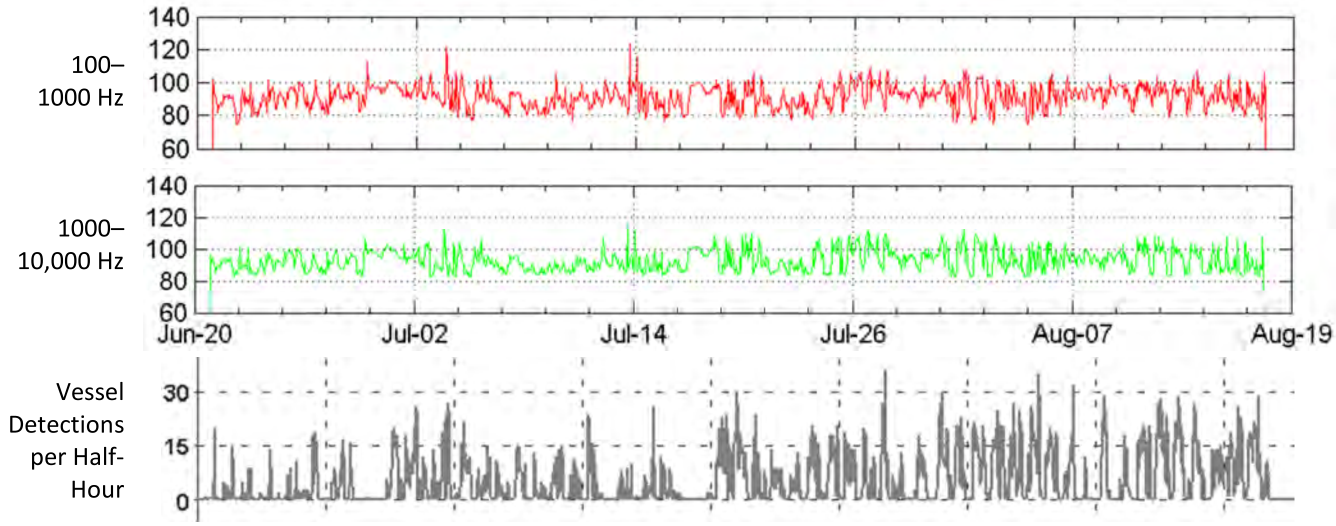


Figure 3.18 Sound Pressure Levels (dB re 1 μPa) in the 100 to 1000 Hz and 1000 to 10,000 Hz Bands Compared to Number of Vessel Noise Detections Per 30-min Recording at the Labrador Station, June to August 2010.

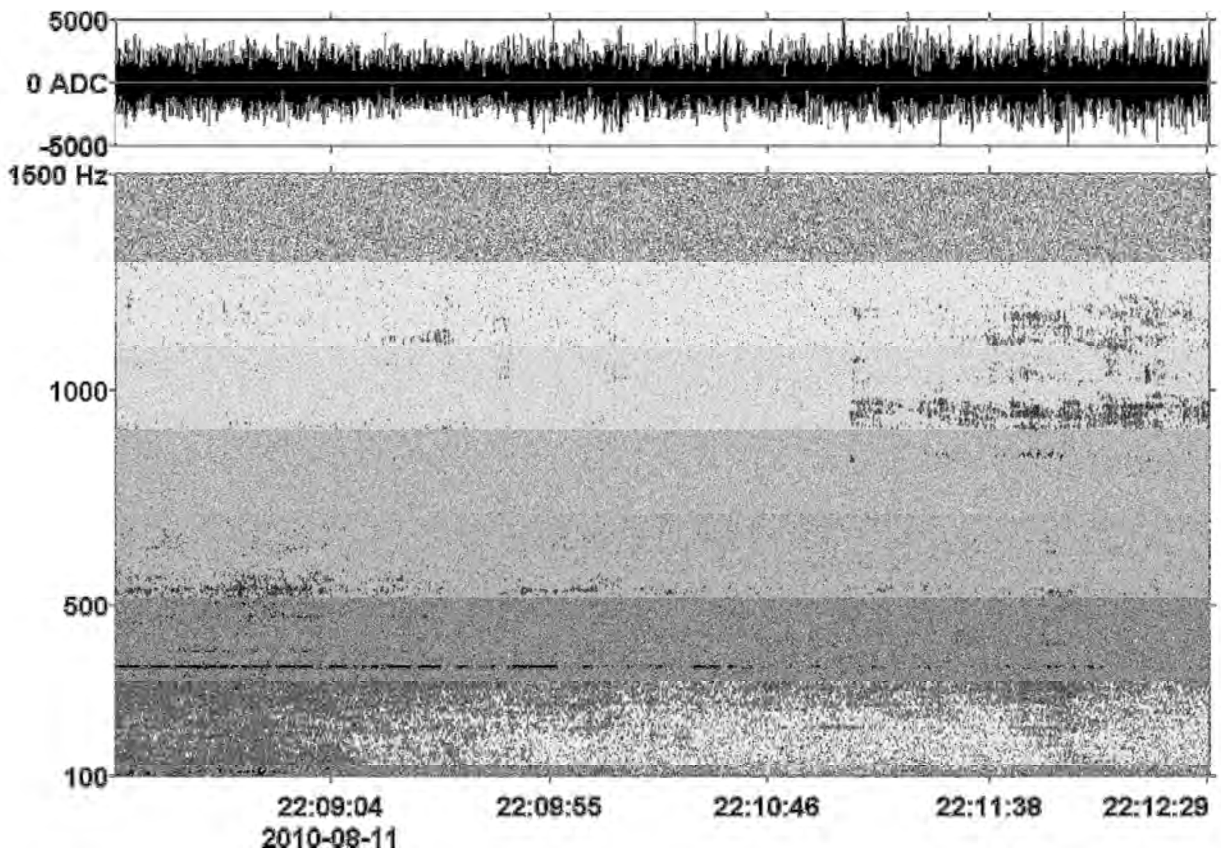


Figure 3.19 (Top) Time-Series and (Bottom) Spectrogram of 364-Hz Tonal and Broadband Noise from Local Vessel Traffic at the Middle Station, 11 August 2010. 4096-point FFT, 1024 point advance.

Variation among Stations

Figure 3.20 compares the third-octave band SPLs for the 50th percentile among recording stations. Sound levels at the Labrador Station were at least 4 dB lower than the maximum of the Newfoundland and Middle Stations in all frequency bands. The Middle Station is highest in the mid-frequencies of 100 to 1000 Hz.

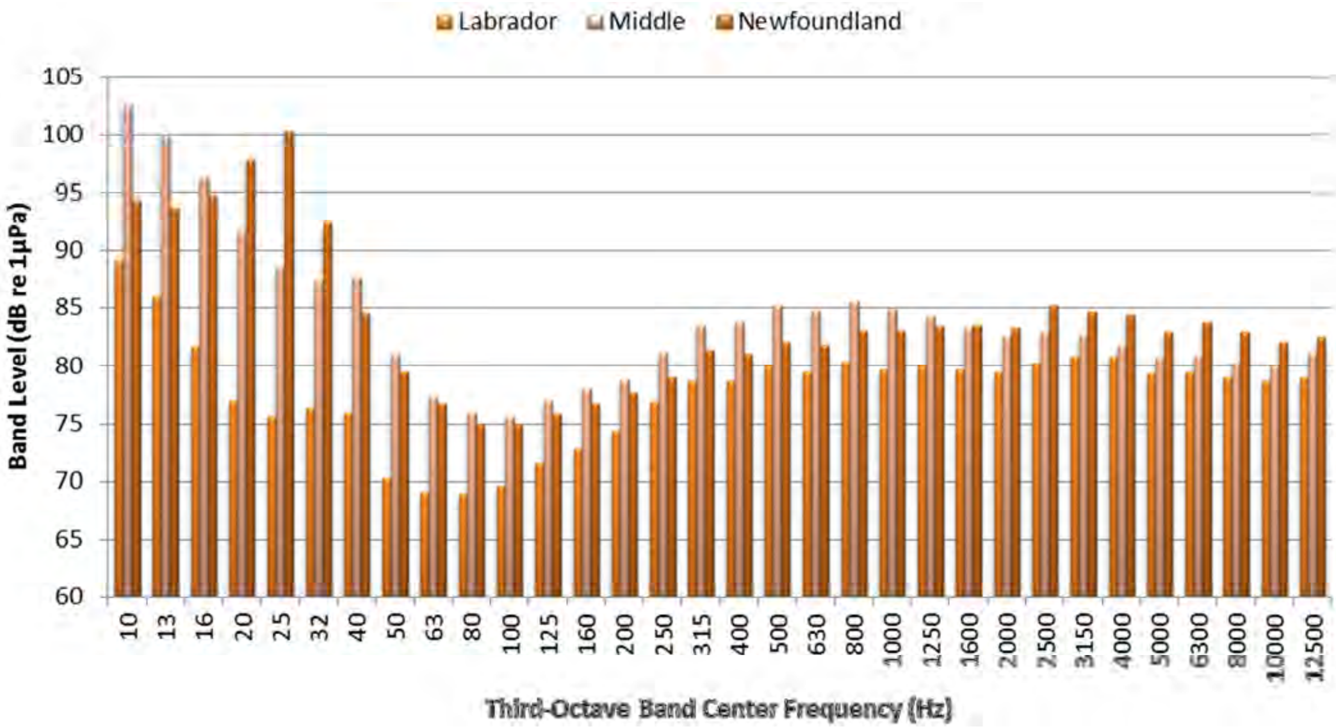


Figure 3.20 Third-Octave Band Sound Pressure Levels for the median of the received sound at each station, June to August 2010.

