Labrador – Island Transmission Link

Strait of Belle Isle Submarine Cable Crossing Corridors Marine Water, Sediment and Benthic Surveys

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Contract # LC-EV-047

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Project #
021-017

March 17, 2011

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 which will include the installation of submarine cables across the Strait of Belle Isle. In preparation for and support of the Project's Environmental Assessment (EA), a series of environmental studies have been completed to provide information on the existing environments in and near the Project area, including the marine environment in the vicinity of these proposed cable crossings. The Marine Water, Sediment and Benthic Surveys reported in this document comprise part of that marine environmental study program.

The Strait of Belle Isle marine sampling program for water, sediment, and benthos was planned and conducted in consideration of field studies previously conducted (2007, 2008, and 2009) in the Strait of Belle Isle. The sampling design was developed to provide good spatial distribution within the study area and to sample areas where there was a good likelihood of obtaining the required samples (i.e., sediment and benthos).

Methods: Water Sampling

The 15 sites for water sampling were pre-selected and were equally distributed (geographically) within the proposed Strait of Belle Isle cable crossing corridors. At each sampling station, a conductivity, temperature, and depth (CTD) profile was determined to characterize the water mass at the time of sampling. At each sampling station, three samples were collected: 1) near the surface, 2) near the bottom, and 3) within the thermocline or halocline (if present) at the sampling station. Water samples (n=44) were collected using Nisken Samplers. Field water quality measurements were recorded at the time of sample collection from the surface sample and water samples were also analyzed at an analytical laboratory for conventional parameters, major ions, nutrients, metals, and hydrocarbons. Data were evaluated in relation to marine water quality guidelines for the protection of aquatic life.

Results: Water Sampling

Field water quality results were generally comparable between sites, with temperatures demonstrating some variability between sites. Dissolved oxygen values were high and supersaturated. Laboratory analyses of water samples indicated there were no noticeable differences between depths at each sampling station, suggesting the water masses were well mixed. Few nutrients were detected in the samples, with orthophosphate, nitrate and total phosphorous detected at low levels. Metal levels were also low, with only boron and strontium detected in all samples, mercury, lead, and selenium in a few, while all other metals tested were undetected. Laboratory results were evaluated in relation to CCME Guidelines for the Protection of Aquatic Life and there were no exceedences of any parameters. Petroleum hydrocarbons were also tested and only toluene was detected in samples tested and all values were well within the CCME guidelines. Water quality data collected in 2010 confirmed the pristine nature of the marine environment in the study area and there was no evidence of any anthropogenic influence on marine water quality.

Methods: Sediment Sampling

Sediment samples were collected using either a stainless steel 30 cm by 30 cm Van Veen grab or a 20 cm by 20 cm Shipek sediment grab. After field testing, the Van Veen grab was the primary sampler used for collection of sediment and benthic samples. Two 500 mL sub-samples were collected, one for physical characterization of sediment and one for chemical analyses. Physical characteristics of sediment included classifying the proportion (%) of sample as gravel, sand, silt and clay, based on the Wentworth (1922) substrate scale, as well as a detailed Particle Size Analysis (PSA) of the silt/clay fraction. Chemical analyses of sediment at the analytical laboratory included major ions, metals, hydrocarbons, organic carbon and moisture. Data were evaluated in relation to CCME (2002) Interim Sediment Quality Guideline (ISQG) limits for the Protection of Aquatic Life and Potential Effect Level (PEL) guidelines.

Results: Sediment Sampling

Sediment sample collection was attempted from a total of 14 locations with sampling successful at seven sampling stations. Physical analysis of sediment demonstrated the coarse nature of the sediments which consisted mainly of rubble, cobble, gravel and fine shell material. Particle size analyses of the finer material revealed that gravel dominated the samples while silt was rare being totally absent in four of seven samples. Chemical analyses of sediment found calcium, and to a lesser extent magnesium levels, to be very high reflecting the contribution of shell fragments to the finer sediment fractions. Organic carbon and moisture content were low also reflecting the lack of fine materials in the sediments. Most metals were below detectable levels and no CCME ISQGs or PEL guidelines were exceeded. Hydrocarbons were only detected in two samples and those detected were in low concentrations with no CCME or PEL guidelines exceeded.

Methods: Benthic Sampling

Benthic samples (n=12) were collected at the same locations that sediment sampling was attempted. More benthic samples than sediment samples were collected as the coarser materials were amenable to analyses of benthic invertebrates but not substrate quality. Intact grabs were transferred to a 20 L bucket for subsequent processing and field sorting. Samples were sorted and identified in the laboratory using a stereo-microscope. Wet weight biomass was estimated by weighing animals at the time of sorting. Organisms were sorted and identified to the lowest practical taxonomic level (LPL), typically genus or species, using current literature. Selected benthic community indicators (indices) were also calculated.

Results: Benthic Sampling

Benthic samples contained moderate to high abundance, biomass, and diversity of organisms. Abundance ranged from 143 to 2,878 organisms/sample while biomass (g/sample wet weight) ranged from 1.12 to 274.91 g/sample. Abundance and biomass were not correlated as several larger taxa and/or individuals were dominant in some samples. Abundance and biomass estimates were considered semi-quantitative as the volume of sample retained for benthic analyses varied between stations. A total of 14,303 organisms representing 308 different taxa at various taxonomic levels (species, genus, family, order, class) were recovered from the samples. The benthic community was dominated by Polychaetes (69.1%), followed by Amphipods (7.5%), Echinoderms (6.3%), Bivalves (3.7%), meiofauna and plankton (2.5%), Gastropods (2.2%), Isopods (1.4%) and Porifera (1.3%). The dominant taxon were members of the encrusting, tube building genus *Spirorbis* which were an order of magnitude greater in abundance than all other benthic taxa combined. Taxon Richness (number of taxon per sample) ranged from 29 to 108 with all but three stations exceeding 50 taxon per sample. A variety of diversity indices including Shannon-Wiener Diversity Index, Pielou's Evenness Index, McIntosh's Index, Simpson's Index, and Margalef's Index were determined to describe the benthic community.

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 Water, Sediment, and Benthos Survey has been completed to collect data on these aspects as baseline information to help characterize the marine environment in support of the Project's EIS. This information is intended to complement that collected through other 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 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 Strait of Belle Isle cable crossings (Figure 1.1), as well as various alternative corridor segments in particular areas. 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 was to collect and compile marine environmental data within the proposed submarine cable corridors in the Strait of Belle Isle associated with the *Labrador – Island Transmission Link*. This included collection of water and sediment quality data and benthic invertebrate community data. This information will be used to characterize the marine environment in the area of the proposed corridors in support of the EIS for the proposed Project. The study further complements the information gathered in the 2008 and 2009 surveys within the Strait of Belle Isle (and reported separately by AMEC Earth and Environmental 2010) and other studies by Nalcor Energy including a literature review of environmental, oceanographic, biological, and fish habitat information in the study area (Sikumiut 2010).

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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 marine environmental baseline information for the proposed Strait of Belle Isle submarine cable crossing corridors. The study consisted of field study design and planning, implementation, laboratory and data analyses, and report preparation. Sampling in the Strait of Belle Isle marine environment focused on the collection of water samples, sediment samples, and benthic invertebrates.

2.1 Study Area

The study area for the marine surveys was directed at the proposed submarine cable corridor crossings for the *Labrador-Island Transmission Link* within the Strait of Belle Isle. Various sampling locations were selected within the proposed corridors (Figure 1.1). As the field survey was ongoing, a concentrated effort was made to collect sediment samples from particular portions of the identified corridors, which engineering and feasibility studies had determined to be the most likely locations for the submarine cable crossing.

2.2 Study Team

The Study Team (Table 2.1) was led by Larry LeDrew, Project Manager, with senior advice and report preparation provided by Dave Scruton. The field team was led by Narcissus Walsh, with field technical support by Grant Vivian. Edmund Moores was the boat contractor and operator. Report preparation was completed by Dave Scruton, Suzanne Thompson and Grant Vivian.

Table 2.1 Study Team Roles and Responsibilities

Name	Role	Responsibilities
Larry LeDrew, M.Sc.	Project Manager	Project management, client liaison
Dave Scruton, M.E.S.	Senior Scientist	Advisor, data analysis, report preparation and review
Narcissus Walsh, B.Sc., B.Ed.	Lead Field Survey Team	Technical lead for mobilization, implementation and completion of field study
Grant Vivian, B. Tech	Field Survey Team Member	Field technical support and geomatics specialist; data analyses, graphics and mapping support
Edmund Moores	Boat Contractor and Operator	Provision and operation of boat during the field study component
Suzanne Thompson, B.Sc.	Biologist	Data analyses and report preparation
Kevin Diamond	Field Survey Team Member	Field technical support

2.3 Study Design and Planning

The sampling program was planned and conducted in consideration of field studies conducted in 2007, 2008, and 2009; specifically:

(i) Marine Habitats in the Strait of Belle Isle: Interpretation of 2007 Geophysical (Sonar) Survey Information for the Submarine Cable Crossings Corridors (Fugro-Jacques Geosurveys 2010);
(ii) Marine Flora, Fauna and Habitat Survey - Strait of Belle Isle Submarine Cable Crossings Corridors, 2008 and 2009 (AMEC Earth and Environmental 2010); and
(iii) Marine Fish and Fish Habitat in the Strait of Belle Isle: Information Review and Compilation (Sikumiut 2010)

These documents informed the study design by identifying locations amenable to sample collection, identifying areas where data may be lacking, and identification of any sampling constraints that may be related to current, tides, water depths, and other natural features. Historical weather summaries were also consulted in order to attempt to schedule the field sampling campaign in consideration of expected weather and sea state conditions (Environment Canada 2010).

The initial sampling design was developed to:

- collect samples to provide good spatial distribution within the study area;
- co-locate water, sediment and benthic sample collections, whenever possible or practical; and
- collect samples in consideration of the proportional representation of substrate and depth (i.e., habitat) categories.

Based on these broad objectives, the Study Team conducted a desktop assessment of the available information to identify sample requirements and candidate sites for discussion with Nalcor Energy. On the basis of the above approach, the Study Team and Nalcor Energy determined that a total of 15 sediment and benthos samples and 45 water samples (three samples from each of the 15 stations), plus 10% quality assurance/quality control (QA/QC) replicate samples, would be targeted for collection and analyses.

During the study planning stages, it was noted that sediment sampling during previous studies in the Strait of Belle Isle had a very low rate in retrieval of sediment grabs (AMEC Earth and Environmental 2010). Sediment and benthos sampling locations (n=15) were subsequently pre-selected using seabed mapping data (Fugro-Jacques Geosurveys 2010; AMEC Earth and Environmental 2010), which included substrate type and general characteristics. Sampling sites were selected to:

(i) provide a good areal distribution of samples to represent the selected cable crossing corridors; and
(ii) target areas with unconsolidated seabed material from which there was a reasonable probability of obtaining a sediment sample (i.e., focus on fine, coarse-small, and shell substrate classes).

During the field survey, Nalcor Energy identified several priority areas for study within the corridors and the sampling locations were subsequently adjusted to focus on these.

As a result of the need to select sediment sampling locations based on distribution of unconsolidated sediments, the sediment sampling sites could not be evenly distributed on a geographical basis. Consequently, a decision was made not to co-locate the sediment/benthos and water samples collection stations so that the water sampling could be completed on a more geographically distributed basis. This permitted the water and sediment/benthos sampling components to be conducted as independent sampling campaigns.

In recognition of the documented challenges in obtaining sediment samples from the Strait of Belle Isle, an *a priori* protocol was developed for sediment grab attempts. This was developed to ensure that an inordinate amount of time was not spent at any one location attempting to collect sediment samples, without success. A maximum of seven attempts to collect a sediment sample were to be made at the pre-selected sampling stations and, if the attempts were not successful, then the sampling platform would relocate to the next sampling station. The initial study plan and design was discussed with Fisheries and Oceans Canada representatives prior to field mobilization, which resulted in some additions and refinements to the sampling program.

2.4 General Field Study Program

The field sampling component of this study was initiated on September 24 and completed on October 6, 2010. Throughout the survey, the field crew was stationed in Plum Point and used a field sampling platform (vessel) stationed in Flower's Cove. All necessary field sampling equipment, including backups, were transported by the field team to Plum Point/Flower's Cove. The field crew mobilized from St. John's to Plum Point on September 24 and set up the vessel and equipment for the study on September 25, which included completing a detailed safety briefing and orientation for the field team and vessel crew, and testing and calibration of all of the field equipment. Details on the sampling platform are provided below (Section 2.5) while details on the various study components; sampling protocols; sample collection; handling, and preservation; sample analyses; and approach to analyses and interpretation of results are provided in Sections 2.6, 2.7, and 2.8 for water, sediment, and benthos, respectfully.

The study program, which initially only included water and sediment sampling, was conceived as a five day field sampling effort (12 h days), plus weather contingency, and not including travel and mobilization. Field sampling was completed in six days (2.5 days for water, 3.5 days for sediment and benthos), while four days were lost to weather, and an additional 4.5 days were used for travel and mobilization, including transportation of samples to Deer Lake for shipping to the contracted analytical laboratories.

2.5 Sampling Platform

The water, sediment and benthos sampling program in the Strait of Belle Isle was completed through the charter of a 13.7 meter longliner, owned and operated by Edmund Moores in Flower's Cove (Figure 2.1). The longliner was certified as a fishing vessel and contained suitable safety equipment including inflatable life rafts and immersion suits for all crew and Study Team members. The boat was equipped with a heavy duty boom and winch system, with metered stainless steel cable, which was intended to deploy the water sampling apparatus and the sediment sampling grab. However, the Study Team determined that a Honda hauler, with a new 0.95 cm braided rope, would be more appropriate for the rapid deployment and retrieval of the conductivity/temperature/depth (CTD) meter, water sample bottles, and sediment grabs. The hauler permitted more control of the speed of descent of the sediment grab, particularly during contact with the sediment/water interface which was important in successfully obtaining the grabs. The hauler was subsequently mounted on the stern of the boat which afforded the Study Team some protection from open sea conditions during sample collection.

The boat was equipped with an onboard GPS Navigation system and had on board refrigeration for sample storage. Additionally, a second GPS system with external antenna, was installed on the survey vessel and connected to a computer based GPS/mapping software (Fugawi™) which displayed the vessel position and survey targets, in real time, on a pre-loaded map of the survey area. All positions collected throughout the survey were recorded using a Wide Area Augmentation System (WAAS) enabled GPS with a manufacturer's stated accuracy within 3 m - 95% of the time. Positions were recorded in latitude and longitude with reference to a WGS84 datum.

Sampling locations were set up as 'navigational targets' and the vessel captain was directed to position the vessel on the center of each target. Sampling equipment (CTD meter; sediment grab and water sampling equipment) was prepared in advance of arriving at the location. The vessel was brought to a stop on the sampling location; the sampling location number was verbally verified and the sampling equipment was deployed. Strong currents and persistent winds introduced some challenges in maintaining position at sampling locations. If the vessel moved several hundred meters from the target during equipment deployment it was repositioned and the sampling effort was repeated.

Figure 2.1 Sampling Platform for the Study (foreground)

2.6 Water Quality

Water quality samples were collected from pre-selected locations and included collection of CTD profiles, determination of field water quality parameters, and collection of water samples for chemical and hydrocarbon analyses at an analytical laboratory. Sampling stations are provided in Figure 2.2. The methods are detailed in the following sections.

2.6.1 **Site Selection**

Initially, 15 sites were pre-selected for survey and this level of effort was considered adequate to represent any spatial variation in water quality during the sampling period. The 15 sample locations were generally equally distributed (geographically) within the proposed cable crossing corridors. At each sampling station, a CTD profile was determined to characterize these parameters in the water mass at the time of sampling. At each sampling station, three waters samples were to be collected as follows; (i) near surface, (ii) near bottom, and (iii) within the thermocline or halocline (if present) as determined from the CTD profile (see Section 2.6.2). If no thermocline/halocline was present then a sample was taken at mid water depth.