3.2 Deployment 2: Recording Period September to December 2010

The data analyzed for Deployment 2 consisted only of the Middle Station recordings since the recorders at the Labrador and Newfoundland Stations are not yet retrieved. The only detected marine mammals were fin whales, humpback whales, and dolphins. All three species were recorded quite consistently from early October until early- to mid-November. The large increase in occurrence of fin whale calls compared to Deployment 1 may be due to a larger number of individuals in the area, but most likely to more vocally active individuals due the onset of singing in that species. Humpback whales also appeared to transition to singing behaviour at the end of the Deployment 2 recording period.

Ambient sound levels at the Middle Station during Deployment 2 were 3 to 5 dB higher than during Deployment 1 for frequencies above 80 Hz. Below 80 Hz, sound levels at the Middle Station were 7 dB higher during Deployment 1 than during Deployment 2.

3.2.1 Detections of Marine Mammal Vocalizations

Blue Whale (*Balaenoptera musculus*)

No blue whale calls were detected at the Middle Station during Deployment 2.

Killer Whale (*Orcinus orca*)

No killer whale calls were detected at the Middle Station during Deployment 2.

Humpback Whale (*Megaptera novaeangliae*)

Humpback whales were detected from 30 September until 8 December 2010, with a virtually continuous detection period between 10 October and 8 November (Figure 3.21). Call counts per file peaked between 28 to 30 October, with up to 1000 calls per file (Figure 3.22). These high calling rates, compared to those during Deployment 1, are likely attributable to increased calling rates associated with the onset of singing in this species. Patterned sequences, which may be maturing songs, were detected. These sequences were characterized by numerous and complex calls, yielding high call count estimates. The decrease in detections around mid-November presumably coincides with the departure of humpback whales to Caribbean breeding grounds where they aggregate in winter (Katona and Beard 1990).

Figure 3.21 Occurrence of Manually Detected Humpback Calls at the Middle Station, September to December 2010. Red dashed lines indicate recording start and end.

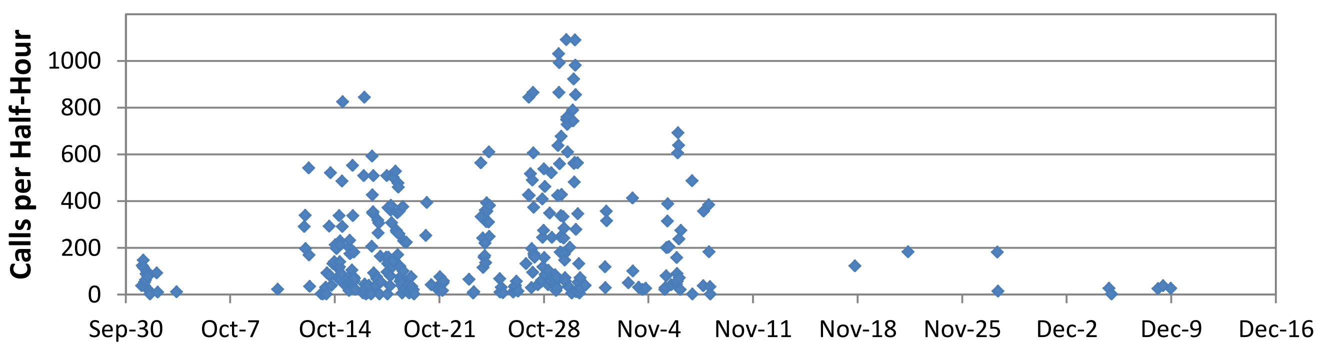


Figure 3.22 Humpback Automated Call Counts per 30-min Recording at the Middle Station from September to December 2010 in the Strait of Belle Isle.

Dolphin (*Lagenorhynchus albirostris, L. acutus*)

The dolphin whistle detections followed a similar temporal trend to humpback whale calls. Whistles were detected from 30 September to 4 December with almost daily detections between 11 October and 14 November (Figure 3.23). Call counts were typically low with the exception of a few peaks in mid- and late October (Figure 3.24). Some whistles detected by manual analysts were too faint to pass the threshold imposed by the detector and thus do not appear in Figure 3.24 (*e.g.*, on 4 December).

Figure 3.23 Occurrence of Manually Detected Dolphin Whistles, September to December 2010. Red dashed lines indicate recording start and end.

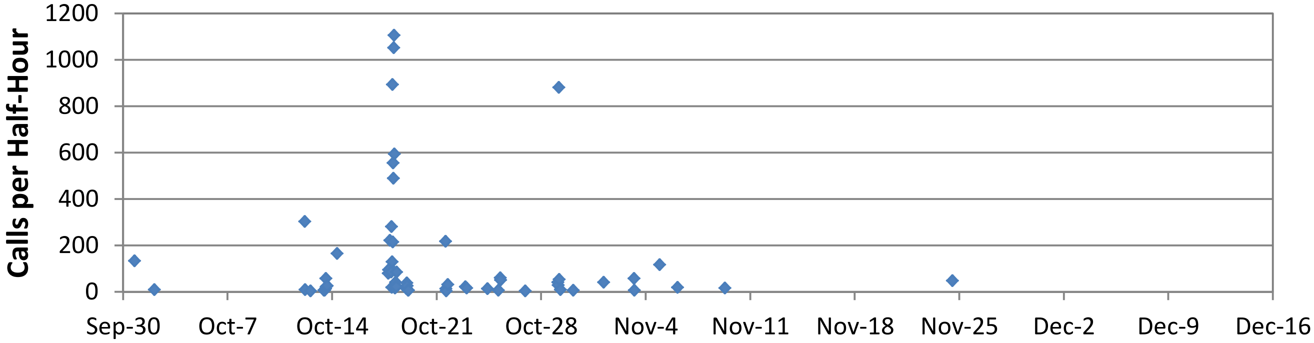


Figure 3.24 Dolphin Whistle Automated Call Counts per 30-min Recording at the Middle Station from September to December 2010 in the Strait of Belle Isle.

Fin Whale (*Balaenoptera physalus*)

Fin whale calls were detected from 30 September to 8 November and on 27 November (Figure 3.25). Call counts per file are shown in Figure 3.26.

All the detections consisted of songs, *i.e.*, stereotyped sequences of identical pulses separated by a constant interval (Watkins 1981). With the exception of the isolated 27 November detection, all songs were characterized by the 12-s pulse interval reported for the Gulf of St. Lawrence fin whales (Delarue *et al.* 2009). The songs detected 27 November were characterized by a 13.5-s pulse interval, consistent with that described for fin whale songs in the Davis Strait in winter (Simon *et al.* 2010).

Figure 3.25 Occurrence of Manually Detected Fin Whale Calls, September to December 2010. Red dashed lines indicate recording start and end.

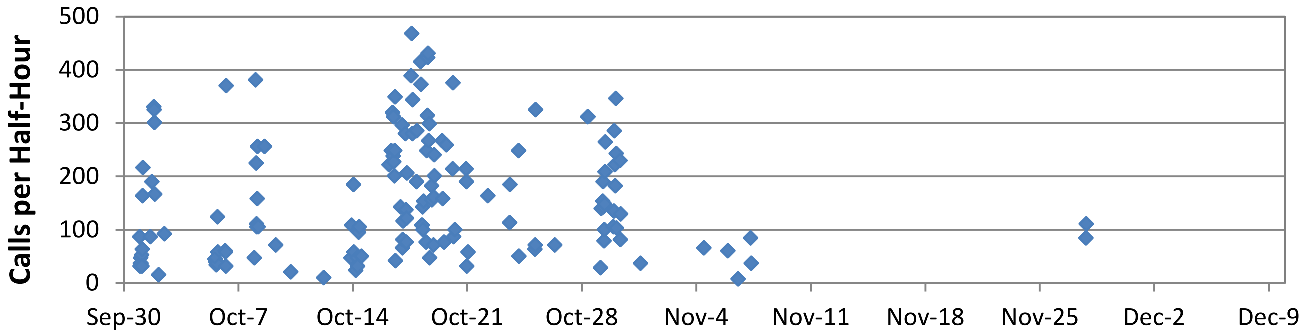
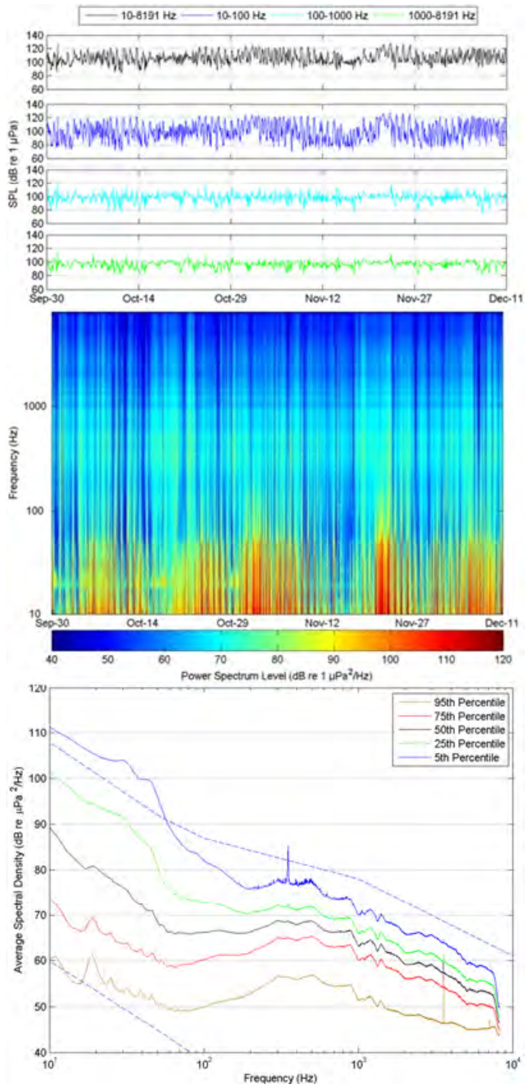


Figure 3.26 Fin Whale Automated Call Counts per 30-min Recording at the Middle Station from September to December 2010 in the Strait of Belle Isle.

3.2.2 **Ambient Noise**

Ambient sound levels during Deployment 2 at the Middle Station are shown in Figure 3.27. The plots show similar structure to those of Deployment 1. The real and pseudo-noise from tidal water flow around the hydrophone caused regular peaks below 70 Hz and has an amplitude modulation from the lunar cycle. The same 364 Hz source detected in the 5th percentile spectrum at the Middle Station during Deployment 1 was also detected in the 5th percentile spectrum of Deployment 2.



Middle

Figure 3.27 (Top) Decade-Band Sound Pressure Levels (SPL), (Middle) Spectrograms, and (Bottom) Percentile 1-min Average Spectral Densities of Underwater Noise at the Middle Station, September to December 2010.

Seasonal Variation

The 50th percentile spectrum indicates that the average sound levels for Deployment 2, September to December 2010, are approximately 5 dB above those of Deployment 1, June to August 2010. This is attributed to increased storm activity in the fall and winter. The median third-octave band levels for the Middle Station during Deployments 1 and 2 are shown in Figure 3.28. This clearly shows the higher sound levels for frequencies above 63 Hz for Deployment 2 compared to Deployment 1.

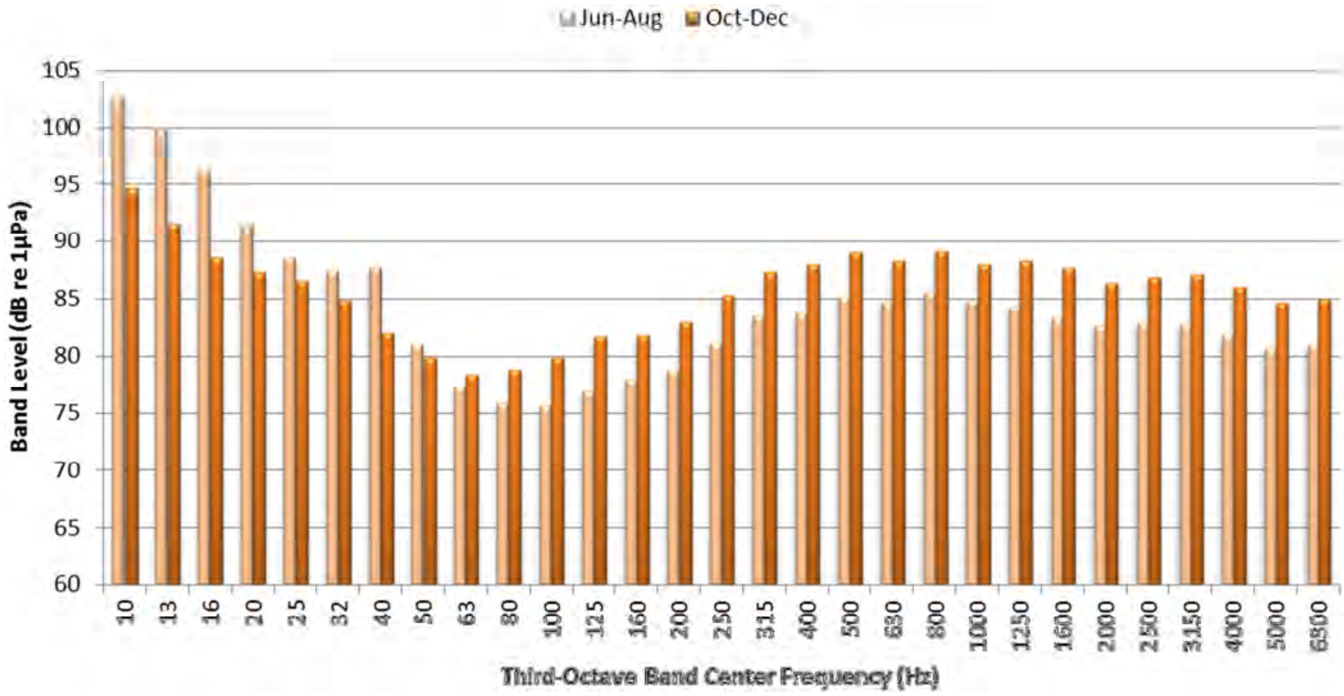


Figure 3.28 Median (50th percentile) Third-Octave Band Sound Pressure Levels at the Middle Station during the June to August (Deployment 1) and September to December (Deployment 2) 2010 recording periods.

4.0 SUMMARY

Nalcor Energy is proposing to develop an HVdc transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula. The EA of the Project is ongoing, with an EIS currently being completed by Nalcor Energy.

In preparation for and support of the Project's EA, this *Ambient Noise and Marine Mammal Survey* was completed with the objective to collect and present information on underwater ambient sound levels and marine mammal acoustic presence in the Strait of Belle Isle.

Acoustic data were recorded in summer and fall 2010 at three locations along or near the two identified cable corridors across the Strait of Belle Isle. Acoustic recorders were deployed and recorded data for two recording periods: initially data was recorded from the three locations from June to August, and then re-deployed to record data from September to December.

Analysis of acoustic data confirmed the presence of several marine mammal species during the survey periods. Humpback whales, killer whales, and dolphins (*Lagenorhynchus* sp.) accounted for most of the acoustic detections. The main detection period for humpback whale calls and dolphin whistles was before 10 November. Killer whale calls were detected at all three stations but were rare after the beginning of August, and were not detected during the September to December recording period. The greatest number of detections for these species was observed from the recorder near the middle of the Strait, followed closely by the Labrador Station. The Newfoundland Station recorded considerably less biological acoustic activity. Blue whale calls and a sei whale call were detected sporadically during the June to August recording period, with the blue whale calls detected at the Newfoundland Station and the sei whale call detected at the Middle Station. Fin whale calls were detected sporadically during the June to August recording period and almost daily until 8 November during the September to December recording period, which coincides with the onset of singing and may not necessarily mean an increased number of fin whales in the area. Additional biological activity was detected but could not be uniquely identified, and there were no confirmed pinniped recordings.

Ambient noise levels in the SOBI are well within the Wenz curve limits of prevailing noise. Below 100 Hz real and pseudo-noise from tidal water flow dominate the measured noise. Above 100 Hz local vessel traffic is the dominant noise source when present. Noise measured from the recorder in the Middle of the Strait was 5 dB higher during the September to December recording period than during the June to August period.

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Appendix A

Automated Detector Performances and Call Count Estimation

APPENDIX A AUTOMATED DETECTOR PERFORMANCES AND CALL COUNT ESTIMATION

A.1 Dataset

The performance of the automated vocalization detectors was tested using the fully-manually-annotated 90-s samples. Because manual analysis was performed on data samples from all three recorders throughout Deployment 1, the test dataset of fully-manually-annotated samples represents well the noise conditions in the study area throughout the survey period. Table A.1 shows the number of vocalizations in the fully-annotated samples for each species. Fewer than 100 vocalizations were annotated manually for both blue and sei whales, so the performance metrics (Precision and Recall, see below) could not be calculated.

Table A.1 Number of fully-manually-annotated samples and associated vocalizations used to calculate the automated detector performance metrics for fin, humpback, and killer whales and dolphins.

Species	Samples	Vocalizations
Fin whale	23	159
Humpback whale	33	250
Killer whale	16	291
Dolphins	11	329

A.2 Definitions: *TP*, *TN*, *FN*, and *FP*

The decisions made by classifiers/detectors can be represented by a structure known as a confusion matrix. This confusion matrix consists of four categories: true positives (*TP*), false positives (*FP*), true negatives (*TN*) and false negatives (*FN*). Table A.2 depicts the confusion matrix, where 'P' is the signal event we want to detect/classify and 'N' is a non-event that we don't want to detect/classify (*i.e.*, noise). The definition of 'P' varies depending on the detector or classifier.

Table A.2 Confusion matrix.

		True Result: P	True Result: N
Classification Result	P	*TP*	*FP*
	N	*FN*	*TN*

A true positive (*TP*) corresponds to a signal of interest being correctly classified as such. A false negative (*FN*) is a signal of interest being classified as noise (*i.e.*, missed). A false positive (*FP*) is a noise classified as a signal of interest (a.k.a. a false alarm). A true negative (*TN*) is a noise correctly classified as such.