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FIGURE 2.2

Strait of Belle Isle Water Sampling Sites

2.6.2 **Conductivity, Temperature and Depth (CTD) Profiles**

A Sea-Bird Electronics SEACAT SBE-19 CTD Meter was used to profile the electrical conductivity, temperature, and depth (pressure) at 15 pre-selected water quality stations in the Strait of Belle Isle. The unit can measure conductivity over the range from 0 to 7 $S \cdot m^{-1}$ with a resolution of 0.0001 $S \cdot m^{-1}$ in most oceanic waters. Similarly, the unit will measure temperatures over the range from -1 to +31 $^{\circ}C$ with a resolution of 0.001 $^{\circ}C$.

Initially, to ensure the unit would not contact the bottom during use, a three meter line with weight was attached to the bottom of the SBE-19. At each station, the vessel operator would stabilize the boat and provide the depth from the vessel sonar to the Study Team. Additionally, the main cable on the unit was marked every meter so the Study Team could monitor water depth when approaching the seabed. The SBE-19 was pre-programmed for data collection and storage, and deployed in profiling mode where vertical profiles were recorded at a rate of two times a second as the instrument was being lowered to the bottom. In profiling mode, the unit records a header, containing real time and cast number data, and stores the CTD data in memory for each profile.

At each station the SBE-19 was placed in the water and held at the surface for 90 seconds to allow the unit sensors to fully initialize. The Study Team then lowered the SBE-19 in the water column at an approximate rate of one meter per second. Once lowered to a depth of three to five meters from the bottom the unit was retrieved to the surface using the Honda hauler. Once the SBE-19 had been safely returned to the surface, the unit was removed from profiling mode, connected to an onboard computer (laptop), and the data from the CTD cast downloaded. SEASOFT software was then used to download, analyze and plot the data.

2.6.3 **Water Sample Collection**

The profile generated from the CTD cast was reviewed to select three depths for water sample collection in accordance with the overall study design. The design required that samples be collected near surface, within the thermocline (or halocline), if present, and near the bottom. A thermocline is a distinct layer of water where temperature changes more rapidly than the water above or below the thermocline, dividing the water column into a mixed surface layer and a deeper colder layer. A halocline is similar with a layer of water where the salinity (conductivity) changes more rapidly than the water above or below. The water samples were collected using a 2.5 L horizontally oriented Nisken Sampler. A white board on the boat was used to record and display the three depths selected for sampling at each station and the associated Nisken number used to label all sampling bottles (Figure 2.3).

Figure 2.3 On Board Documentation of Selected Water Sample Depths as Determined from the CTD Profile

The same line was used to deploy all three Nisken sampling bottles and the line was marked in one meter increments, with a different colour used to delineate every five meters. The first Nisken bottle attached was for the near bottom sample, followed by the thermocline or mid water depth sample, and then the near surface sample. Once all bottles had been lowered to the appropriate depth, a messenger was dropped to trigger the closure of all three sample bottles. Once the first (near surface) bottle was triggered it released a second messenger which triggered the second (thermocline) bottle and the same process triggered the third bottle (near bottom). The three Nisken bottles were then retrieved, one by one, and placed in a custom rack.

After all three bottles were placed in the storage rack, the water samples were drawn off as required for the selected chemical analyses (Figure 2.4). Nine sample bottles per station were collected. All samples were packed and shipped to the contracted analytical laboratory (Maxxam Analytics, Bedford, Nova Scotia), with chain of custody (CoC) forms, within 48 hours of collection.

Figure 2.4 Field Team Drawing Off Water Samples from Nisken Bottles on Storage Rack

2.6.3.1 Field Measurements

Field water quality measurements were recorded at the time of sample collection from the surface sample using an YSI 600 QS water quality meter multi-parameter sonde. For field measurements, water was drawn off into a 500 ml Nalgene® bottle, the probe from the water quality meter was placed in the sample, allowed to equilibrate, and the appropriate measurements recorded on field data sheets customized for the program. Field measurements included temperature (0.01 $^{\circ}$C), dissolved oxygen (DO, 0.01 mg·L^{-1}), percent saturation of dissolved oxygen (% DO, 0.1%), pH (0.01 pH units, 0.1 mV), conductivity (1 S·cm^{-1}), and oxygen reduction potential (ORP, 0.1 mV).

2.6.4 **Analysis and Interpretation**

Laboratory analyses of water samples by Maxxam Analytics included general chemistry, major ions, nutrients, metals and hydrocarbons. Maxxam Analytics is accredited by the Canadian Association of Environmental Analytical Laboratories (CAEAL) which regulates, monitors, and accredits the performance of analytical laboratories in Canada.

Water samples were analyzed for various parameters as summarized in Table 2.2. Methods of analyses, units of reporting, reportable detection limits (RDL), and Canadian Council of Ministers of the Environment (CCME) values for Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007), where applicable, are included. Major ions were determined using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES), while trace elements were determined using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS), with the exception of mercury which was analyzed using Cold-Vapor Atomic Absorption Spectrometry (CVAA) methods.

Water samples were also analyzed for Total Petroleum Hydrocarbons (TPH) and included Benzene, Toluene, Ethylbenzene, and Xylene(s) (BTEX), gasoline range organics (C_6 to C_{10}), and analysis of extractable hydrocarbons - diesel (>C_{10} to C_{16}), diesel (>C_{16} to C_{21}) and lube (>C_{21} to C_{32}) range organics. BTEX and gasoline range organics were analyzed by purge and trap-gas chromatography/ mass spectrometry or headspace – gas chromatography (MS/flame ionization detectors). Extractible hydrocarbons, including diesel and lube range organics were analyzed using capillary column gas chromatography (flame ionization detector).

Table 2.2 Water Quality Parameters Measured in the Strait of Belle Isle 2010

	Units	RDL	CCME Guideline	Analysis Method
Conventional Parameters				
pH	pH	N/A	7.0 - 8.7	meter
Total Alkalinity (Total as $CaCO_3$)	$mg \cdot L^{-1}$	5		colourimetry
Hardness ($CaCO_3$)	$mg \cdot L^{-1}$	1		calculation
Turbidity	NTU	0.1		nephelometer
Conductivity	$\mu S \cdot cm^{-1}$	1		meter
Colour	TCU	1		colourimetry
Total Suspended Solids (TSS)	$mg \cdot L^{-1}$	1		dry weight
Calculated TDS	$mg \cdot L^{-1}$	5		gravimetric
Total Organic Carbon (C)	$mg \cdot L^{-1}$	5		spectrophotometry
Reactive Silica (SiO_2)	$mg \cdot L^{-1}$	0.5		spectrophotometry
Nutrients				
Nitrate + Nitrite	$mg \cdot L^{-1}$	0.05		chromatography
Nitrite (N)	$mg \cdot L^{-1}$	0.01		chromatography
Nitrate (N)	$mg \cdot L^{-1}$	0.05	16[a]	chromatography
Nitrogen (Ammonia)	$mg \cdot L^{-1}$	0.05		colourimetry
Total Phosphorous (P)	$mg \cdot L^{-1}$	10		OES
Orthophosphate (P)	$mg \cdot L^{-1}$	0.01		spectrophotometry
Major Ions				
Total Calcium (Ca)	$mg \cdot L^{-1}$	10		OES
Total Magnesium (Mg)	$mg \cdot L^{-1}$	10		OES
Total Sodium (Na)	$mg \cdot L^{-1}$	10		OES
Total Potassium (K)	$mg \cdot L^{-1}$	10		OES
Dissolved Chloride (Cl)	$mg \cdot L^{-1}$	300		colourimetry
Dissolved Sulphate (SO_4)	$mg \cdot L^{-1}$	50		spectrophotometry
Trace Elements				
Total Aluminum (Al)	$\mu g \cdot L^{-1}$	500		ICP-MS
Total Antimony (Sb)	$\mu g \cdot L^{-1}$	100		ICP-MS

Table 2.2 Water Quality Parameters Measured in the Strait of Belle Isle 2010 (Cont'd)

	Units	RDL	CCME Guideline	Analysis Method
Total Arsenic (As)	$\mu g \cdot L^{-1}$	100	12.5	ICP-MS
Total Barium (Ba)	$\mu g \cdot L^{-1}$	100		ICP-MS
Total Beryllium (Be)	$\mu g \cdot L^{-1}$	100		ICP-MS
Total Bismuth (Bi)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Boron (B)	$\mu g \cdot L^{-1}$	500		ICP-MS
Total Cadmium (Cd)	$\mu g \cdot L^{-1}$	30	0.12	ICP-MS
Total Chromium (Cr)	$\mu g \cdot L^{-1}$	100	56, 1.5[c]	ICP-MS
Total Cobalt (Co)	$\mu g \cdot L^{-1}$	40		ICP-MS
Total Copper (Cu)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Iron (Fe)	$\mu g \cdot L^{-1}$	5000		ICP-MS
Total Lead (Pb)	$\mu g \cdot L^{-1}$	50		ICP-MS
Total Manganese (Mn)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Mercury (Hg)	$\mu g \cdot L^{-1}$	0.013	0.016[b]	CVAA
Total Molybdenum (Mb)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Nickel (Ni)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Selenium (Se)	$\mu g \cdot L^{-1}$	100		ICP-MS
Total Silver (Ag)	$\mu g \cdot L^{-1}$	10		ICP-MS
Total Strontium (Sr)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Thallium (Tl)	$\mu g \cdot L^{-1}$	10		ICP-MS
Total Tin (Sn)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Titanium (Ti)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Uranium (U)	$\mu g \cdot L^{-1}$	10		ICP-MS
Total Vanadium (V)	$\mu g \cdot L^{-1}$	200		ICP-MS
Total Zinc (Zn)	$\mu g \cdot L^{-1}$	500		ICP-MS
Petroleum Hydrocarbons				
Benzene	$mg \cdot L^{-1}$	0.001	0.11	
Toluene	$mg \cdot L^{-1}$	0.001	0.215	
Ethylbenzene	$mg \cdot L^{-1}$	0.001	0.025	
Xylene (Total)	$mg \cdot L^{-1}$	0.002		
C_6 - C_{10} (less BTEX)	$mg \cdot L^{-1}$	0.010		
>C_{10}-C_{16} Hydrocarbons	$mg \cdot L^{-1}$	0.050		
>C_{16}-C_{21} Hydrocarbons	$mg \cdot L^{-1}$	0.050		
>C_{21}-<C_{32} Hydrocarbons	$mg \cdot L^{-1}$	0.100		
Modified TPH (Tier1)	$mg \cdot L^{-1}$	0.100		
Reached Baseline at C_{32}	$mg \cdot L^{-1}$	N/A		

Table 2.2 Water Quality Parameters Measured in the Strait of Belle Isle 2010 (Cont'd)

	Units	RDL	CCME Guideline	Analysis Method
Surrogate Recovery (%)				
Isobutylbenzene - Extractable	%			N/A
n-Dotriacontane - Extractable	%			N/A
Isobutylbenzene - Volatile	%			N/A

Notes:
RDL = Reportable Detection Limit
Results relate only to the items tested.
[a] - CCME Guideline is for direct effects only and does not consider indirect effects from eutrophication
[b] - CCME Guideline is for inorganic mercury only, whereas the concentration reported is for total mercury
[c] - CCME Guideline values are for hexavalent and trivalent chromium, whereas the concentration reported is for total chromium

The purpose of the water sampling program was to characterize spatial patterns in marine water quality for the study area. Appropriate descriptive and summary statistics (minimums, maximums, means and standard deviations) were calculated and presented for each parameter analyzed for the Strait of Belle Isle.

2.7 Sediment Quality

Sediment quality samples were collected from pre-selected locations as described in Section 2.3 and included collection of samples for physical characterization of sediment and chemical and hydrocarbon analyses at an analytical laboratory. Given some of the weather challenges and associated delays encountered during the field program, sample locations for the sediment and benthos sampling were re-evaluated and revised during the course of the field work, as directed by Nalcor Energy, in order to focus efforts on a number of key and core segments of the identified corridors. Sampling stations are provided in Figure 2.5. The methods are detailed in the following sections.

2.7.1 Sample Collection

Initially, sediment samples were to be collected using either a stainless steel Van Veen grab (30 cm by 30 cm, volume of 13.5 L) or a Shipek sediment grab (20 cm by 20 cm, volume of 3 L). Both sampling devices are grab devices that are capable of collecting soft, fine to medium grained material, to a depth of 10 to 20 cm, from shallow to moderate water depth (500 m), and are known to be effective even on a sloping bottom (20° or more). Both samplers are known to be effective in rough sea conditions without premature release of the triggering mechanism (U.S. EPA 2001). After field testing of both devices, the Study Team determined the Van Veen was the more effective sampling grab and also retained the greater volume of sample which was important for the benthic sampling protocol. Subsequently, the Van Veen grab was the primary sampler used for collection of all sediment and benthic samples in this study (Figure 2.6). In some instances where the Van Veen grab was not successful in obtaining a sample the Shipek was also deployed but often without successful retrieval of substrate material.

FIGURE 2.5

Strait of Belle Isle Sediment and Benthic Sampling Locations

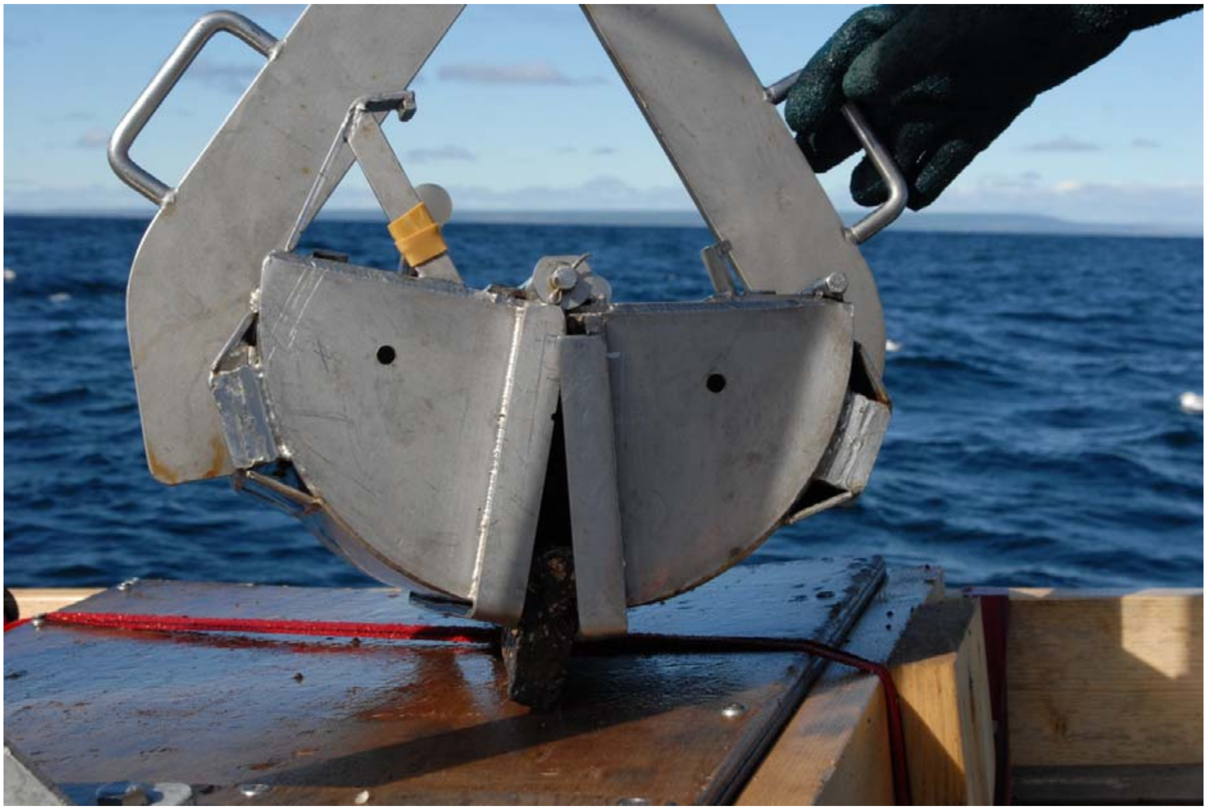

Figure 2.6 Van Veen Sediment Grab with Jaws Held Open by Large Substrate Material

The sampling platform was maintained in position at each sampling station and the Van Veen grab was primed for release and attached to a 0.95 cm new braided rope and Honda hauler system. The grab sampler was lowered over the side of the vessel in a vertical position and allowed to freefall at a set rate to just above (5 m) the ocean bottom, as determined from the vessel's depth sounder. The grab was then maneuvered into a fully vertical position and allowed to freefall into the ocean bottom. Upon contact of the bottom, a trigger weight on the grab caused the sample compartment to close to encapsulate the seabed sediment sample. The depth and geo-position of the sample were then recorded. The sample was retrieved to the surface, the grab opened and examined by the Study Team to determine the integrity of the sample. Assessing sample integrity included ensuring the grab was not open during retrieval, thereby losing sediment, and determining that the sediment-water interface had not been disturbed.