TP, *FP*, and *FN* were calculated for each detector by comparing manual annotations of detections with detections from the automated detector analysis of the entire dataset, where assuming the manual annotations were assumed to be correct. *TP* and *FN* were calculated on all annotated calls (vocalization recordings). If an annotation is well detected then it is a *TP*, otherwise it's a *FN*. As recordings are not fully annotated (only 1 annotation per species and per sample) FPs are calculated on recordings that don't have any annotations of the target species (noise recordings). If the number of false alarms in the tested recording is greater than zero then the total number of *FP* is increased by one. Noise recordings were randomly selected such that the number of noise recordings equals the number of vocalization recordings. FPs are re-calculated 100 times by re-shuffling the noise recordings. The final *FP* is the average of all the *FP* values obtained.

A.3 Performance Metrics: Precision and Recall

To assess the performance of the detectors, the precision and recall metrics were calculated from *TP*, *FP*, and *FN*:

$$precision = \frac{TP}{TP + FP} \quad recall = \frac{TP}{TP + FN} \tag{1}$$

The precision can be seen as a measure of exactness, and the recall is a measure of completeness. For instance, a precision score for humpback whale of 0.9 means that 90% of the detections classified as humpback were in fact humpback calls, but says nothing about whether all the humpback vocalizations from the dataset were identified. A recall score for humpback of 0.8 means that 80% of all the humpback vocalizations in the dataset were correctly classified, but says nothing about how many of those classifications were wrong. Thus, a perfect detector/classifier would have precision and recall scores of 1. Note that the precision or recall alone cannot describe the performance of a detector/classifier on a given dataset, both metrics are required.

The precision-recall (*P-R*) metric presents advantages over the True-Positive Rate (TPR) and False-Positive Rate (FPR) generally used in Receiver Operating Characteristic (ROC) curves. Firstly, this metric is more adapted to skewed datasets. Secondly, it has been demonstrated that an algorithm dominates in ROC space if and only if it dominates in *P-R* space (Davis and Goadrich 2006). Finally, a significant advantage of using *P-R* values over ROC values comes in defining a *TN* count in continuous data. A subjective criterion is necessary to define a length of time that counts as one *TN* value over a continuous recording that contains no targeted vocalizations, whereas *TN* need not be calculated for the *P-R* metric. Therefore, using *P-R* values is better suited to the analysis of the summer data.

A.4 Call Count Estimation

A realistic estimation of call counts can be achieved with the use of the precision (*P*) and recall (*R*) values obtained. These values characterize the relationship between the detector/classifier and the dataset. Therefore, these values are specific and are dependent to both the classifier and the dataset and changing either will result in new *P* and *R* values. Provided that the subset of data used to characterize *P* and *R* are a good representation of the entire dataset, these values can be used to extrapolate the total number of vocalizations for a given species as follows. The total number of detections (N_{det}) found by the classifier is the sum of the true and false positives.

$$N_{\mathrm{det}} = TP + FP \tag{2}$$

and from the definition of *P* (Equation 1), *TP* can be defined as:

$$TP = P \cdot (TP + FP) = P \cdot N_{\text{det}} \tag{3}$$

The total number of vocalizations in the data (N_{voc}) is the sum of those correctly identified (*TP*) and those that were missed (*FN*):

$$N_{voc} = TP + FN \tag{4}$$

Therefore *R* (Equation 1) becomes:

$$R = \frac{TP}{TP + FN} = \frac{TP}{N_{voc}} \tag{5}$$

Combining Equations 3 and 5 yields the total number of vocalizations in terms of the number of detections, *P*, and *R*:

$$N_{voc} = \frac{TP}{R} = \frac{P \cdot N_{\text{det}}}{R} \tag{6}$$

Appendix B

Ambient Noise Results

APPENDIX B AMBIENT NOISE RESULTS

B.1

B.1.1

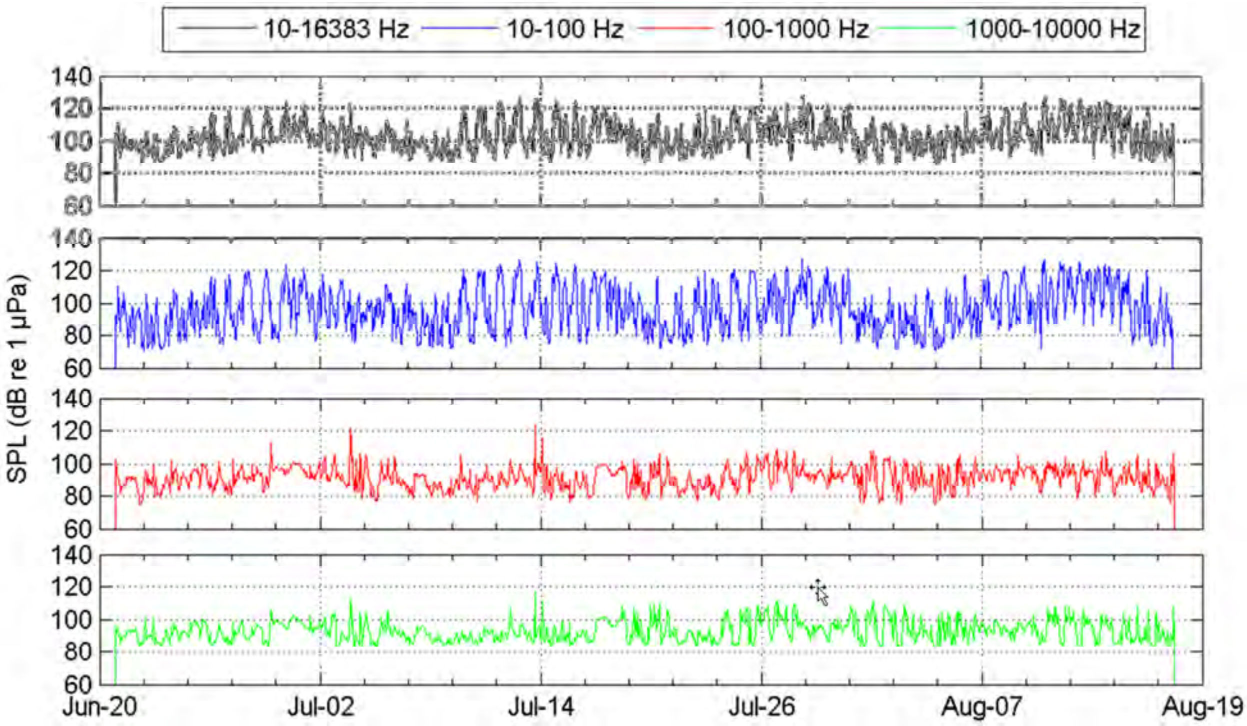

Figure B.1 Decade-Band Sound Pressure Levels (SPL) of Underwater Noise at the Labrador Station, June to August 2010.

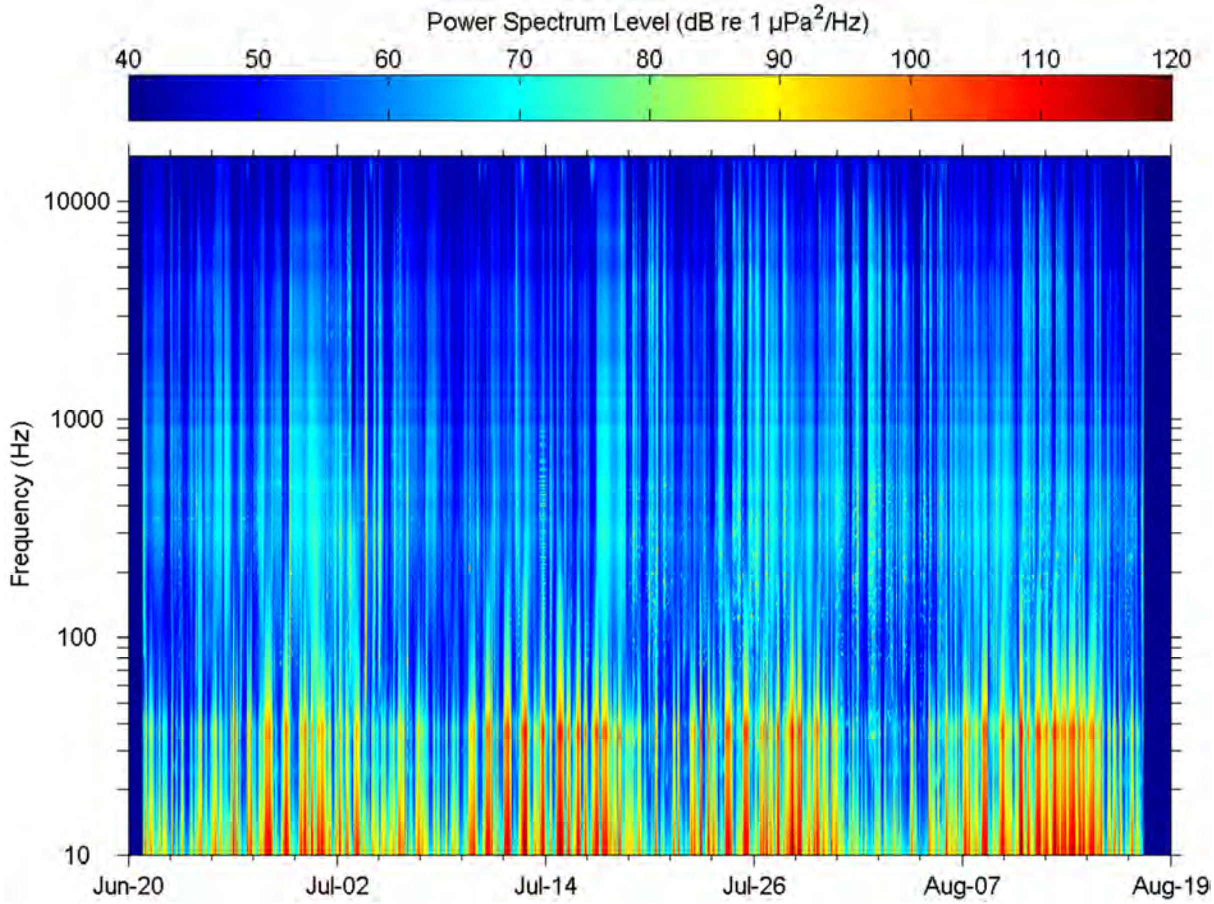

Figure B. 2 Spectrogram of Underwater Noise at the Labrador Station, June to August 2010.