Prior to collecting sub-samples for chemical and physical analyses in the laboratory, the grab was emptied into a 20 liter Rubbermaid™ tub and thoroughly mixed with a stainless steel spoon. Three 500 ml sub-samples, one each for chemical analyses, hydrocarbon analyses, and physical characterization of sediment, were collected in pre-labelled glass jars. After collection, sample jars were retained at 4 °C in insulated coolers with freezer packs and then stored in a refrigerator on shore until they were shipped to the analytical laboratory. Sampling equipment was thoroughly rinsed with sea water between collections.

2.7.2 **Physical Analyses**

Physical characteristics of sediment samples analyzed at the laboratory included classifying the proportion (percent) of sample as gravel, sand, silt and clay, based on the Wentworth (1922) substrate scale, as well as a detailed Particle Size Analysis (PSA) of the silt/clay fraction.

To determine the proportion of sample as gravel, sand, silt and clay, organic matter and carbonates were destroyed by treating it with hydrogen peroxide. Wet sieving (63 micron mesh sieve) was used to separate the gravel and sand fractions. These were subsequently passed through a series of nested sieves to separate the fractions based on particle diameter.

A detailed PSA was determined by pipette analysis. Sample aliquots were extracted by pipette from the sample and dried to constant weight. Stoke's Law was used to determine the diameter of each fraction and quantify it on the Phi Scale. The Phi scale is a logarithmic representation of the Wentworth scale and is computed as follows:

$$\Phi = -\log 2 \text{ (grain size, mm)}$$ (Krumbein 1936).

2.7.3 **Chemical Analyses**

Parameters analyzed in sediment samples are listed in Table 2.3, including analysis methods and reportable detection limits. Metals were determined via Atomic Emission Spectrometry (AES), with the exception of mercury, which was determined using Cold-Vapor Atomic Absorption Spectrometry (CVAA). Total Organic Carbon (TOC) was also determined using Leco furnace methods. Samples were analyzed for 'available' metals. This method targets the biologically available fraction and does not remove metals bound in the lattice framework of the sediment. Available metals are determined using a mild digestion method with a nitric acid solution for digestion. Available metals are reported and discussed as they are considered more biologically relevant for assessing sediment quality.

Sediment samples were also analyzed for Total Petroleum Hydrocarbons (TPH) and included Benzene, Toluene, Ethylbenzene, and Xylene(s) (BTEX), gasoline range organics (C_6 to C_{10}), and analysis of extractable hydrocarbons - diesel (>C_{10} to C_{16}), diesel (>C_{16} to C_{21}) and lube (>C_{21} to C_{32}) range organics. BTEX and gasoline range organics were analyzed by purge and trap-gas chromatography/mass spectrometry or headspace – gas chromatography (MS/flame ionization detectors). Extractable hydrocarbons, including diesel and lube range organics were analyzed using capillary column gas chromatography (flame ionization detector).

Methods of analyses, units of reporting, reportable detection limits, and CCME (2002) Interim Sediment Quality Guideline (ISQG) limits for the Protection of Aquatic Life and Potential Effect Level (PEL) guidelines, where available, are included in the results (Tables 3.9 to 3.12).

Table 2.3 Sediment Quality Parameters Measured in the Strait of Belle Isle 2010

	Units	RDL	ISQG	PEL	Analysis Method
Major Ions					
Available Calcium (Ca)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Magnesium (Mg)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Phosphorous (P)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Potassium (K)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Sodium (Na)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Sulphur (S)	$mg \cdot kg^{-1}$	500			ICP-AES
Metals					
Available Aluminum (Al)	$mg \cdot kg^{-1}$	100			ICP-AES
Available Antimony (Sb)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Arsenic (As)	$mg \cdot kg^{-1}$	20	7.24	41.6	ICP-AES
Available Barium (Ba)	$mg \cdot kg^{-1}$	50			ICP-AES
Available Beryllium (Be)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Bismuth (Bi)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Boron (B)	$mg \cdot kg^{-1}$	50			ICP-AES
Available Cadmium (Cd)	$mg \cdot kg^{-1}$	3	0.7	4.2	ICP-AES
Available Chromium (Cr)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Cobalt (Co)	$mg \cdot kg^{-1}$	10			ICP-AES
Available Copper (Cu)	$mg \cdot kg^{-1}$	20	18.7	108	ICP-AES
Available Iron (Fe)	$mg \cdot kg^{-1}$	500			ICP-AES
Available Lead (Pb)	$mg \cdot kg^{-1}$	5	30.2	112	ICP-AES
Available Lithium (Li)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Manganese (Mn)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Mercury (Hg)	$mg \cdot kg^{-1}$	1	0.13	0.7	CVAA
Available Molybdenum (Mo)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Nickel (Ni)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Rubidium (Rb)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Selenium (Se)	$mg \cdot kg^{-1}$	10			ICP-AES
Available Silver (Ag)	$mg \cdot kg^{-1}$	5			ICP-AES
Available Strontium (Sr)	$mg \cdot kg^{-1}$	50			ICP-AES
Available Thallium (Tl)	$mg \cdot kg^{-1}$	1			ICP-AES
Available Tin (Sn)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Uranium (U)	$mg \cdot kg^{-1}$	1			ICP-AES
Available Vanadium (V)	$mg \cdot kg^{-1}$	20			ICP-AES
Available Zinc (Zn)	$mg \cdot kg^{-1}$	50	124	271	ICP-AES
Organic Carbon					
Organic Carbon (TOC)	$g \cdot kg^{-1}$	0.7			Leco furnace
Inorganics					
Moisture	%	1			

Notes:
RDL = Reportable Detection Limit
ISQG - Interim Marine Sediment Quality Guideline
PEL - Probably Effect Levels
ICP-AES – Inductively Coupled Plasma - Atomic Emission Spectrometry
CVAA - Cold-Vapor Atomic Absorption Spectrometry

2.7.4 Analysis and Interpretation

The purpose of the sediment sampling program was to characterize spatial patterns in marine sediment quality within the study area. Appropriate descriptive and summary statistics (minimums, maximums, means and standard deviations) were calculated and presented for each parameter analyzed.

The CCME has established ISQGs and PELs for the Protection of Aquatic Life in the marine environment (CCME 2002; Table 2.3). The CCME has established ISQGs and PELs for several metals that were analyzed for including arsenic, cadmium, chromium, copper, lead, zinc and mercury (CCME 2002). The data generated during this study have been tabulated and compared with these two sets of sediment quality guidelines in Section 3.2.2.

2.8 Benthic Invertebrates

Benthic invertebrates were collected from the sites selected for sediment sampling and analyzed to determine the benthic community characteristics (Figure 2.5). Given some of the weather challenges and associated delays encountered during the field program, the sample locations for the sediment and benthos sampling were re-evaluated and revised during the course of the field work, as directed by Nalcor Energy, in order to focus on a number of key and core segments of the identified corridors. Detailed methods for the collection and analyses of benthic invertebrate samples are described in the following sections.

2.8.1 Sample Collection

The approach to benthic invertebrate sample collection, including QA/QC principles, was developed from Environment Canada's Pulp and Paper and Metal Mining environmental effects monitoring (EEM) programs (Environment Canada 1998; 2002). These documents detail the sampling equipment to be used, sample collection protocols, sample handling protocols, describe the *a priori* acceptance criteria for samples, detail the methods for field sieving and preservation, and describe the appropriate shipping and storage procedures for samples.

Benthic samples were collected at sediment sampling locations and the method of grab deployment and retrieval were as described in Section 2.7.1, Sample Collection. Upon retrieval, each grab was landed in a sturdy tray or sieving table and examined to determine if the grab was fully intact (i.e., the grab captured all surface material and was closed properly and did not lose material upon retrieval). Any grabs deemed not fully intact were discarded. All intact grabs were examined and then transferred to a 20 L bucket for subsequent processing and field sorting later that evening when back on shore. Rocky samples were field processed by manual removal of attached organisms such as barnacles and anemones and visual checks of the remaining material for heavy components (e.g., clams, gastropods) (Figures 2.7 and 2.8).

Field sorting was conducted using a 30 cm by 60 cm, 500 µm mesh, sieving table which included elutriated with water flow through the sample on the sieving table to suspend organisms that were not readily observable in the sample (Figure 2.9). The samples were lightly washed using a hose and with gentle manipulation by the field technicians so as not to damage any of the benthic organisms. Mud and fine sand were washed directly through the sieve while coarse sand and larger materials were retained on the sieve and visually examined for the presence of organisms. All identified organisms were subsequently transferred to pre-labelled 500 ml sample jars or 18 L sample buckets. The resulting material was field preserved in 10% buffered seawater/formalin.

Figure 2.7 Coarse Sediment Material with Encrusted Benthic Organisms

Figure 2.8 Van Veen Sediment Grab with Shell Substrate Material

Figure 2.9 Field Sorting of Benthic Organisms

All benthic samples were kept cool until shipped to Envirosphere Consultants Limited, Windsor, Nova Scotia who were retained to complete analyses of biological species composition and abundance of the benthic samples. This company has considerable experience with marine benthic sample analyses and has completed most of the benthic identifications for the offshore oil production environmental effects monitoring (EEM) programs in Atlantic Canada.

2.8.2 Laboratory Analyses of Benthic Samples

2.8.2.1 Sieving of Whole Sediments

Within a week to ten days of receipt of samples, all samples were washed to remove any residual formalin and then transferred to 70% isopropanol.

2.8.2.2 Sorting and Identification

Field samples were initially washed over a 500 µm mesh screen to remove fine debris and excess preservative. Processing involved sorting and/or removing organisms from samples at 6.4 to 10x magnification, with a final brief check at 16x, on a stereomicroscope. Sorting efficiency was checked by resorting 10% of samples to ensure sorting efficiencies of 95% or better. Organisms were removed from the sample debris using fine forceps, transferred to a separate container, and re-preserved (70% ethanol). Wet weight biomass (g/sample) was estimated by weighing organisms at the time of sorting to the nearest milligram after blotting to remove surface water. Species abundance and number of taxa were also determined for each sample. Larger samples were sub-sampled because of time constraints, and for sub-samples the volume of sediment processed relative to the total volume of sediment in the various containers from the station was estimated and noted.

Organisms were sorted and identified to the lowest practical taxonomic level (LPL), typically genus or species, using current literature (general and regional keys) for the groups involved (see Section 5.1) and enumerated. Organisms were identified by experienced taxonomic experts with Envirosphere Consultants Limited. Several small types of organisms collectively known as meiofauna (e.g., nematodes worms and harpacticoid copepods) were not included in abundance estimates because they are not sampled quantitatively by the 500 µm sieve. Polychaete worms in several groups which contained a range of species which are typically small and numerous in the samples (e.g., Ampharetidae, Syllidae, Sabellidae) were identified to the family level only. Species abundance, number of species and wet weight biomass were estimated from the data. The data were entered into a spreadsheet in the form of a species by sample matrix and all entries were double-checked to ensure accuracy of data transcription. Principles employed in the sample analysis followed environmental monitoring protocols for benthic analysis in national Pulp and Paper and environmental effects monitoring (EEM) programs (Environment Canada 1998) and the Metal Mining EEM Guidance Document (Environment Canada 2002).

A reference collection has been developed and archived for future use.

2.8.3 **Data Analyses and Interpretation**

All of the descriptors used to describe the results of the benthic sample analyses were determined from equations and methods provided in Environment Canada’s Metal Mining EEM Guidance Document (Environment Canada 2002) and references within. The selected benthic community indicators also followed recommendations in Costello et al. (2001) which identified suitable approaches for characterizing benthic biodiversity in marine environmental assessments for the Canadian Environmental Assessment Agency (CEAA). The selected descriptors included:

- total abundance;
- biomass;
- taxonomic richness; and
- diversity indices including:
  - (i)Shannon-Wiener Diversity;
  - (ii) Pielou’s Evenness;
  - (iii) McIntosh’s Index;
  - (iv) Simpson’s Index; and
  - (v) Margalef’s Index.

Species diversity was estimated by the *Shannon-Wiener Index (H')* (Pielou 1974). The Shannon-Wiener Diversity index is widely used in ecology and represents both the number of species and distribution among individuals, with higher numbers of species generally resulting in increased values and high values of single species resulting in low diversity measures. The Shannon-Wiener index is defined as:

$$H' = -\sum(p_i \times \log_{10} p_i)$$

where *p* is the probability that an individual belongs to species *i*. *p* is the proportion of individuals in the *i*th species to the total number of individuals in the sample.

Pielou's Evenness Index (J') (Pielou 1974) was used to express equitability of distribution of individuals among species. It is defined as:

$$J' = H' / \log_{10} S$$

where S is the total number of species present.

McIntosh's Index measures evenness (a measure of whether the species are present in about the same numbers or whether single species dominate) and the value falls in a range of from zero to one, reaching a maximum if all individuals are present in perfectly equal numbers (Legendre and Legendre 1983). It is defined as:

$$M = \frac{N - \sqrt{(\sum n_i^2)}}{N - \sqrt{N}}$$

where N is the total number of organisms in the sample, and n_i is the abundance of each species.

Simpson's Index of diversity measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). *Simpson's Index* (P) measures dominance and is higher when a few species make up a large proportion of the individuals in a sample, i.e., the greater the value, the greater the diversity. It is defined as:

$$P = \sum p_1^2$$

where p_i = proportion of the number of individuals of a given species to the total number of individuals in the sample ($p_i = n_i/N$).

Margalef's Index (R) measures species richness (number of species per individual) and so is generally higher when more species are present, although it can be reduced for a given number of species if single species are present in high abundance. It is defined as:

$$R = \frac{S - 1}{\ln N}$$

where S is the total number of species and N is the total number of organisms in the sample.

2.9 Quality Management

The Study Team developed a Quality Management System which was implemented in the field study components as well as during the analyses of data and preparation of the final reports. Quality is achieved through the use of skilled personnel, adequate planning, use of suitable tools and procedures, proper definition of job requirements, proper supervision and effective technical direction. This section outlines the specific QA/QC techniques utilized by the Study Team during this study.

2.9.1 **Field Quality Assurance/Quality Control**

The following control procedures were implemented by Study Team personnel during field sample collection in 2010:

- Standard Operating Procedures (SOPs) were developed for key study components and were present with field crews at all times, and samples were collected accordingly;
- All major study components had key personnel designated as lead responsibility and these individuals ensured that SOPs were being followed;
- Regular meetings of field team members were held to review study progress, assess methodologies and sample collection efforts, discuss any health and safety issues, and to set and revise priorities in relation to accomplishments and field conditions;
- All personnel involved in field procedures had appropriate education, training, and experience;
- Sampling methodologies were consistently applied among sites throughout the study area;
- Sampling equipment was appropriate for the habitat/study component being studied, properly cleaned, and properly calibrated;
- All samples were collected in the proper container with the appropriate preservative and/or fixative added;
- Field personnel maintained detailed notes in appropriate field notebooks;
- All data were transcribed from field note books and field data sheets into a digital format (spreadsheet), and duplicated onto separate digital media, on a frequent basis (nightly when possible). Study component leads were responsible to ensure data integrity;
- All sample movements/shipments were recorded on detailed CoC forms; and
- QA/QC stations were randomly selected prior to sampling, and represented approximately 10% of all samples collected.

2.9.2 **Laboratory Quality Assurance/Quality Control**

Samples were given randomly assigned numbers and submitted ‘blind’ to the respective laboratory. Water and sediment samples were sent to Maxxam Analytics in Bedford, Nova Scotia, while benthic samples were sent to Envirosphere in Windsor, Nova Scotia.

Maxxam Analytics implemented a rigorous internal QA/QC program. This entailed:

- laboratory duplicates (10%);
- laboratory internal spikes;
- analyses of certified reference material (sediment only); and
- analyses of method blanks.

The results of the laboratory's internal QA/QC procedures for water and sediment analysis were reported with analytical results in Appendix A.

The QA/QC followed by Envirosphere for processing of benthic invertebrate sampling in the laboratory included:

- 10% replication of any sub-sampling procedures;
- re-sorting of randomly selected samples;
- use of appropriate regional and recent identification keys;
- preparation of a reference collection;
- archiving of samples; and
- maintaining detailed notes of sample processing.

2.9.3 **Report Preparation Quality Assurance/Quality Control**

The draft and final reports were reviewed by senior staff within Sikumiut prior to submission to Nalcor Energy.

3.0 RESULTS

The results of the 2010 Marine Water, Sediment and Benthic Surveys within the proposed Strait of Belle Isle submarine cable crossing corridors are presented and summarized below. The results and discussion are largely descriptive in nature and the results are compared with available water, sediment, and benthos data for the study area as summarized in Sikumiut (2010). Where appropriate, comparisons with relevant guidelines are made.

3.1 Water Quality

Water quality was determined at 15 pre-selected sites along the proposed submarine cable crossing corridors in the Strait of Belle Isle. Water quality included measurement of selected parameters in the field, chemical and hydrocarbon analyses at an analytical laboratory and determination of conductivity and temperature profiles, with depth.

3.1.1 Conductivity, Temperature, and Depth Profiles

CTD profiles were collected with a Sea-Bird Electronics SEACAT SBE-19 CTD meter at 15 pre-selected water quality stations in the Strait of Belle Isle. The CTD profiles are illustrated in Figure 3.1 (Stations W-001 to W-015) and data summarized in Table 3.1. After reviewing the CTD data from station W-008 it was determined there was an equipment malfunction during collection of these data and they have not been reported. In two instances the depth of the CTD cast was slightly deeper than the maximum depth of the water quality station as determined by the depth sounder on the boat. This may reflect the relative accuracies of the two measurements or that the position of the sampling platform may have moved slightly during the CTD cast.

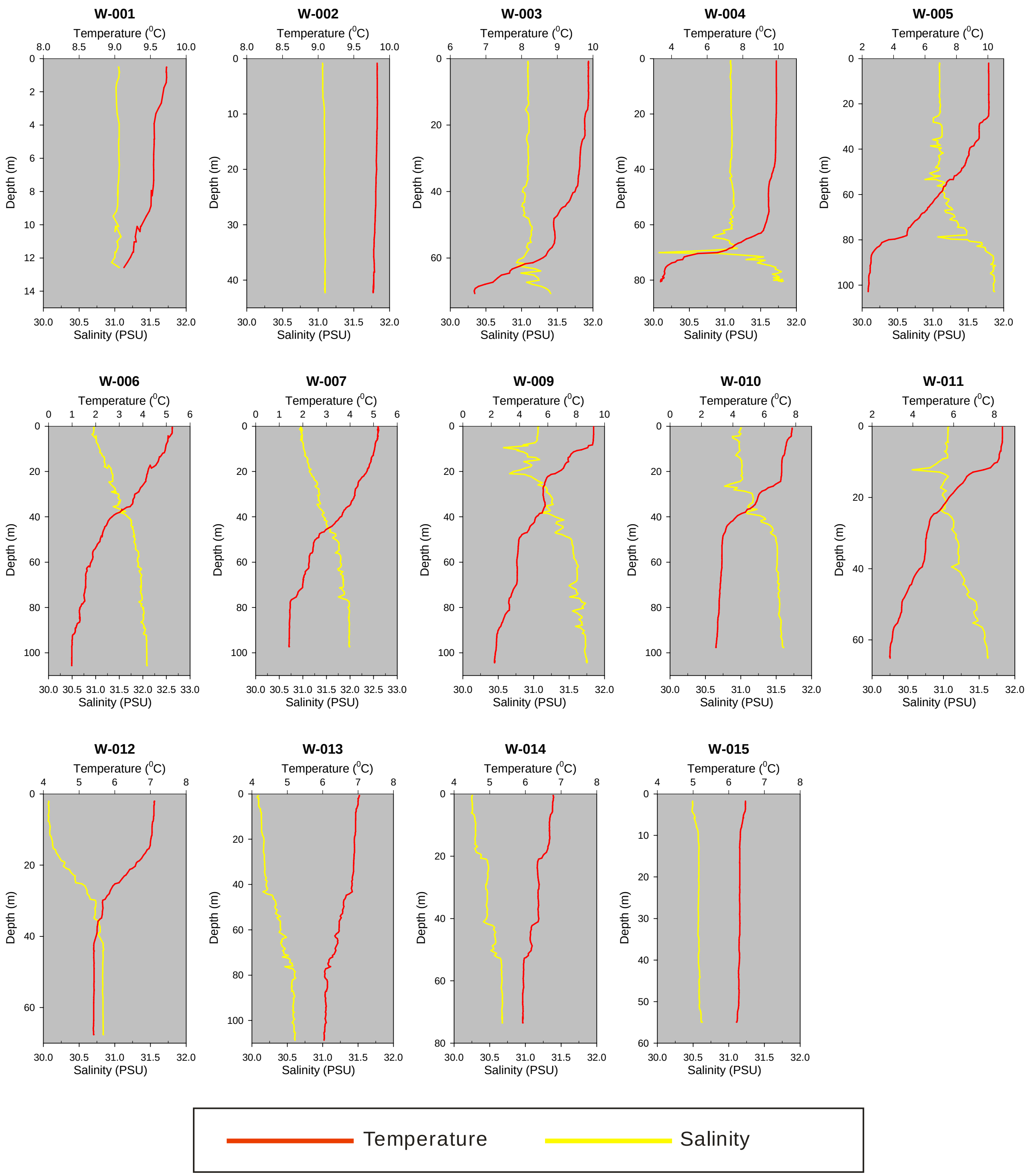

Figure 3.1 Salinity, Temperature, and Depth Profiles for Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

Table 3.1 Summary of CTD Data Collected from the Proposed Strait of Belle Isle Submarine Cable Corridors

Station	Maximum Depth (m)	Depth of CTD Cast (m)	Min. Temp. (°C)	Max. Temp. (°C)	Temperature Difference (C°)	Salinity Difference (PSU[1])	Approx. Depth of Thermocline (m)
W-001	13.9	12.6	9.13	9.73	0.60	0.13	none
W-002	40	42.3	9.77	9.83	0.06	0.04	none
W-003	76	70.7	6.67	9.88	3.21	0.48	40 to 50
W-004	91	80.6	3.39	9.89	6.50	1.74	60 to 75
W-005	108	100.8	2.38	10.06	7.68	0.99	75 to 85
W-006	121	105.1	0.99	5.25	4.26	1.16	No clear thermocline
W-007	115	97.1	1.41	5.20	3.79	1.06	No clear thermocline
W-009	109	104.2	2.24	9.23	6.99	1.18	10 to 20, 35 to 45
W-010	103	96.8	2.92	7.77	4.85	0.83	25 to 45
W-011	70	64.9	2.87	8.40	5.53	1.06	10 to 25
W-012	65	65.6	5.40	7.11	1.71	0.80	15 to 25
W-013	115	107.9	6.04	7.03	0.99	0.54	none
W-014	86	73.0	5.92	6.79	0.87	0.44	none
W-015	55	53.2	6.22	6.47	0.25	0.14	none

Note[1]: PSU = Practical Salinity Units

Stations W-001 and W-002, on the Newfoundland side of the Straits, were relatively shallow at 13.9 and 40 m depth, respectively, and had no thermocline with very little temperature difference from top to bottom. Thermoclines were apparent at stations W-003, W-004 and W-005, which were deeper at 76, 91, and 108 m, respectively. Temperature differences for stations W-003, W-004 and W-005 were 3.21, 6.50, 7.68 C°, respectively, and depth of thermocline were 40 to 50 m, 60 to 75 m, and 75 to 85 m, respectively, with the depth of thermocline becoming progressively deeper as the station depth increased. Stations W-006 and W-007, with depths of 121 and 115 m, respectively, demonstrated temperature differences of 4.26 and 3.79 C°, respectively. The temperature change at these stations was more gradual with no clear sharp temperature gradient and hence no clear depth of thermocline. Station W-009 at 109 m depth had a large temperature change of 6.99 C° and appeared to have two thermoclines at depths from 10 to 20 m and again from 35 to 45 m. Stations W-010, W-011, and W-012 with depths of 103, 70, and 65 m, respectively, had temperature differences of 4.85, 5.53 and 1.71 C°, respectively. Station W-010 had a thermocline at 25 to 45 m while stations W-011 and W-012 had shallower thermoclines at 10 to 25 m and 15 to 25 m, respectively. Stations W-013, W-14, and W-015, located closest to the Labrador side of the Strait of Belle Isle had depths of 115, 86, and 55 m, respectively. The temperature difference at stations W-013, W-014, and W-015 were 1.00, 0.87, and 0.25 C°, respectively, and no thermocline was apparent at these stations. There was an equipment malfunction during the CTD profiling at Station W-008 therefore no data has been presented for this site.

Water samples were collected at these 15 sampling stations (W-001 through W-015) with samples taken at each of three depths representing near surface, near bottom, and within a thermocline or halocline, if one existed, or mid water depth if no thermocline/halocline was present. At station W-001, only two samples were collected due to the shallow depth of the station (at 2 and 10 m).

A total of 44 water samples were collected during the 2010 marine surveys. In addition, five duplicate QA/QC samples were also collected, identified B-001 through B-005, and corresponded to the sample stations W-001 through W-005, respectively (Table 3.1; Figure 2.2). The detailed results of the analysis of these samples are contained in Appendix A. Sampling depths, timing and locations (in UTMs, Zone 21) of the sampling sites are listed in Table 3.2.

Table 3.2 Summary of Date and Location of Water Sampling in the Strait of Belle Isle Cable Corridor Marine Surveys 2010

Date	Station ID	Location (see Figure 2.2)		Water Depth (m)	Sampling Depths (m)		
		Easting	Northing		A (near surface)	B (mid)	C (near bottom)
29-Sept-10	W-001	518611	5686273	13.9	2	N/A	12
29-Sept-10	W-002	516824	5686768	40	2	20	40
29-Sept-10	W-003	517401	5689105	76	2	40	70
29-Sept-10	W-004	515256	5688830	91	2	50	75
29-Sept-10	W-005	515146	5691553	108	2	50	100
26-Sept-10	W-006	510939	5688473	121	2	45	100
26-Sept-10	W-007	510884	5690480	115	2	45	85
26-Sept-10	W-008	509812	5693203	88	2	40	80
30-Sept-10	W-009	508024	5690150	109	2	35	85
30-Sept-10	W-010	504367	5690425	103	2	30	85
30-Sept-10	W-011	505797	5693643	70	2	30	65
26-Sept-10	W-012	509537	5696475	65	2	25	60
26-Sept-10	W-013	506732	5696750	115	1	50	100
26-Sept-10	W-014	504477	5696778	86	2	40	70
26-Sept-10	W-015	508134	5701095	55	1	25	50

3.1.2 Field Water Quality

Field water quality measurements were taken at all sampling stations. Field measurements were taken from the samples collected at or near the surface. Table 3.3 presents the field water quality measurements for all stations sampled (Figure 2.2). Field water quality results were generally comparable between sites, with temperatures demonstrating some variability between sites, ranging from 5.99 to 10.91 ˚C. Conductivity values ranged from 4.72 to 4.87 $S \cdot m^{-1}$, which are near typical of seawater (Garrison 2010). Values for pH were alkaline ranging from 7.89 to 8.15. Dissolved oxygen values ranged between 9.64 to 11.51 $mg \cdot L^{-1}$ and were supersaturated (102.3 to 114.9% saturation). An oxygen reduction potential (ORP) value, which is an indication of the ability to break down contaminants, ranged from 73.4 to 112.0 mV.

Table 3.3 Results of Field Water Quality Measurements for Samples Collected in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

Sampling Station	**Depth** (m)	**Temperature** °C	**Conductivity** ($S \cdot m^{-1}$)	**pH**	**DO** ($mg \cdot L^{-1}$)	**DO** (% sat)	**ORP** (mV)
W-001	2	9.92	4.81	8.04	9.64	104	73.4
W-002	2	9.56	4.78	8.15	9.87	105.5	88.8
W-003	2	9.79	4.74	8.13	9.78	105	89.3
W-004	2	10.48	4.79	8.03	9.66	105.4	87.2
W-005	2	10.91	4.83	7.91	9.73	107.4	78
W-006	2	5.99	4.84	8.13	11.5	114.9	101.4
W-007	2	6.29	4.87	8.12	11.51	114.7	102.7
W-008	2	6.71	4.82	8.08	11.28	113.3	98.7
W-009	2	8.48	4.74	8.05	9.82	102.3	97.8
W-010	2	8.20	4.80	7.99	10.31	106.7	105.1
W-011	2	9.02	4.79	7.89	10.03	106	108
W-012	2	8.77	4.72	8.08	10.88	114.2	102.4
W-013	1	8.79	4.77	8.06	10.88	114.2	103
W-014	2	7.89	4.75	8.10	11.13	114.3	106.7
W-015	1	8.13	4.74	8.07	11.00	112.3	112

3.1.3 **Laboratory Water Quality**

Results of water quality analysis for conventional parameters, nutrients, major ions, and metals are presented in Table 3.4, while summary statistics were calculated and include all depths and stations, and are presented in Table 3.5. Results of analysis for petroleum hydrocarbons are presented in Table 3.6, while summary statistics were calculated and include all depths and stations, and are presented in Table 3.7. Although water samples were collected from different depths, noticeable differences were not evident between depths at each sampling station. Detailed results of laboratory water analysis are presented in Appendix A including sample duplicates and laboratory QA/QC data. Note that in several cases the reportable detection limit (RDL) for some trace elements was elevated due to the sample matrix. This was apparent for total phosphorous where the detection limit is two orders of magnitude larger in some cases (Table 3.4). This was noted and outlined in each table when necessary.

Conventional parameters were similar between all sampling stations and at all depths. Values for pH were alkaline and ranged from 7.78 to 7.91 with an average of 7.85 which is well within the CCME guidelines. Very few nutrients were detected in the samples, with orthophosphate (n=30) detected in the most samples and nitrate (n=7) and total phosphorous (n=12) detected in a few samples, all at low levels. Metals in samples were also low, with only boron and strontium detected in all samples, while most metals were not detected in any samples including aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, silver, thallium, tin, titanium, uranium, vanadium and zinc. Mercury and lead were detected in two samples each, while selenium was detected in only one sample. CCME Water Quality Guidelines for the Protection of Aquatic Life (2002) were not exceeded for any parameters tested.