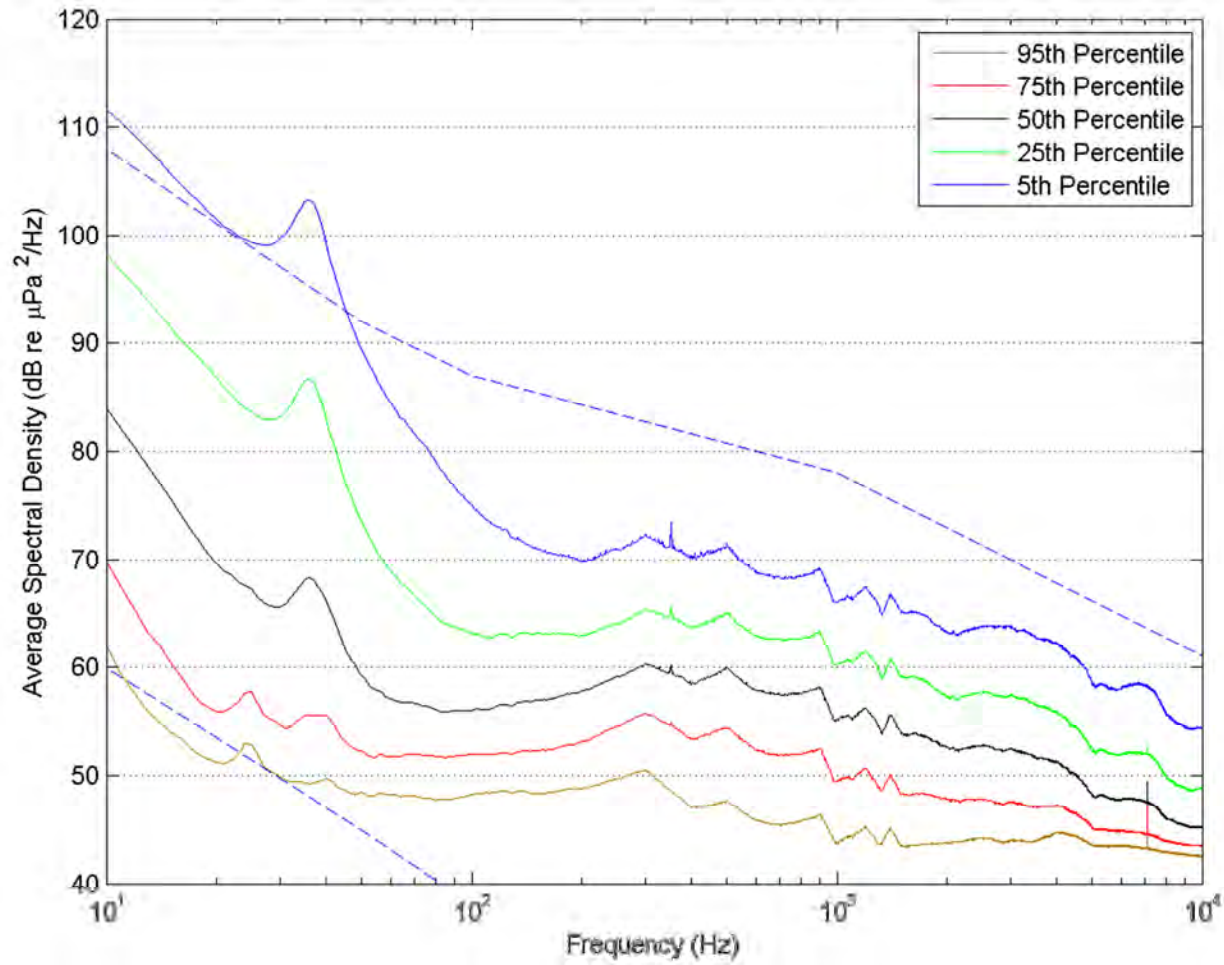

Figure B.3 Percentile 1-min Average Spectral Density Levels of Underwater Noise at the Labrador Station, June to August 2010. Dashed lines are the Wenz curve limits of prevailing noise (see Figure 2.3).

B.1.2

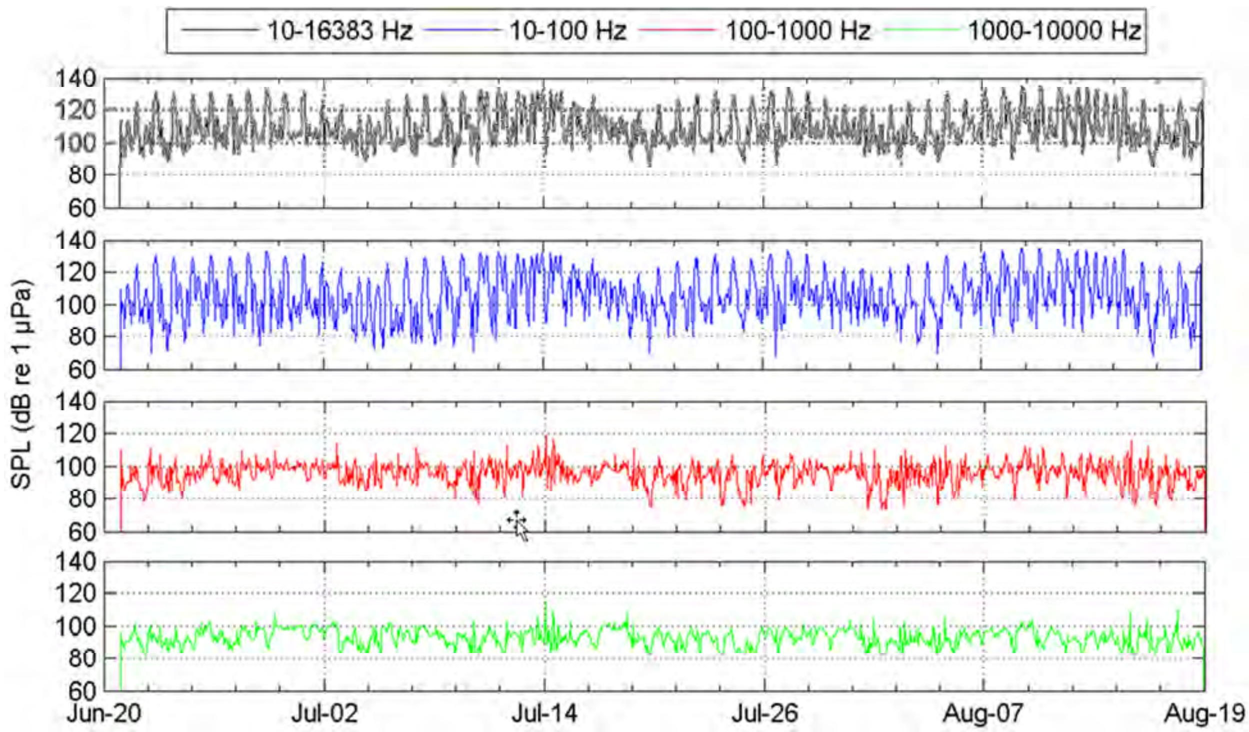

Figure B.4 Decade-Band Sound Pressure Levels (SPL) of Underwater Noise at the Middle Station, June to August 2010.