For petroleum hydrocarbons, only toluene was detectable in any of the samples tested (n=33) although levels were well within the CCME water quality guideline of 0.215 $mg \cdot L^{-1}$. All other hydrocarbons were below the reportable detection limit.

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals

				W-001		W-002			W-003			W-004			W-005			W-006		
	Units	**RDL**	**CCME Guideline**	**A**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Conventional Parameters																				
pH	pH	N/A	7.0 - 8.7	7.80	7.84	7.87	7.87	7.87	7.85	7.83	7.83	7.87	7.86	7.83	7.78	7.80	7.84	7.88	7.84	7.83
Total Alkalinity (Total as $CaCO_3$)	mg·L^{-1}	5		95	95	94	93	95	95	93	94	95	95	95	95	95	95	97	98	97
Hardness ($CaCO_3$)	mg·L^{-1}	1		5100	5500	5300	5500	5300	5400	5600	5500	5400	5200	5400	5200	5600	5500	5300	5400	5200
Turbidity	NTU	0.1		0.3	0.2	ND	0.2	0.3	0.4	0.2	0.3	0.4	0.3	0.3	0.4	0.2	ND	ND	0.4	0.1
Conductivity	µS·cm^{-1}	1		43000	43000	42000	42000	42000	42000	42000	42000	41000	42000	42000	43000	42000	42000	40000	41000	42000
Total Suspended Solids (TSS)	mg·L^{-1}	1[a]		1	1	ND	1	ND*	ND	ND	1	ND	1	2	1	1	ND*	1	2	1
Calculated TDS	mg·L^{-1}	1		31200	31600	31400	31900	31500	31800	31100	31600	31100	31100	30700	30600	31000	31000	31900	32500	32500
Colour	TCU	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon (C)	mg·L^{-1}	5[b]		ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND	ND	ND
Reactive Silica (SiO_2)	mg·L^{-1}	0.5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients																				
Nitrate + Nitrite	mg·L^{-1}	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.06	0.08
Nitrite (N)	mg·L^{-1}	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	mg·L^{-1}	0.05	16[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.06	0.08
Nitrogen (Ammonia Nitrogen)	mg·L^{-1}	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Phosphorous (P)	µg·L^{-1}	100[d]		ND**	ND**	ND**	ND**	ND**	11000**	ND**	10000**	ND**	ND**	ND**	ND**	ND**	ND**	199	135	129
Orthophosphate (P)	mg·L^{-1}	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND	0.01	0.01	0.02	0.02
Major Ions																				
Total Calcium (Ca)	mg·L^{-1}	10		397	407	395	408	405	393	385	396	391	385	383	378	389	396	372	370	362
Total Magnesium (Mg)	mg·L^{-1}	10		1000	1080	1050	1090	1050	1080	1120	1090	1080	1040	1070	1040	1110	1100	1060	1080	1030
Total Sodium (Na)	mg·L^{-1}	0.1[e]		10100*	10200*	10000*	10300*	10100*	10200*	9860*	10300*	9890*	9910*	9620*	9540*	9670*	9830*	10300	10500	10300
Total Potassium (K)	mg·L^{-1}	0.1[f]		360**	365**	358**	370**	357**	364**	353**	363**	360**	351**	345**	343**	345**	356**	366	379	370
Dissolved Chloride (Cl)	mg·L^{-1}	300		17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	18000	18000
Dissolved Sulphate (SO_4)	mg·L^{-1}	50[g]		2400	2400	2300	2500	2400	2400	2400	2400	2300	2400	2400	2400	2400	2400	2400	2400	2400

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals (Cont'd)

				W-001		W-002			W-003			W-004			W-005			W-006		
	Units	**RDL**	**CCME Guideline**	**A**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Metals																				
Total Mercury (Hg)	$\mu g \cdot L^{-1}$	0.013	0.016[h]	ND	ND	ND	ND	ND	0.019	ND	ND	ND	ND	ND	ND	0.014	ND	ND	ND	ND
Total Aluminum (Al)	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Antimony (Sb)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Arsenic (As)	$\mu g \cdot L^{-1}$	100	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Barium (Ba)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Beryllium (Be)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Bismuth (Bi)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Boron (B)	$\mu g \cdot L^{-1}$	500		3480	4150	4000	4370	3910	4160	3820	3580	3370	3340	3300	3140	3630	3470	3260	4530	4230
Total Cadmium (Cd)	$\mu g \cdot L^{-1}$	1.7[i]	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr)	$\mu g \cdot L^{-1}$	100	56, 1.5[j]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Cobalt (Co)	$\mu g \cdot L^{-1}$	40		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Copper (Cu)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Iron (Fe)	$\mu g \cdot L^{-1}$	5000		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Lead (Pb)	$\mu g \cdot L^{-1}$	50		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Molybdenum (Mo)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Nickel (Ni)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Selenium (Se)	$\mu g \cdot L^{-1}$	100[k]		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND*	ND*	ND*
Total Silver (Ag)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Strontium (Sr)	$\mu g \cdot L^{-1}$	200		7000	7190	6840	7180	6830	6910	6820	6800	6560	6590	6570	6350	6790	6780	6430	6550	6510
Total Thallium (Tl)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Tin (Sn)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Titanium (Ti)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Uranium (U)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Vanadium (V)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Zinc (Zn)	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

ND = Not detected

RDL = Reportable Detection Limit

[a] –Those values marked with an asterisk (*) have elevated RDL for TSS due to sample matrix (RDL = 2 $mg \cdot L^{-1}$)

[b] – Those values marked with an asterisk (*) have elevated RDL due to sample matrix. Sample pre-dilution required.

[c] – CCME Guideline is for direct effects only and does not consider indirect effects from eutrophication

[d] – Those values marked with an asterisk (*) have elevated RDL for Total Phosphorous (P) due to sample matrix (RDL = 1,000 $\mu g \cdot L^{-1}$); those values marked with a double asterisk (**) have elevated RDL of 10,000 $\mu g \cdot L^{-1}$.

[e] – Those values marked with an asterisk (*) have elevated RDL for Total Sodium (Na) due to sample matrix (RDL = 10 $mg \cdot L^{-1}$)

[f] – Those values marked with an asterisk (*) have elevated RDL for Total Potassium (K) due to sample matrix (RDL = 1 $mg \cdot L^{-1}$); those values marked with a double asterisk (**) have elevated RDL of 10 $mg \cdot L^{-1}$

[g] – Those values marked with an asterisk (*) have elevated RDL for Dissolved Sulphate (SO_4) due to sample matrix (RDL = 100$mg \cdot L^{-1}$)

[h] – CCME Guideline is for inorganic mercury only, whereas the concentration reported is for total mercury

[i] – RDL for Total Cadmium (Cd) is elevated due to sample matrix (RDL = 30 $\mu g \cdot L^{-1}$)

[j] – CCME Guideline values are for hexavalent and trivalent chromium, whereas the concentration reported is for total chromium

[k] – Those values marked with an asterisk (*) have elevated RDL for Total Selenium (Se) due to sample matrix (RDL = 200 $\mu g \cdot L^{-1}$)

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals (Cont'd)

				W-007			W-008			W-009			W-010			W-011		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Conventional Parameters																		
pH	pH	N/A	7.0 - 8.7	7.89	7.85	7.83	7.90	7.89	7.82	7.85	7.80	7.78	7.86	7.84	7.79	7.84	7.80	7.79
Total Alkalinity (Total as $CaCO_3$)	$mg \cdot L^{-1}$	5		97	95	100	96	97	96	94	94	97	94	94	95	94	95	95
Hardness ($CaCO_3$)	$mg \cdot L^{-1}$	1		5000	5000	5300	4900	5000	5000	5600	5500	5400	5200	5300	5600	5800	5400	5600
Turbidity	NTU	0.1		0.3	0.2	0.3	0.2	0.5	0.3	ND	ND	ND	ND	ND	ND	0.4	0.1	0.3
Conductivity	$\mu S \cdot cm^{-1}$	1		41000	41000	42000	41000	41000	42000	42000	43000	43000	42000	42000	43000	42000	43000	43000
Total Suspended Solids (TSS)	$mg \cdot L^{-1}$	1[a]		2	2	2	2	1	ND	1	1	2	ND	1	1	3	8	ND
Calculated TDS	$mg \cdot L^{-1}$	1		32000	32500	33300	31700	31700	31800	31600	31300	32200	31100	31300	31900	31300	30700	31800
Colour	TCU	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon (C)	$mg \cdot L^{-1}$	5[b]		ND	ND	ND	ND	ND	ND	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*
Reactive Silica (SiO_2)	$mg \cdot L^{-1}$	0.5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients																		
Nitrate + Nitrite	$mg \cdot L^{-1}$	0.05		ND	ND	0.07	ND	ND	ND	ND	ND	0.07	ND	0.05	ND	ND	0.05	0.06
Nitrite (N)	$mg \cdot L^{-1}$	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	$mg \cdot L^{-1}$	0.05	16[c]	ND	ND	0.07	ND	ND	ND	ND	ND	0.07	ND	0.05	ND	ND	0.05	0.06
Nitrogen (Ammonia Nitrogen)	$mg \cdot L^{-1}$	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Phosphorous (P)	$\mu g \cdot L^{-1}$	100[d]		ND	181	148	ND	ND	144	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*
Orthophosphate (P)	$mg \cdot L^{-1}$	0.01		0.01	0.02	0.02	0.01	0.01	0.01	ND	0.01	0.02	ND	0.01	0.01	0.01	0.01	0.02
Major Ions																		
Total Calcium (Ca)	$mg \cdot L^{-1}$	10		349	347	375	344	345	351	405	391	387	380	378	397	406	393	407
Total Magnesium (Mg)	$mg \cdot L^{-1}$	10		1010	1010	1050	989	998	993	1120	1100	1080	1040	1050	1120	1170	1080	1110
Total Sodium (Na)	$mg \cdot L^{-1}$	0.1[e]		10200	10400	10800	10100	10100	10300	10100*	10000*	10300*	10000*	9970*	10200*	10200*	9260*	10500*
Total Potassium (K)	$mg \cdot L^{-1}$	0.1[f]		367	379	405	363	363	368	349*	343*	362*	345*	352*	357*	352*	347*	355*
Dissolved Chloride (Cl)	$mg \cdot L^{-1}$	300		18000	18000	18000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000
Dissolved Sulphate (SO_4)	$mg \cdot L^{-1}$	50[g]		2500	2500	2400	2400	2400	2400	2500	2400	2500	2400	2500*	2600*	2400	2300	2400

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals (Cont'd)

				W-007			W-008			W-009			W-010			W-011		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Metals																		
Total Mercury (Hg)	µg·L^{-1}	0.013	0.016[h]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Aluminum (Al)	µg·L^{-1}	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Antimony (Sb)	µg·L^{-1}	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Arsenic (As)	µg·L^{-1}	100	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Barium (Ba)	µg·L^{-1}	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Beryllium (Be)	µg·L^{-1}	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Bismuth (Bi)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Boron (B)	µg·L^{-1}	500		4980	3460	4800	4470	4630	3250	3990	3980	3670	3740	3940	4340	3710	3840	4090
Total Cadmium (Cd)	µg·L^{-1}	1.7[i]	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr)	µg·L^{-1}	100	56, 1.5[j]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Cobalt (Co)	µg·L^{-1}	40		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Copper (Cu)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Iron (Fe)	µg·L^{-1}	5000		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Lead (Pb)	µg·L^{-1}	50		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Molybdenum (Mo)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Nickel (Ni)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Selenium (Se)	µg·L^{-1}	100[k]		ND*	ND*	ND*	ND*	ND*	ND*	ND	ND	ND	ND*	ND*	ND	ND*	ND*	ND*
Total Silver (Ag)	µg·L^{-1}	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Strontium (Sr)	µg·L^{-1}	200		6520	6650	6710	6450	6400	6490	6990	6740	6690	6540	6550	6960	6990	6730	6930
Total Thallium (Tl)	µg·L^{-1}	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Tin (Sn)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Titanium (Ti)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Uranium (U)	µg·L^{-1}	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Vanadium (V)	µg·L^{-1}	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Zinc (Zn)	µg·L^{-1}	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes

ND = Not detected

RDL = Reportable Detection Limit

[a] –Those values marked with an asterisk (*) have elevated RDL for TSS due to sample matrix (RDL = 2 mg·L^{-1})

[b] – Those values marked with an asterisk (*) have elevated RDL due to sample matrix. Sample pre-dilution required.

[c] – CCME Guideline is for direct effects only and does not consider indirect effects from eutrophication

[d] – Those values marked with an asterisk (*) have elevated RDL for Total Phosphorous (P) due to sample matrix (RDL = 1,000 µg·L^{-1}); those values marked with a double asterisk (**) have elevated RDL of 10,000 µg·L^{-1}.

[e] – Those values marked with an asterisk (*) have elevated RDL for Total Sodium (Na) due to sample matrix (RDL = 10 mg·L^{-1})

[f] – Those values marked with an asterisk (*) have elevated RDL for Total Potassium (K) due to sample matrix (RDL = 1 mg·L^{-1}); those values marked with a double asterisk (**) have elevated RDL of 10 mg·L^{-1}

[g] – Those values marked with an asterisk (*) have elevated RDL for Dissolved Sulphate (SO_4) due to sample matrix (RDL = 100mg·L^{-1})

[h] – CCME Guideline is for inorganic mercury only, whereas the concentration reported is for total mercury

[i] – RDL for Total Cadmium (Cd) is elevated due to sample matrix (RDL = 30 µg·L^{-1})

[j] – CCME Guideline values are for hexavalent and trivalent chromium, whereas the concentration reported is for total chromium

[k] – Those values marked with an asterisk (*) have elevated RDL for Total Selenium (Se) due to sample matrix (RDL = 200 µg·L^{-1})

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals (Cont'd)

				W-012			W-013			W-014			W-015		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Conventional Parameters															
pH	pH	N/A	7.0 - 8.7	7.89	7.88	7.89	7.89	7.91	7.86	7.86	7.87	7.87	7.88	7.88	7.86
Total Alkalinity (Total as $CaCO_3$)	$mg{\cdot}L^{-1}$	5		95	99	98	95	96	96	94	95	97	96	97	97
Hardness ($CaCO_3$)	$mg{\cdot}L^{-1}$	1		4800	4900	5200	4900	4700	5000	5700	5600	5500	5600	5900	5600
Turbidity	NTU	0.1		0.3	0.2	0.1	0.2	ND	0.1	ND	0.1	0.2	0.1	0.2	0.2
Conductivity	$\mu S{\cdot}cm^{-1}$	1		39000	40000	40000	39000	41000	40000	40000	40000	40000	40000	40000	40000
Total Suspended Solids (TSS)	$mg{\cdot}L^{-1}$	1[a]		1	1	1	2	2	1	ND	2	3	2	2	1
Calculated TDS	$mg{\cdot}L^{-1}$	1		30900	31600	32200	31100	31100	31200	31800	31500	31500	31400	32000	31700
Colour	TCU	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon (C)	$mg{\cdot}L^{-1}$	5[b]		ND	ND	ND	ND	ND	ND	ND*	ND*	ND*	ND*	ND*	ND*
Reactive Silica (SiO_2)	$mg{\cdot}L^{-1}$	0.5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients															
Nitrate + Nitrite	$mg{\cdot}L^{-1}$	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrite (N)	$mg{\cdot}L^{-1}$	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	$mg{\cdot}L^{-1}$	0.05	16[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	$mg{\cdot}L^{-1}$	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Phosphorous (P)	$\mu g{\cdot}L^{-1}$	100[d]		ND	148	ND	162	247	ND	ND**	ND**	ND**	ND**	8900	ND**
Orthophosphate (P)	$mg{\cdot}L^{-1}$	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Major Ions															
Total Calcium (Ca)	$mg{\cdot}L^{-1}$	10		344	352	364	352	337	350	402	410	404	397	424	409
Total Magnesium (Mg)	$mg{\cdot}L^{-1}$	10		950	973	1050	981	946	1010	1150	1100	1090	1130	1170	1120
Total Sodium (Na)	$mg{\cdot}L^{-1}$	0.1[e]		9820	10000	10400	9970	9900	9890	10000*	9890	10100	9910	10400	10100
Total Potassium (K)	$mg{\cdot}L^{-1}$	0.1[f]		343*	345*	371	353	355	354	363**	359**	366**	351**	376	372**
Dissolved Chloride (Cl)	$mg{\cdot}L^{-1}$	300		17000	18000	18000	17000	17000	17000	17000	17000	17000	17000	17000	17000
Dissolved Sulphate (SO_4)	$mg{\cdot}L^{-1}$	50[g]		2300	2300	2300	2400	2400	2400	2400	2400	2400	2400	2400	2400

Table 3.4 Results for Analysis of Water Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Conventional Parameters, Nutrients, Major Ions and Metals (Cont'd)

				W-012			W-013			W-014			W-015		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Metals															
Total Mercury (Hg)	$\mu g \cdot L^{-1}$	0.013	0.016[h]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Aluminum (Al)	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Antimony (Sb)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Arsenic (As)	$\mu g \cdot L^{-1}$	100	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Barium (Ba)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Beryllium (Be)	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Bismuth (Bi)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Boron (B)	$\mu g \cdot L^{-1}$	500		3780	3180	4950	3870	3660	4330	3840	3940	3810	3800	3990	3840
Total Cadmium (Cd)	$\mu g \cdot L^{-1}$	1.7[i]	0.12	ND	ND	ND	ND	ND	ND	ND*	ND	ND	ND*	ND*	ND*
Total Chromium (Cr)	$\mu g \cdot L^{-1}$	100	56, 1.5[j]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Cobalt (Co)	$\mu g \cdot L^{-1}$	40		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Copper (Cu)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Iron (Fe)	$\mu g \cdot L^{-1}$	5000		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Lead (Pb)	$\mu g \cdot L^{-1}$	50		ND	ND	ND	ND	ND	ND	127	ND	ND	67	ND	ND
Total Manganese (Mn)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Molybdenum (Mo)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Nickel (Ni)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Selenium (Se)	$\mu g \cdot L^{-1}$	100[k]		ND	116	ND*	ND*	ND*	ND*	ND	ND	ND	ND	ND	ND
Total Silver (Ag)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Strontium (Sr)	$\mu g \cdot L^{-1}$	200		6450	6560	6490	6320	6240	6190	6890	6840	6690	6680	6990	6960
Total Thallium (Tl)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Tin (Sn)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Titanium (Ti)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Uranium (U)	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Vanadium (V)	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Zinc (Zn)	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

ND = Not detected

RDL = Reportable Detection Limit

[a] –Those values marked with an asterisk (*) have elevated RDL for TSS due to sample matrix (RDL = 2 $mg \cdot L^{-1}$)

[b] – Those values marked with an asterisk (*) have elevated RDL due to sample matrix. Sample pre-dilution required.

[c] – CCME Guideline is for direct effects only and does not consider indirect effects from eutrophication

[d] – Those values marked with an asterisk (*) have elevated RDL for Total Phosphorous (P) due to sample matrix (RDL = 1,000 $\mu g \cdot L^{-1}$); those values marked with a double asterisk (**) have elevated RDL of 10,000 $\mu g \cdot L^{-1}$.

[e] – Those values marked with an asterisk (*) have elevated RDL for Total Sodium (Na) due to sample matrix (RDL = 10 $mg \cdot L^{-1}$)

[f] – Those values marked with an asterisk (*) have elevated RDL for Total Potassium (K) due to sample matrix (RDL = 1 $mg \cdot L^{-1}$); those values marked with a double asterisk (**) have elevated RDL of 10 $mg \cdot L^{-1}$

[g] – Those values marked with an asterisk (*) have elevated RDL for Dissolved Sulphate (SO_4) due to sample matrix (RDL = 100$mg \cdot L^{-1}$)

[h] – CCME Guideline is for inorganic mercury only, whereas the concentration reported is for total mercury

[i] – RDL for Total Cadmium (Cd) is elevated due to sample matrix (RDL = 30 $\mu g \cdot L^{-1}$)

[j] – CCME Guideline values are for hexavalent and trivalent chromium, whereas the concentration reported is for total chromium

[k] – Those values marked with an asterisk (*) have elevated RDL for Total Selenium (Se) due to sample matrix (RDL = 200 $\mu g \cdot L^{-1}$)

Table 3.5 Summary Statistics for Water Quality Data in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

	Units	RDL	CCME Guideline	N	Min	Max	Mean	SD
Conventional Parameters								
pH	pH	N/A	7.0 - 8.7	44	7.78	7.91	7.85	0.03
Total Alkalinity (Total as $CaCO_3$)	$mg·L^{-1}$	5		44	93	100	95.55	1.52
Hardness ($CaCO_3$)	$mg·L^{-1}$	1		44	4700	5900	5327.27	280.67
Turbidity	NTU	0.1		33	0.10	0.50	0.25	0.11
Conductivity	$\mu S·cm^{-1}$	1		44	39000	43000	41431.82	1169.33
Total Suspended Solids (TSS)	$mg·L^{-1}$	1		34	1	8	1.68	1.27
Calculated TDS	$mg·L^{-1}$	1		44	30600	33300	31561.36	545.26
Colour	TCU	5						
Total Organic Carbon (C)	$mg·L^{-1}$	5						
Reactive Silica (SiO_2)	$mg·L^{-1}$	0.5						
Nutrients								
Nitrate + Nitrite	$mg·L^{-1}$	0.05		7	0.05	0.08	0.06	0.01
Nitrite (N)	$mg·L^{-1}$	0.01						
Nitrate	$mg·L^{-1}$	0.05	16[a]	7	0.05	0.08	0.06	0.01
Nitrogen (Ammonia Nitrogen)	$mg·L^{-1}$	0.05						
Total Phosphorous (P)	$\mu g·L^{-1}$	10000		12	129.00	11000.00	2616.08	4455.26
Orthophosphate (P)	$mg·L^{-1}$	0.01		30	0.01	0.02	0.01	0.00
Major Ions								
Total Calcium (Ca)	$mg·L^{-1}$	10		44	337	424	382.09	23.07
Total Magnesium (Mg)	$mg·L^{-1}$	10		44	946	1170	1062.73	55.46
Total Sodium (Na)	$mg·L^{-1}$	10		44	9260	10800	10077.96	277.88
Total Potassium (K)	$mg·L^{-1}$	10		44	343	405	359.55	12.10
Dissolved Chloride (Cl)	$mg·L^{-1}$	300		44	17000	18000	17159.09	369.99
Dissolved Sulphate (SO_4)	$mg·L^{-1}$	50		44	2300	2600	2404.55	60.83

Table 3.5 Summary Statistics for Water Quality Data in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors (Cont'd)

	Units	RDL	CCME Guideline	N	Min	Max	Mean	SD
Metals								
Total Mercury (Hg)	$\mu g \cdot L^{-1}$	0.013	0.016[b]	2	0.01	0.02	0.02	0.00
Total Aluminum (Al)	$\mu g \cdot L^{-1}$	500						
Total Antimony (Sb)	$\mu g \cdot L^{-1}$	100						
Total Arsenic (As)	$\mu g \cdot L^{-1}$	100	12.5					
Total Barium (Ba)	$\mu g \cdot L^{-1}$	100						
Total Beryllium (Be)	$\mu g \cdot L^{-1}$	100						
Total Bismuth (Bi)	$\mu g \cdot L^{-1}$	200						
Total Boron (B)	$\mu g \cdot L^{-1}$	500		44	3140.00	4980.00	3900.45	459.51
Total Cadmium (Cd)	$\mu g \cdot L^{-1}$	1.7	0.12					
Total Chromium (Cr)	$\mu g \cdot L^{-1}$	100	56, 1.5[c]					
Total Cobalt (Co)	$\mu g \cdot L^{-1}$	40						
Total Copper (Cu)	$\mu g \cdot L^{-1}$	200						
Total Iron (Fe)	$\mu g \cdot L^{-1}$	5000						
Total Lead (Pb)	$\mu g \cdot L^{-1}$	50		2	67.00	127.00	97.00	42.43
Total Manganese (Mn)	$\mu g \cdot L^{-1}$	200						
Total Molybdenum (Mo)	$\mu g \cdot L^{-1}$	200						
Total Nickel (Ni)	$\mu g \cdot L^{-1}$	200						
Total Selenium (Se)	$\mu g \cdot L^{-1}$	100		1	116.00	116.00	116.00	N/A
Total Silver (Ag)	$\mu g \cdot L^{-1}$	10						
Total Strontium (Sr)	$\mu g \cdot L^{-1}$	200		44	6190.00	7190.00	6689.55	241.07
Total Thallium (Tl)	$\mu g \cdot L^{-1}$	10						
Total Tin (Sn)	$\mu g \cdot L^{-1}$	200						
Total Titanium (Ti)	$\mu g \cdot L^{-1}$	200						
Total Uranium (U)	$\mu g \cdot L^{-1}$	10						
Total Vanadium (V)	$\mu g \cdot L^{-1}$	200						
Total Zinc (Zn)	$\mu g \cdot L^{-1}$	500						

Notes:

SD = Standard Deviation

[a] - CCME Guideline is for direct effects only and does not consider indirect effects from eutrophication

[b] - CCME Guideline is for inorganic mercury only, whereas the concentration reported is for total mercury

[c] - CCME Guideline values are for hexavalent and trivalent chromium, whereas the concentration reported is for total chromium

Table 3.6 Results of Analysis of Water for Petroleum Hydrocarbons from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

				W-001		W-002			W-003			W-004			W-005			W-006			W-007		
	Units	**RDL**	**CCME Guideline**	**A**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Petroleum Hydrocarbons																							
Benzene	$mg \cdot L^{-1}$	0.001	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	$mg \cdot L^{-1}$	0.001	0.215	0.002	0.001	ND	0.001	0.002	0.002	0.001	ND	0.001	ND	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.002
Ethylbenzene	$mg \cdot L^{-1}$	0.001	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	$mg \cdot L^{-1}$	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg \cdot L^{-1}$	0.010		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot L^{-1}$	0.050		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot L^{-1}$	0.050		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot L^{-1}$	0.100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Modified TPH (Tier1)	$mg \cdot L^{-1}$	0.100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Reached Baseline at C_{32}	$mg \cdot L^{-1}$	N/A		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Surrogate Recovery (%)																							
Isobutylbenzene - Extractable	%			83	88	89	88	91	87	88	89	87	89	84	89	92	89	103	97	96	98	100	99
n-Dotriacontane - Extractable	%			80	83	86	83	85	83	87	84	83	86	77	81	87	82	93	89	89	86	89	88
Isobutylbenzene - Volatile	%			103	96	98	102	97	108	81	97	88	106	91	106	102	100	100	103	96	100	97	100

				W-008			W-009			W-010			W-011			W-012			W-013			W-014		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Petroleum Hydrocarbons																								
Benzene	$mg \cdot L^{-1}$	0.001	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	$mg \cdot L^{-1}$	0.001	0.215	0.002	0.002	0.002	0.001	0.001	ND	0.001	0.001	ND	ND	ND	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	ND
Ethylbenzene	$mg \cdot L^{-1}$	0.001	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	$mg \cdot L^{-1}$	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg \cdot L^{-1}$	0.010		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot L^{-1}$	0.050		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot L^{-1}$	0.050		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot L^{-1}$	0.100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Modified TPH (Tier1)	$mg \cdot L^{-1}$	0.100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Reached Baseline at C_{32}	$mg \cdot L^{-1}$	N/A		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Surrogate Recovery (%)																								
Isobutylbenzene - Extractable	%			101	99	97	93	95	94	96	89	95	93	92	96	99	98	101	101	101	101	94	95	98
n-Dotriacontane - Extractable	%			90	89	87	81	85	87	85	75	83	83	81	85	95	92	94	89	89	90	83	85	88
Isobutylbenzene - Volatile	%			101	80	91	97	104	104	108	99	94	100	94	103	97	99	102	111	105	102	96	101	96

Notes:

RDL = Reportable Detection Limit

Table 3.6 Results of Analysis of Water for Petroleum Hydrocarbons from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors (Cont'd)

				W-015		
	Units	**RDL**	**CCME Guideline**	**A**	**B**	**C**
Petroleum Hydrocarbons						
Benzene	mg·L^{-1}	0.001	0.11	ND	ND	ND
Toluene	mg·L^{-1}	0.001	0.215	ND	ND	ND
Ethylbenzene	mg·L^{-1}	0.001	0.025	ND	ND	ND
Xylene (Total)	mg·L^{-1}	0.002		ND	ND	ND
C_6 - C_{10} (less BTEX)	mg·L^{-1}	0.010		ND	ND	ND
>C_{10}-C_{16} Hydrocarbons	mg·L^{-1}	0.050		ND	ND	ND
>C_{16}-C_{21} Hydrocarbons	mg·L^{-1}	0.050		ND	ND	ND
>C_{21}-<C_{32} Hydrocarbons	mg·L^{-1}	0.100		ND	ND	ND
Modified TPH (Tier1)	mg·L^{-1}	0.100		ND	ND	ND
Reached Baseline at C_{32}	mg·L^{-1}	N/A		Yes	Yes	Yes
Surrogate Recovery (%)						
Isobutylbenzene - Extractable	%			97	99	99
n-Dotriacontane - Extractable	%			90	96	96
Isobutylbenzene - Volatile	%			98	98	103

Notes:
RDL = Reportable Detection Limit

Table 3.7 Summary Statistics for Petroleum Hydrocarbons in Water Samples from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

Petroleum Hydrocarbons	**Units**	**RDL**	**CCME Guideline**	**N**	**Min**	**Max**	**Mean**	**SD**
Benzene	mg·L^{-1}	0.001	0.11					
Toluene	mg·L^{-1}	0.001	0.215	33	0.001	0.002	0.001	0.000
Ethylbenzene	mg·L^{-1}	0.001	0.025					
Xylene (Total)	mg·L^{-1}	0.002						
C_6 - C_{10} (less BTEX)	mg·L^{-1}	0.010						
>C_{10}-C_{16} Hydrocarbons	mg·L^{-1}	0.050						
>C_{16}-C_{21} Hydrocarbons	mg·L^{-1}	0.050						
>C_{21}-<C_{32} Hydrocarbons	mg·L^{-1}	0.100						
Modified TPH (Tier1)	mg·L^{-1}	0.100						
Reached Baseline at C_{32}	mg·L^{-1}	N/A						
Surrogate Recovery (%)								
Isobutylbenzene - Extractable	%			44	83	103	94.30	5.21
n-Dotriacontane - Extractable	%			44	75	96	86.34	4.68
Isobutylbenzene - Volatile	%			44	80	111	98.95	6.19

Notes:
RDL = Reportable Detection Limit
SD = Standard Deviation

3.2 Sediment Quality

Sediment samples were taken at selected locations along the potential submarine cable crossing corridors (Figure 2.5, Table 3.8). Efforts were made to co-locate sediment sampling with water and benthos sampling; however, this was not always possible due to hard bottom conditions that negated the possibility of sediment sampling at certain sites. A total of seven sediment samples were collected. Sampling was unsuccessful at stations S-001, S-002, S-003, S-005, S-006, S-010, and S-012 due to substrate conditions (i.e., large substrate or bedrock, few fines associated). Sampling station location, date and description of sediment are presented in Table 3.8.