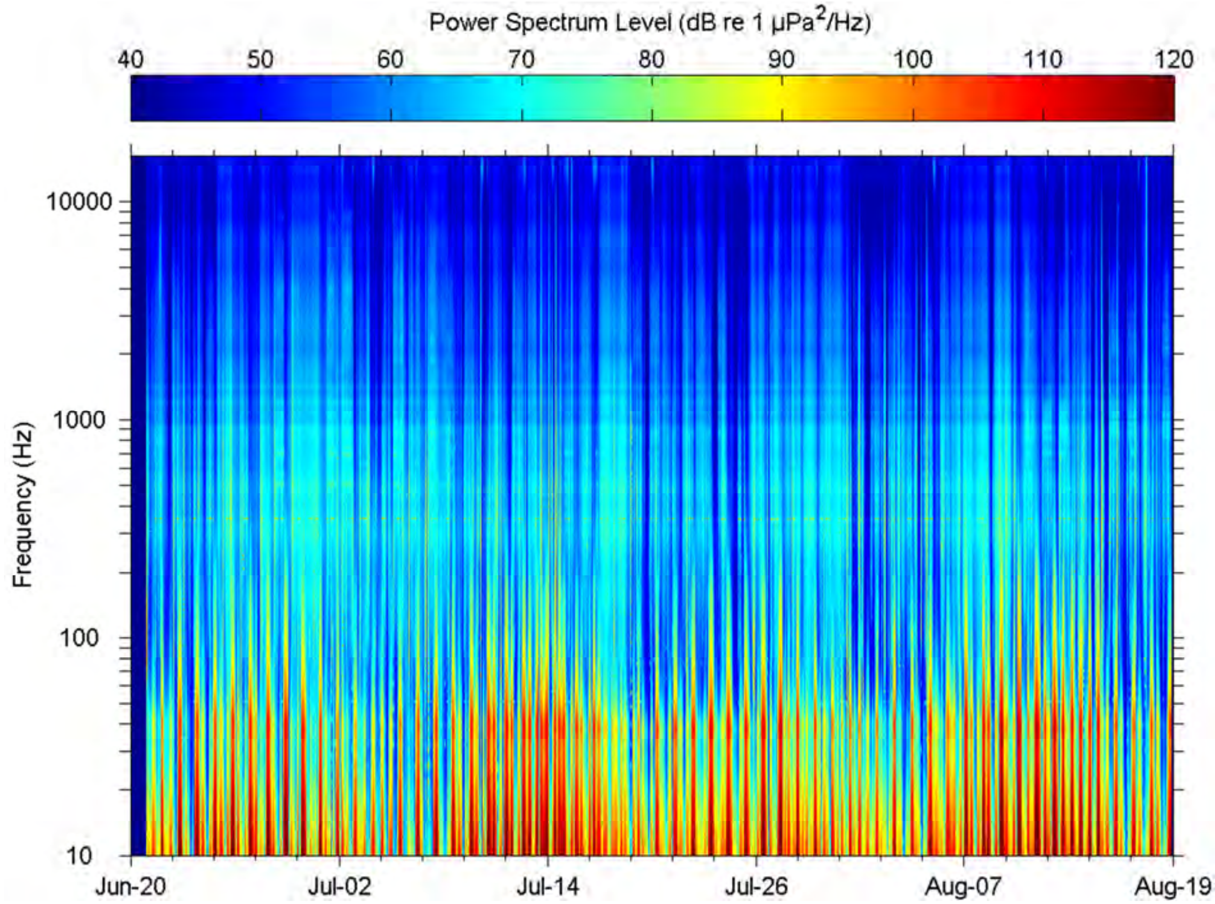

Figure B.5 Spectrogram of Underwater Noise at the Middle Station, June to August 2010.

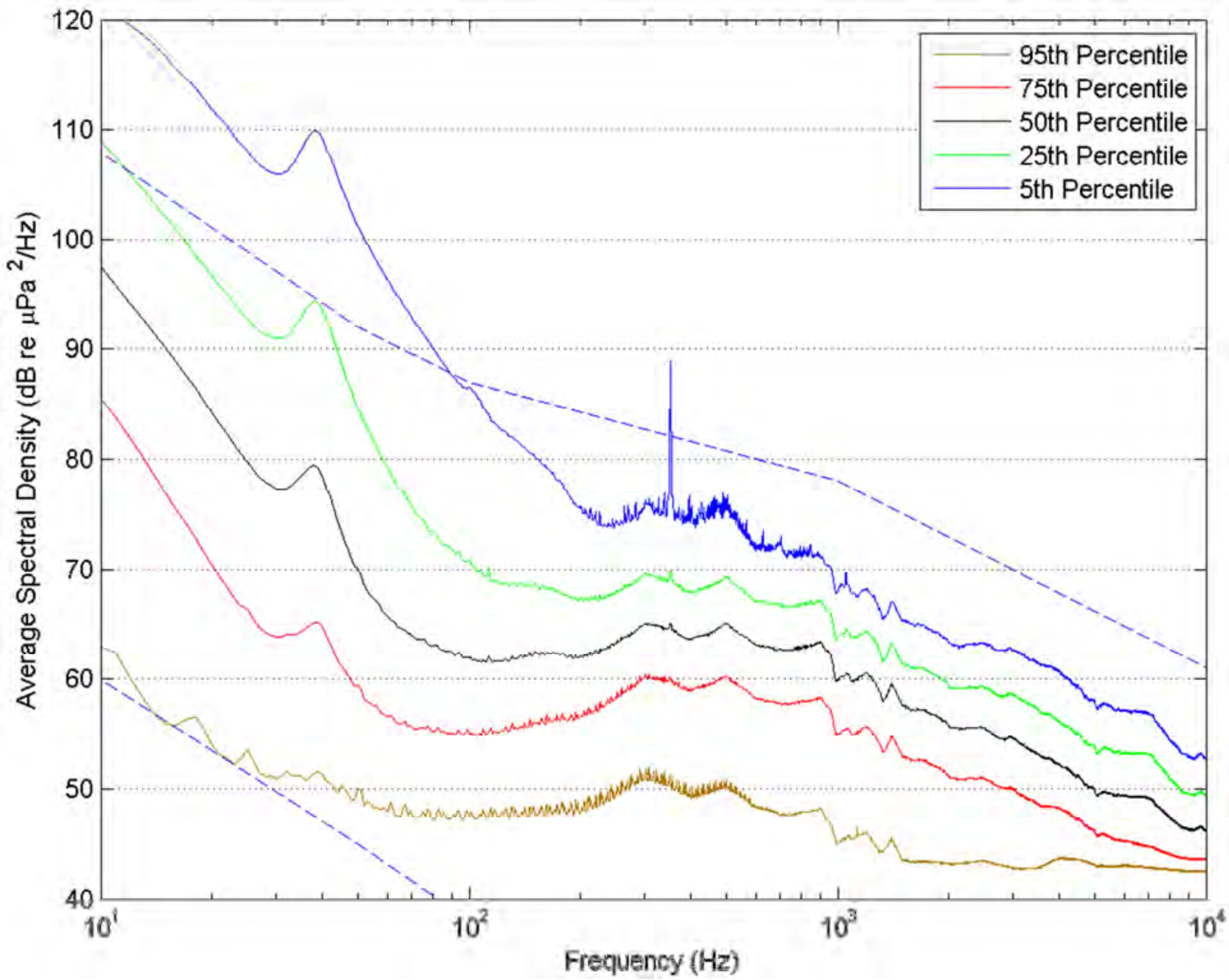

Figure B.6 Percentile 1-min Average Spectral Density Levels of Underwater Noise at the Middle Station, June to August 2010. Dashed lines are the Wenz curve limits of prevailing noise (see Figure 2.3).

B.1.3

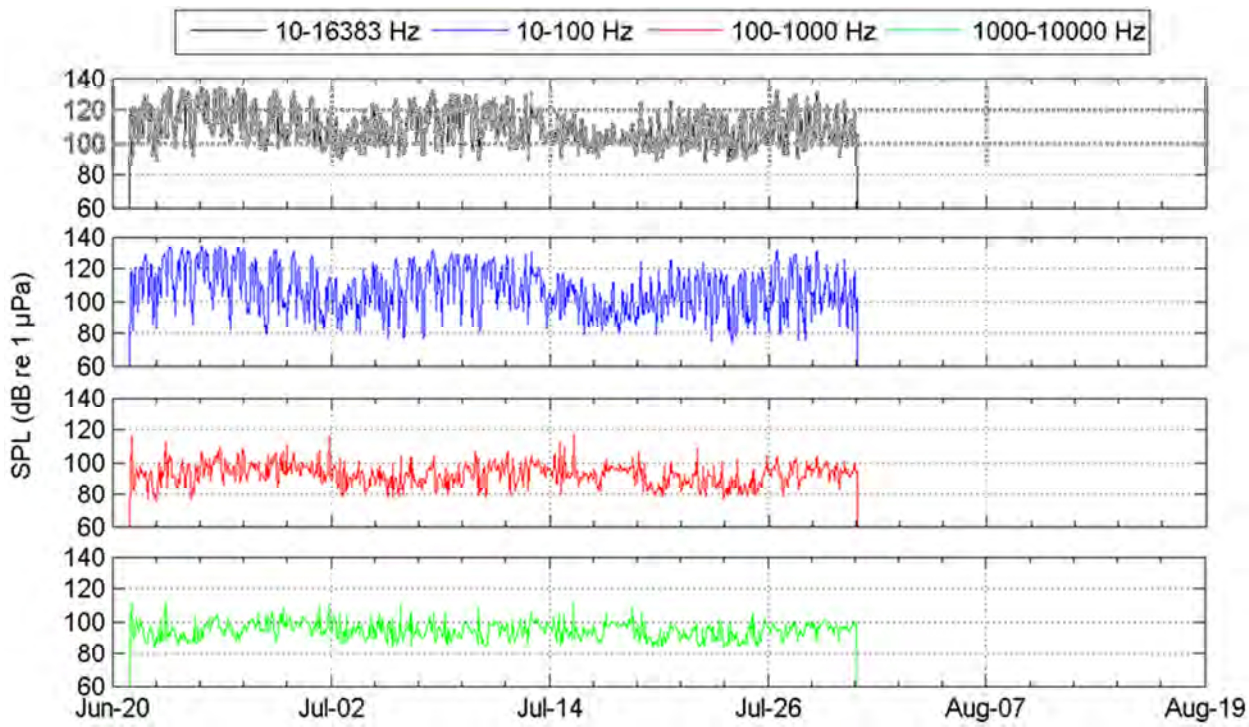

Figure B.7 Decade-Band Sound Pressure Levels (SPL) of Underwater Noise at the Newfoundland Station, June to August 2010.

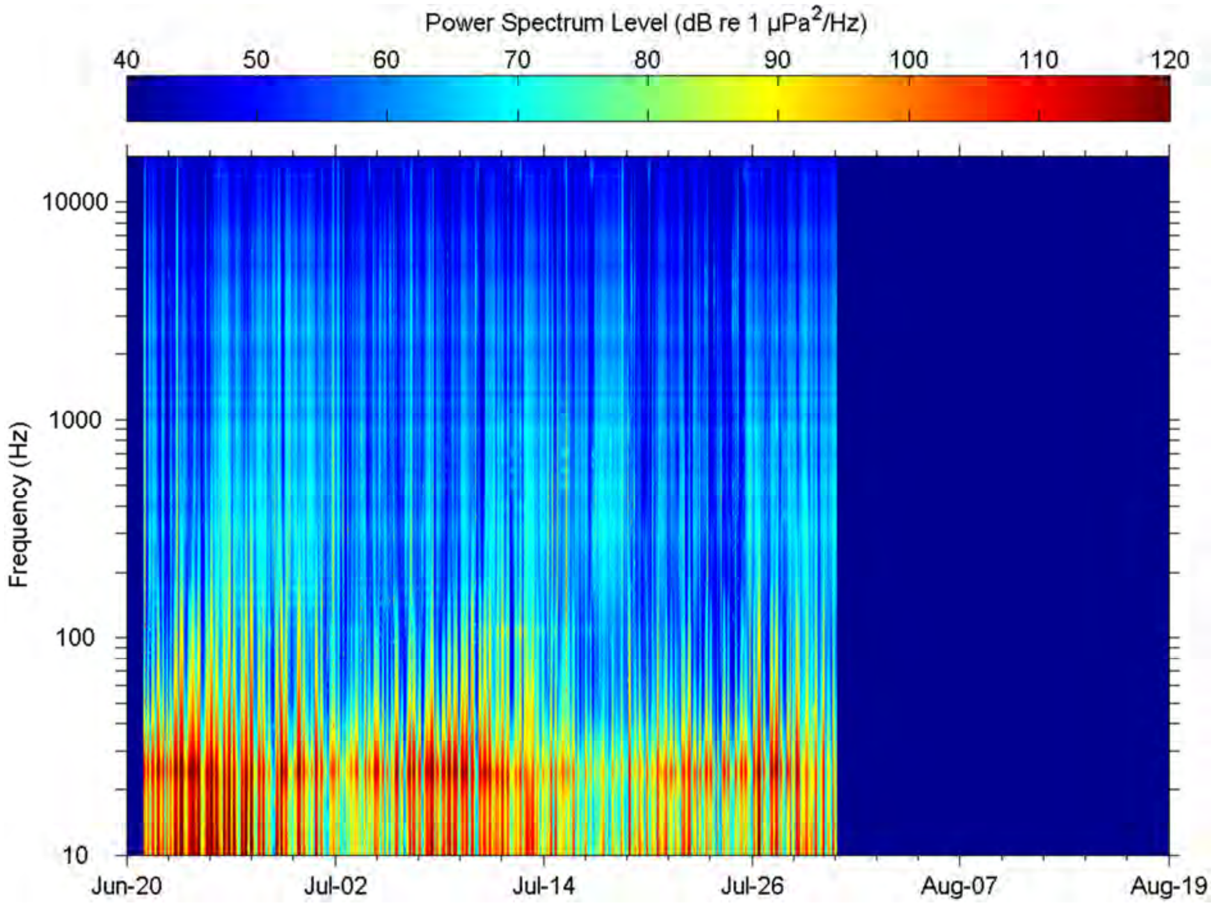

Figure B.8 Spectrogram of Underwater Noise at the Newfoundland Station, June to August 2010.

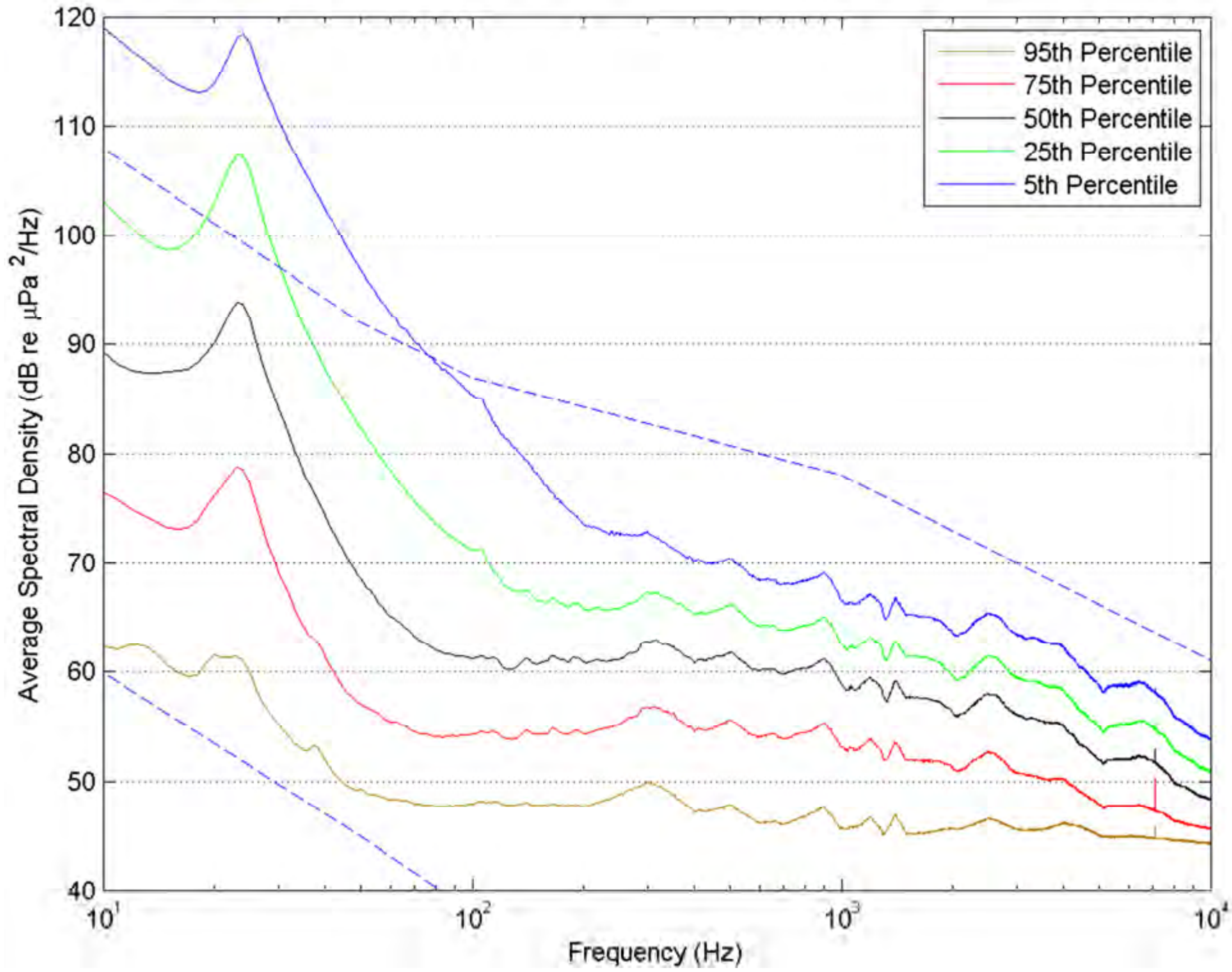

Figure B.9 Percentile 1-min Average Spectral Density Levels of Underwater Noise at the Newfoundland Station, June to August 2010. Dashed lines are the Wenz curve limits of prevailing noise (see Figure 2.3).

B.2

B.2.1

The Labrador recorder has yet to be retrieved.