Table 3.8 Summary of Date, Location, Depth and Description of Sediment Sampling Stations in the Strait of Belle Isle Marine Surveys

Date	Station ID	Location (see Figure 2.5)		Depth (m)	Description
		Easting	Northing		
Sediment Collected					
Oct 3, 2010	S-011	505520	5693006	90	Coarse sediment with primarily shell material
Oct 4, 2010	S-013	504596	5696580	95	Coarse sediment with primarily shell material
Oct 4, 2010	S-012 RV6	506191	5694677	85	Coarse sediment with large volume of shell material
Oct 4, 2010	S-015 RV5	504933	5691806	99	Primarily shell material with gravel sediment
Oct 4, 2010	S-014 RV4	507031	5689655	108	Coarse sediment with large volume of shell fragments
Oct 4, 2010	S-009 RV3	509168	5690536	104	Primarily shell with small quantity of coarse sediments.
Oct 3, 2010	S-008	510339	5691307	105	Large quantity of fine shell material with burrowing organisms noted in material. Some coarse substrate and gravel associated

Table 3.8 Summary of Date, Location, Depth and Description of Sediment Sampling Stations in the Strait of Belle Isle Marine Surveys (Cont'd)

Date	Station ID	Location (see Figure 2.5)		Depth (m)	Description
		Easting	Northing		
Sediment Not Collected					
Oct 3, 2010	S-001	518540	5686258	14	Primarily bedrock and boulder – no sample collected
Oct 3, 2010	S-002	516781	5686929	47	Cobble with coralline algae, very small quantity of fines - no sample collected
Oct 3, 2010	S-003	517221	5689272	79	Primarily cobble and rubble, no fines associated. Limited quantity of shell material with numerous brittle stars – no sample collected
Oct 3, 2010	S-005	515183	5691529	105	Primarily cobble and rubble with few fines associated – no sample collected
Oct 3, 2010	S-006	512415	5690795	99	Rubble, cobble and small amount of gravel – no sample collected
Oct 3, 2010	S-010	504719	5689805	91	Coarse sediment, no fines associated – no sample collected
Oct 4, 2010	S-012	506648	5695651	85	Small quantity of shell fragments but mostly bedrock boulder – no sample collected

3.2.1 Physical Analyses of Sediment

Substrate composition (i.e., gravel, sand, silt or clay) for each sample is presented in Figure 3.2, while a more detailed analysis of sediment composition (i.e., the phi scale) is presented in Figure 3.3. The physical analysis of sediment demonstrated the coarse nature of the sediments analyzed. The samples consisted mainly of gravel and fine shell material. Results of physical analysis of sediment samples collected are presented in Appendix A, including sample duplicates and laboratory QA/QC data.

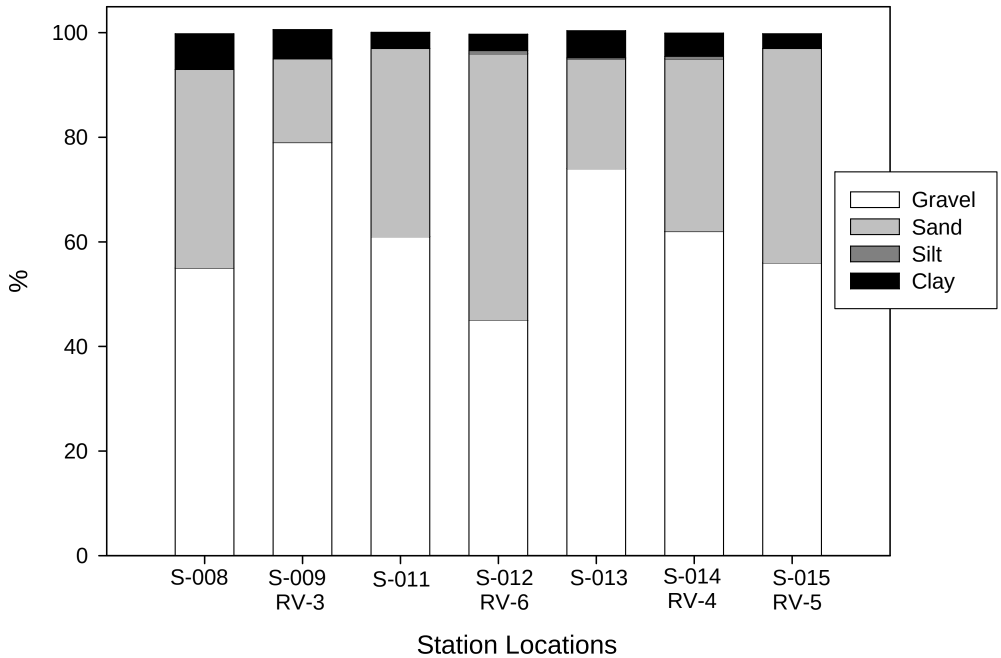

Figure 3.2 Particle Size Analysis (after Wentworth 1922) of Sediment Samples Collected in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

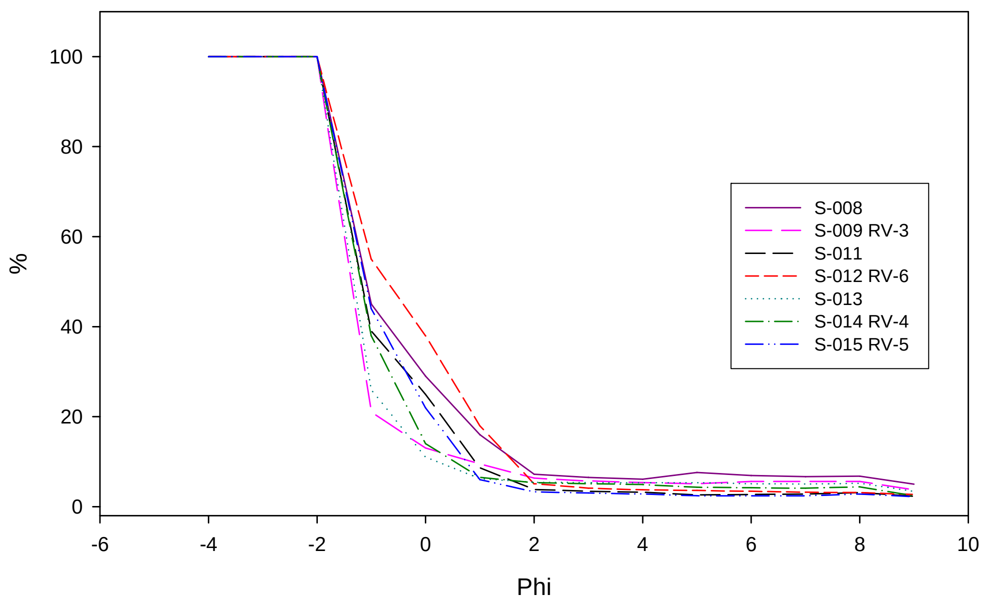

Figure 3.3 Particle Size Analysis (Phi Scale) of Sediment Samples Collected in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

3.2.2 **Chemical Analyses of Sediment**

Results of chemical analyses of sediment including analysis for major ions, metals, total organic carbon and moisture content are presented in Table 3.9, with summary statistics presented in Table 3.10. Results of analysis of sediment for petroleum hydrocarbons are located in Table 3.11, with summary statistics presented in Table 3.12. Results of chemical analysis of sediment samples collected are presented in Appendix A, including sample duplicates and laboratory QA/QC data.

Chemical analyses of sediment determined that the cations calcium, ranging from 180,000 to 400,000 $mg \cdot kg^{-1}$ (mean ± Standard Deviation or SD; 268,571.4 ± 79,252.5 $mg \cdot kg^{-1}$), and to a lesser extent magnesium, ranging from 3,800 to 8,800 $mg \cdot kg^{-1}$ (mean ± SD; 5,014.29 ± 1,812.39 $mg \cdot kg^{-1}$), were very high reflecting the contribution of very fine calcareous shell material to the finer sediment fractions that were digested for chemical analysis. Organic carbon content was low ranging from 2 to 20 $g \cdot kg^{-1}$ (mean ± SD; 6.47 ± 6.13 $g \cdot kg^{-1}$) while moisture content ranged from 17 to 28% (mean ± SD; 23.29 ± 3.99%). For metals, only aluminum, iron, manganese and strontium were detected in all samples while lead (n=3), vanadium (n=2) and barium (n=1) were also detected. Antimony, arsenic, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, lithium, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, tin, uranium and zinc were not detected in any sample. No CCME (2002) ISQGs or PELs for the Protection of Aquatic Life were exceeded in sediment samples collected in the Strait of Belle Isle.

Hydrocarbons were only detected in two samples and those detected were in low concentrations and no CCME or PEL guidelines were exceeded.

Table 3.9 Results for Analysis of Sediment Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Major Ions, Metals, Total Organic Carbon and Moisture

	Units	RDL	ISQG	PEL	S-008	S-009 RV3	S-011	S-012 RV6	S-013	S-014 RV4	S-015 RV5
Major Ions											
Available Calcium (Ca)	$mg \cdot kg^{-1}$	100			180000	320000	210000	220000	400000	320000	230000
Available Magnesium (Mg)	$mg \cdot kg^{-1}$	100			4400	5900	4200	4100	8800	3900	3800
Available Phosphorous (P)	$mg \cdot kg^{-1}$	100			380	390	290	310	570	320	150
Available Potassium (K)	$mg \cdot kg^{-1}$	100			420	760	320	450	1200	570	340
Available Sodium (Na)	$mg \cdot kg^{-1}$	100			4300	9000	4800	5900	11000	7800	4700
Available Sulphur (S)	$mg \cdot kg^{-1}$	500			2800	5200	3300	3600	6300	5100	3500
Metals											
Available Aluminum (Al)	$mg \cdot kg^{-1}$	100			800	1100	660	840	1400	890	550
Available Antimony (Sb)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Arsenic (As)	$mg \cdot kg^{-1}$	20	7.24	41.6	ND	ND	ND	ND	ND	ND	ND
Available Barium (Ba)	$mg \cdot kg^{-1}$	50			ND	ND	ND	ND	ND	68	ND
Available Beryllium (Be)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Bismuth (Bi)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Boron (B)	$mg \cdot kg^{-1}$	50			ND	ND	ND	ND	ND	ND	ND
Available Cadmium (Cd)	$mg \cdot kg^{-1}$	3	0.7	4.2	ND	ND	ND	ND	ND	ND	ND
Available Chromium (Cr)	$mg \cdot kg^{-1}$	20[a]			ND	ND	ND	ND	ND	ND*	ND
Available Cobalt (Co)	$mg \cdot kg^{-1}$	10			ND	ND	ND	ND	ND	ND	ND
Available Copper (Cu)	$mg \cdot kg^{-1}$	20	18.7	108	ND	ND	ND	ND	ND	ND	ND
Available Iron (Fe)	$mg \cdot kg^{-1}$	500			3600	4600	2900	3300	5200	4600	2300
Available Lead (Pb)	$mg \cdot kg^{-1}$	5	30.2	112	ND	8	ND	ND	5	7	ND
Available Lithium (Li)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Manganese (Mn)	$mg \cdot kg^{-1}$	20			270	390	240	160	230	400	170
Available Mercury (Hg)	$mg \cdot kg^{-1}$	1	0.13	0.7	ND	ND	ND	ND	ND	ND	ND
Available Molybdenum (Mo)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Nickel (Ni)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Rubidium (Rb)	$mg \cdot kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Selenium (Se)	$mg \cdot kg^{-1}$	10			ND	ND	ND	ND	ND	ND	ND
Available Silver (Ag)	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND	ND	ND	ND

Table 3.9 Results for Analysis of Sediment Quality Samples in 2010 from the Strait of Belle Isle Proposed Submarine Cable Corridor Crossings Including Major Ions, Metals, Total Organic Carbon and Moisture (Cont'd)

	Units	RDL	ISQG	PEL	S-008	S-009 RV3	S-011	S-012 RV6	S-013	S-014 RV4	S-015 RV5
Available Strontium (Sr)	$mg{\cdot}kg^{-1}$	50			1400	2300	1600	1700	1700	2400	1800
Available Thallium (Tl)	$mg{\cdot}kg^{-1}$	1			ND	ND	ND	ND	ND	ND	ND
Available Tin (Sn)	$mg{\cdot}kg^{-1}$	20			ND	ND	ND	ND	ND	ND	ND
Available Uranium (U)	$mg{\cdot}kg^{-1}$	1			ND	ND	ND	ND	ND	ND	ND
Available Vanadium (V)	$mg{\cdot}kg^{-1}$	20			ND	30	ND	ND	ND	26	ND
Available Zinc (Zn)	$mg{\cdot}kg^{-1}$	50	124	271	ND	ND	ND	ND	ND	ND	ND
Organic Carbon											
Organic Carbon (TOC)	$g{\cdot}kg^{-1}$	0.7			6.6	20	3.5	4	4.1	5.1	2
Inorganics											
Moisture	%	1			26	25	20	26	21	28	17

Notes:
ND = Not detected
RDL = Reportable Detection Limit
[a] – Those samples marked with an asterisk (*) have elevated reporting limits for available chromium (Cr) due to sample matrix.
Results relate only to the items tested.
ISQG - Interim Marine Sediment Quality Guideline
PEL - Probably Effect Levels

Table 3.10 Summary Statistics for Sediment Quality Data in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

	Units	RDL	ISQG	PEL	N	Min	Max	Mean	SD
Major Ions									
Available Calcium (Ca)	$mg\cdot kg^{-1}$	100			7	180000	400000	268571.43	79252.46
Available Magnesium (Mg)	$mg\cdot kg^{-1}$	100			7	3800	8800	5014.29	1812.39
Available Phosphorous (P)	$mg\cdot kg^{-1}$	100			7	150	570	344.29	127.00
Available Potassium (K)	$mg\cdot kg^{-1}$	100			7	320	1200	580.00	312.14
Available Sodium (Na)	$mg\cdot kg^{-1}$	100			7	4300	11000	6785.71	2547.83
Available Sulphur (S)	$mg\cdot kg^{-1}$	500			7	2800	6300	4257.14	1279.14
Metals									
Available Aluminum (Al)	$mg\cdot kg^{-1}$	100			7	550	1400	891.4286	283.8091
Available Antimony (Sb)	$mg\cdot kg^{-1}$	20							
Available Arsenic (As)	$mg\cdot kg^{-1}$	20	7.24	41.6					
Available Barium (Ba)	$mg\cdot kg^{-1}$	50			1	68	68	68	N/A
Available Beryllium (Be)	$mg\cdot kg^{-1}$	20							
Available Bismuth (Bi)	$mg\cdot kg^{-1}$	20							
Available Boron (B)	$mg\cdot kg^{-1}$	50							
Available Cadmium (Cd)	$mg\cdot kg^{-1}$	3	0.7	4.2					
Available Chromium (Cr)	$mg\cdot kg^{-1}$	20							
Available Cobalt (Co)	$mg\cdot kg^{-1}$	10							
Available Copper (Cu)	$mg\cdot kg^{-1}$	20	18.7	108					
Available Iron (Fe)	$mg\cdot kg^{-1}$	500			7	2300	5200	3785.71	1047.90
Available Lead (Pb)	$mg\cdot kg^{-1}$	5	30.2	112	3	5	8	6.67	1.53
Available Lithium (Li)	$mg\cdot kg^{-1}$	20							
Available Manganese (Mn)	$mg\cdot kg^{-1}$	20			7	160	400	265.71	96.41
Available Mercury (Hg)	$mg\cdot kg^{-1}$	1	0.13	0.7					
Available Molybdenum (Mo)	$mg\cdot kg^{-1}$	20							
Available Nickel (Ni)	$mg\cdot kg^{-1}$	20							
Available Rubidium (Rb)	$mg\cdot kg^{-1}$	20							
Available Selenium (Se)	$mg\cdot kg^{-1}$	10							
Available Silver (Ag)	$mg\cdot kg^{-1}$	5							

Table 3.10 Summary Statistics for Sediment Quality Data in the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors (Cont'd)