B.2.2

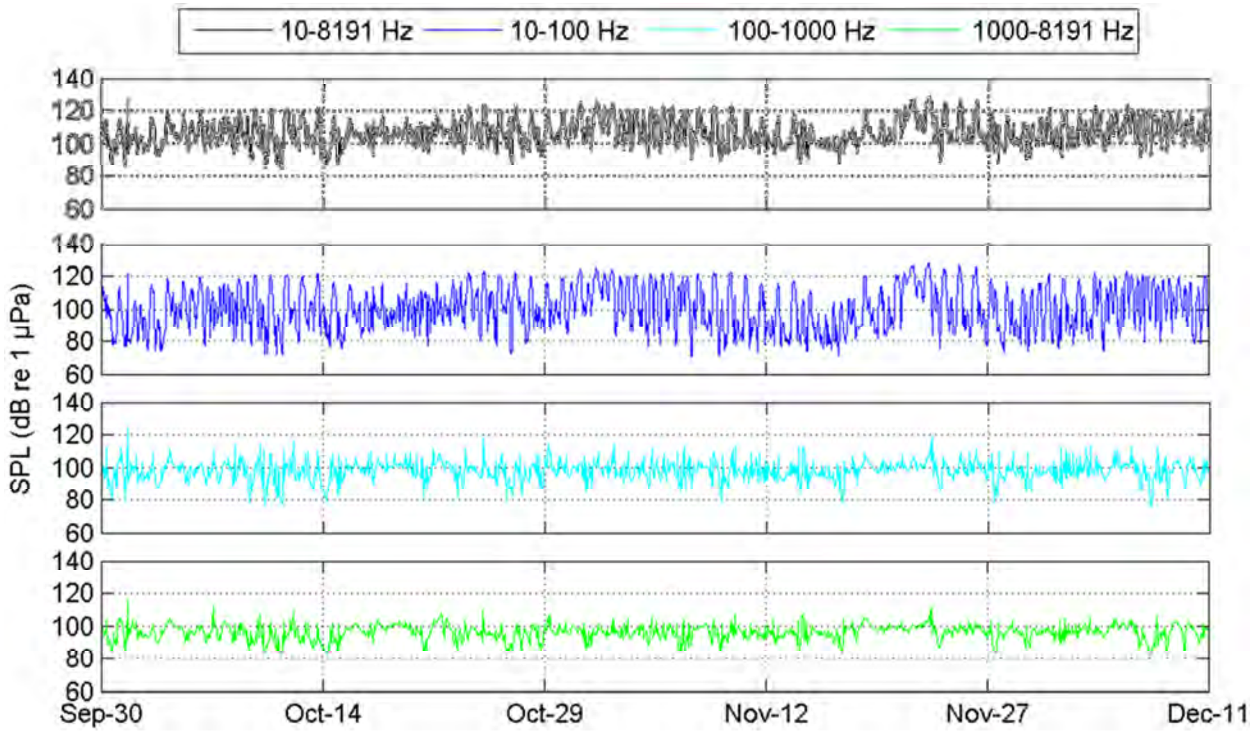

Figure B.10 Decade-Band Sound Pressure Levels (SPL) of Underwater Noise at the Middle Station, September to December 2010.

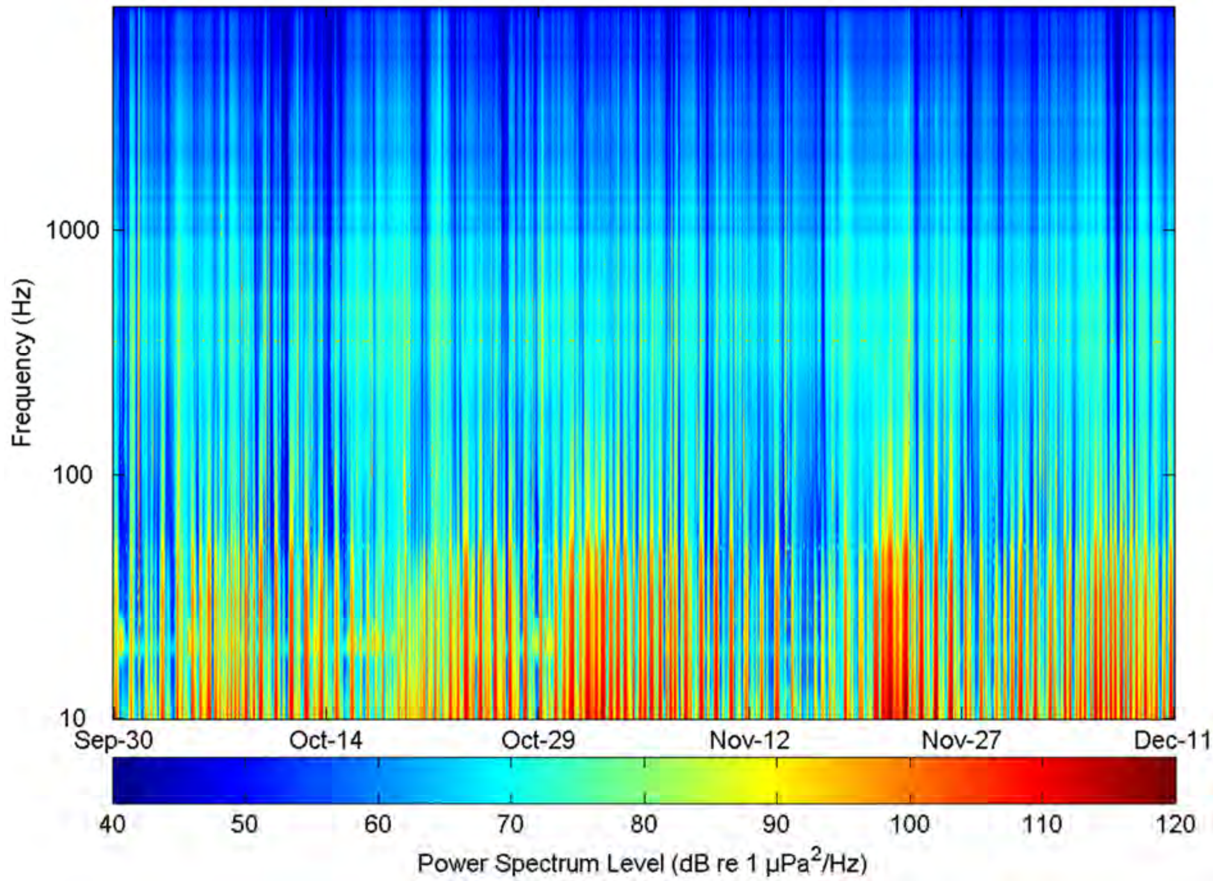

Figure B.11 Spectrogram Plot for the Middle Station, September to December 2010.

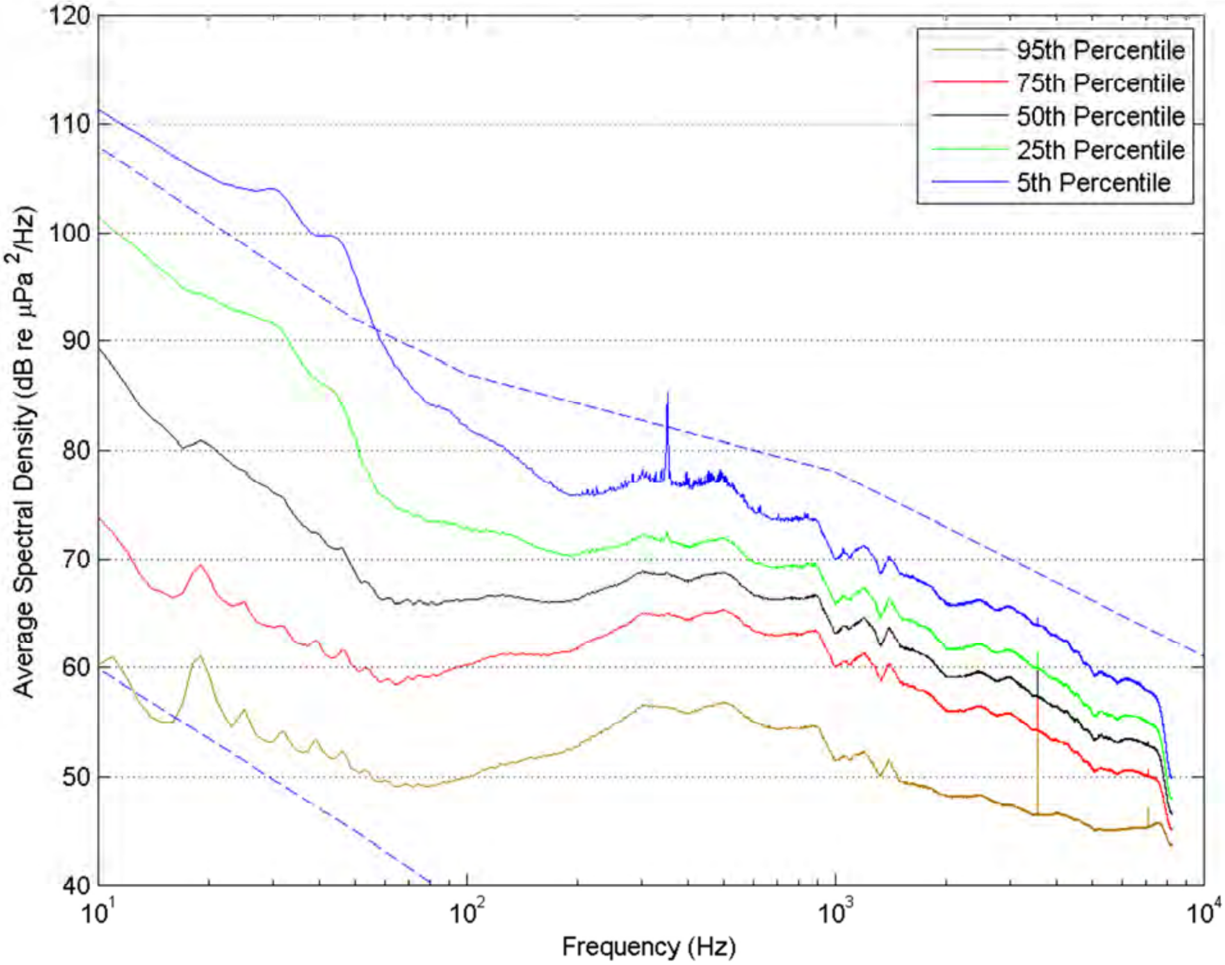

Figure B.12 Percentile 1-min Average Spectral Density Levels of Underwater Noise at the Middle Station, September to December 2010. The large spike near 360 Hz in the 5th percentile is likely due to a strong source on a vessel regularly passing the Middle Station. Dashed lines are the Wenz curve limits of prevailing noise (see Figure 2.3)

B.2.3

The Newfoundland recorder has yet to be retrieved.

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