	Units	RDL	ISQG	PEL	N	Min	Max	Mean	SD
Available Strontium (Sr)	$mg{\cdot}kg^{-1}$	50			7	1400	2400	1842.86	369.04
Available Thallium (Tl)	$mg{\cdot}kg^{-1}$	1							
Available Tin (Sn)	$mg{\cdot}kg^{-1}$	20							
Available Uranium (U)	$mg{\cdot}kg^{-1}$	1							
Available Vanadium (V)	$mg{\cdot}kg^{-1}$	20			2	26	30	28.00	2.83
Available Zinc (Zn)	$mg{\cdot}kg^{-1}$	50	124	271					
Organic Carbon									
Organic Carbon (TOC)	$g{\cdot}kg^{-1}$	0.7			7	2	20	6.47	6.13
Inorganics									
Moisture	%	1			7	17	28	23.29	3.99

Notes:
RDL = Reportable Detection Limit
SD = Standard Deviation
Results relate only to the items tested.
ISQG - Interim Marine Sediment Quality Guideline
PEL - Probably Effect Levels

Table 3.11 Results of Analysis of Sediment for Petroleum Hydrocarbons from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

	Units	RDL	S-008	S-009 RV3	S-011	S-012 RV6	S-013	S-014 RV4	S-015 RV5
Petroleum Hydrocarbons									
Benzene	$mg \cdot kg^{-1}$	0.003	ND	ND	ND	ND	ND	ND	ND
Toluene	$mg \cdot kg^{-1}$	0.03	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	$mg \cdot kg^{-1}$	0.01	ND	ND	ND	ND	ND	ND	ND
Xylene (Total)	$mg \cdot kg^{-1}$	0.05	ND	ND	ND	ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg \cdot kg^{-1}$	3	ND	ND	ND	ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot kg^{-1}$	10	ND	ND	ND	ND	25	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot kg^{-1}$	10	ND	14	ND	ND	200	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot kg^{-1}$	15	ND	ND	ND	ND	220	ND	ND
Modified TPH (Tier1)	$mg \cdot kg^{-1}$	20	ND	ND	ND	ND	450	ND	ND
Reached Baseline at C_{32}	$mg \cdot kg^{-1}$	ND	ND	Yes	ND	ND	Yes	ND	ND
Hydrocarbon Resemblance	$mg \cdot kg^{-1}$	ND	ND	COMMENT (2)	ND	ND	COMMENT (1)	ND	ND
Surrogate Recovery (%)									
Isobutylbenzene - Extractable	%		91	93	93	94	92	96	95
n-Dotriacontane - Extractable	%		103	98	96	97	104	99	105
Isobutylbenzene - Volatile	%		99	96	100	107	95	101	98

Notes:
ND = Not detected
RDL = Reportable Detection Limit
COMMENT (1) - One product in fuel / lube range. Unidentified compound(s) in fuel / lube range.
COMMENT (2) - Unidentified compound(s) in fuel oil range.
Results relate only to the items tested.

Table 3.12 Summary Statistics for Petroleum Hydrocarbons in Sediment from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

	Units	RDL	N	Min	Max	Mean	SD
Petroleum Hydrocarbons							
Benzene	$mg \cdot kg^{-1}$	0.003					
Toluene	$mg \cdot kg^{-1}$	0.03					
Ethylbenzene	$mg \cdot kg^{-1}$	0.01					
Xylene (Total)	$mg \cdot kg^{-1}$	0.05					
C_6 - C_{10} (less BTEX)	$mg \cdot kg^{-1}$	3					
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot kg^{-1}$	10	1	25	25	25.00	N/A
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot kg^{-1}$	10	2	14	200	107.00	131.52
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot kg^{-1}$	15	1	220	220	220.00	N/A
Modified TPH (Tier1)	$mg \cdot kg^{-1}$	20	1	450	450	450.00	N/A
Reached Baseline at C_{32}	$mg \cdot kg^{-1}$	N/A					
Hydrocarbon Resemblance	$mg \cdot kg^{-1}$	N/A					
Surrogate Recovery (%)							
Isobutylbenzene - Extractable	%		7	91	96	93.43	1.72
n-Dotriacontane - Extractable	%		7	96	105	100.29	3.64
Isobutylbenzene - Volatile	%		7	95	107	99.43	3.95

Notes:
RDL = Reportable Detection Limit
Results relate only to the items tested.

3.3 Benthic Invertebrates

A total of 12 sites were successfully sampled for benthos and a brief description of the sediment characteristics as described in the field, and the sediment and organism community description as provided by the benthic laboratory, are provided in Table 3.13. Seven sites were successfully sampled on October 3, 2010 and 5 sites were completed on October 4, 2010.

Table 3.13 Sediment Characteristics and Benthic Community in Samples Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

Sample ID	Field Collection and Sediment Assessment	Laboratory Assessment of Sediment and Organism Community Description
S-002	Six grabs attempted; two grabs with cobble material, and some fines, with coralline algae used for benthos collection.	Large rocks covered in *Lithothamnium.* Foramnifers, shell debris and *Spirorbis* spp. as well as sea stars, polychaetes and sea urchins present.
S-003	Six grabs attempted; two grabs partially open with rubble/cobble substrate, some shells, no fines used for benthos collection. Many brittle stars apparent.	Rocks and shell debris with abundant sea stars, foraminifers and *Spirorbis* spp as well as sea urchins, amphipods and polychaetes.
S-005	Seven grabs attempted; benthos sample from composite of six grabs (four partial) with limited material. Primarily rubble/cobble with few fines apparent.	Shell debris with foraminifers and tube-dwelling *Spirorbis* worms. Starfish, sea urchins and amphipods also present.
S-006	Six grabs attempted; three samples retained and used for benthos. Primarily rubble/cobble with some gravels and fines. Removed encrusting organisms from large rocks.	Gravel and shell debris with foraminifers and tube-dwelling *Spirorbis* spp. Sea stars, sea urchins and amphipods also present.
S-008	Six grabs attempted; one grab with fine shell material, with some cobble and gravel, retained for benthos sample. Burrowing organisms noted.	Shell debris with some gravel. Foraminifers and *Spirorbis* worms present as well as sea stars, polychaetes and amphipods.
S-009 RV-003	Four grabs attempted; one grab with shell material (large and small fragments), retained for benthos sample.	Shell debris, abundant foraminifers, bryozoans, *Lithothamnium* present as well as *Spirorbis* spp. echinoderms, barnacles and crustaceans.
S-010	Six grabs attempted; one grab with rubble material, no fines, retained for benthos sample. Heavily encrusted with benthic organisms.	Large cobble covered in barnacles. Foraminifers, and *Spirorbis* spp. present in sample as well as sea stars, polychaetes, amphipods and shells.
S-011	Six grabs attempted; two grabs with primarily shell material with some cobble retained for benthos sample. Cobble heavily encrusted with small oysters observed.	Abundant large and small shelly debris as well as foraminifers, *Spirorbis* spp, sea stars, amphipods and polychaetes.
S-012 RV-006	Seven grabs attempted; large volume of shell fragments with some cobble/gravel.	Large and small shelly debris with some gravel as well as foraminifers, *Spirorbis* spp, sea stars, amphipods, sea urchins and polychaetes.

Table 3.13 Sediments Characteristics and Benthic Community in Samples Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Sample	Field Collection and Sediment Assessment	Laboratory Assessment of Sediment and Organism Community Description
S-013	Five grabs attempted; two grabs filled with shell fragments and some cobble.	Shell debris, Sea stars, polychaetes, amphipods, foraminifers and *Spirorbis* spp.
S-014	Six grabs attempted; two grabs retained for benthic analyses containing 50% cobble, 50% shell fragments.	Shell debris, large cobble with barnacles and sponges, foraminifers and *Spirorbis* spp. present as well as sea stars, polychaetes and amphipods.
S-015	Four grabs attempted; two grabs retained for benthic analyses. Primarily containing shell fragments with gravel.	Shell debris, encrusting bryozoans, foraminifers, *Spirorbis* spp, echinoderms and crustaceans.

Detailed species identifications and enumerations are provided in Appendix B. Variables used to characterize the benthic community included:

- a general description of the community composition (relative [%] occurrence, total number of organisms in the study);
- total abundance (total number of organisms per station);
- biomass or standing crop (total wet weight of invertebrates per station);
- taxonomic richness (number of taxa per station); and
- diversity indices (richness relative to abundance) including:
  - Shannon-Wiener Diversity;
  - Pielou's Evenness;
  - McIntosh's Index;
  - Simpson's Index; and
  - Margalef's Index.

It is important to note that the benthic organisms in seven of the stations were enumerated in their entirety while five stations were sub-sampled owing to the large numbers of organisms in these samples. Sub-sampling ranged from 28.57% (S-013) to 66.67% (S-009). For stations that were sub-sampled, abundance and biomass estimates were scaled up accordingly to represent 100% of the sample. It is also important to note that the abundance and biomass estimates should be considered semi-quantitative at best and these variables should not be compared between sites. This is because in many instances grabs were composited in order to get sufficient volume of sample for analyses. In many instances only partial grabs were obtained with limited amounts of material in each. As a result the volume of sample retained for benthic analyses is variable between stations.

A total of 14,303 benthic organisms were recovered from the 12 stations. The benthic community was dominated by Polychaetes (9,878 organisms, 69.1%), followed by Amphipods (1,077 organisms, 7.5%), Echinoderms (896 organisms, 6.3%), Bivalves (532 organisms, 3.7%), various meiofauna and plankton (355 organisms, 2.5%), Gastropods (314 organisms, 2.2%), Isopods (199 organisms, 1.4%) and Porifera (184 organisms, 1.3%). Table 3.14 presents the relative occurrence of benthic taxa in the Strait of Belle Isle marine sediment samples. Taxa occurring in 75 to 100% of the samples (9 to 12 stations) are considered abundant and these included several members of the Polychaeta , or segmented worms, including the tube worms *Spirorbis* sp., found in all samples, *Exogone hebes* and unidentified *Sabellidae* sp. (feather duster or fan worms) found in 10 samples, and unidentified tube worms *Syllidae* spp. (10 samples). Brittle stars including *Ophiopholis aculeate* and *Ophiura robusta* were also found in all 12 samples. Hard coral were present in all 12 samples while the hard shelled clam, *Hermithiris psittacea* was found in 11 samples. Other taxa that were also abundant included unidentified crustacean amphipods species from Stenothidae (n=11) and Ischyroceridae (n=10) as well as Harpacticoid copepods (n=9), the thin shelled bivalve *Limatula subauriculata*, the white northern chiton *Ischnochiton albus* (n=9), colonial bryozoans sp. (n=9), and small nematode meiofauna (n=9).

Taxa found in 50 to 75% of the samples (6 to 8 stations) included several polychaetes (*Nothria conchylega, Pholoe minuta, Chitinopoma serrula, Exogone verugera, Pheruse* sp., and *Polycirrus* sp.), amphipods (*Amphilochus manudens, Eurystheus melanops, Tiron spinferum,* and *Ericthonius rubicornis*), bivalves (*Cyclocardia novaeangliae, Hiatella artica,* and *Crenella decussate*), isopods (*Munna fabricii, Pleurogonium spinosissmum*, and unidentified isopod species), the ribbon worms Nemertea (*Cerebratulus* sp. and other unidentified Nemertean species), the shrimp-like Tanaidacea (*Tanaid* sp.), Cnidaria corals (*Alcyonaria* sp.), the sponges porifera (*Scypha* sp.), and various meiofauna including fish lice and Ostracoda.

Table 3.14 Relative Occurrence of Benthic Taxa, Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

Species	Taxon	Occurrence[1]	Species	Taxon	Occurrence
75 to 100% Distribution					
Spirorbis spp.	POLYCHAETA	12	Sabellidae unid	POLYCHAETA	10
Ophiopholis aculeata	ECHINODERMATA	12	Syllidae unid	POLYCHAETA	10
Ophiura robusta	ECHINODERMATA	12	Ischyroceridae unid	AMPHIPODA	10
Hard Coral	MEIOFAUNA/PLANKTON	12	*Limatula subauriculata*	BIVALVIA	9
Hermithiris psittacea	BRACHIOPODA	11	*Ischnochiton albus*	POLYPLACOPHORA	9
Stenothoidae unid	AMPHIPODA	11	Bryozoa (Present/Absent)	MEIOFAUNA/PLANKTON	9
Ampharetidae unid	POLYCHAETA	10	Harpacticoid Copepod	MEIOFAUNA/PLANKTON	9
Exogone hebes	POLYCHAETA	10	Nematoda	MEIOFAUNA/PLANKTON	9
50 to 75% Distribution					
Cyclocardia novaeangliae	BIVALVIA	8	*Crenella decussata*	BIVALVIA	6
Puncturella noachina	GASTROPODA	8	*Chitinopoma serrula*	POLYCHAETA	6
Nothria conchylega	POLYCHAETA	8	*Exogone verugera*	POLYCHAETA	6
Amphilochus manudens	AMPHIPODA	8	*Pherusa sp.*	POLYCHAETA	6
Eurystheus melanops	AMPHIPODA	8	*Polycirrus sp.*	POLYCHAETA	6
Tiron spiniferum	AMPHIPODA	8	Protodrilidae unid.	ARCHIANNELIDA	6
Munna fabricii	ISOPODA	8	Isopod sp. C	ISOPODA	6
Hiatella arctica	BIVALVIA	7	*Pleurogonium spinosissmum*	ISOPODA	6
Pholoe minuta	POLYCHAETA	7	*Cerebratulus sp.*	NEMERTEA	6
Ericthonius rubricornis	AMPHIPODA	7	Nemertean unid	NEMERTEA	6
Tanaid sp. A	TANAIDACEA	7	Alcyonaria sp. A	CNIDARIA	6
Scypha sp.	PORIFERA	7	Ostracoda	MEIOFAUNA/PLANKTON	6
Fish Lice	MEIOFAUNA/PLANKTON	7			
25 to 50% Distribution					
Anomia squamula	GASTROPODA	5	Hydrachnidia	MEIOFAUNA/PLANKTON	4
Solariella varicosa	GASTROPODA	5	*Boreotrophan truncatus*	GASTROPODA	3
Exogone dispar	POLYCHAETA	5	Gastropod sp. J	GASTROPODA	3
Glycera capitata	POLYCHAETA	5	*Moelleria costulata*	GASTROPODA	3
Maldanidae sp. B	POLYCHAETA	5	*Solariella obscura*	GASTROPODA	3
Thelepus cincinnatus	POLYCHAETA	5	*Glaciarcula spitzbergensis*	BRACHIOPODA	3
Oligochaete sp.	ARCHIANNELIDA	5	Capitellidae unid	POLYCHAETA	3

Table 3.14 Relative Occurrence of Benthic Taxa, Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Species	Taxon	Occurrence	Species	Taxon	Occurrence
25 to 50% Distribution					
Ophiuroid sp. D	ECHINODERMATA	5	*Mediomastus ambiseta*	POLYCHAETA	3
Psolus phantapus	ECHINODERMATA	5	*Nereis sp.*	POLYCHAETA	3
Strongylocentrotus pallidus	ECHINODERMATA	5	*Pholoe sp.*	POLYCHAETA	3
Metopa norvegica	AMPHIPODA	5	Polychaete unid	POLYCHAETA	3
Synidotea nodulosa	ISOPODA	5	*Travisia sp.*	POLYCHAETA	3
Edwardsia elegans	CNIDARIA	5	Ophiuroid sp. C	ECHINODERMATA	3
Gersemia rubiformis	CNIDARIA	5	*Strongylocentrotus droebachiensis*	ECHINODERMATA	3
Crenella glandula	BIVALVIA	4	Caprellidae unid.	AMPHIPODA	3
Gastropod sp. C	GASTROPODA	4	*Eusirus cuspidatus*	AMPHIPODA	3
Gastropod sp. D	GASTROPODA	4	*Guernea nordenskjoldi*	AMPHIPODA	3
Gastropod unid.	GASTROPODA	4	Pleustidae unid.	AMPHIPODA	3
Solariella obscura	GASTROPODA	4	Amphipod unid	AMPHIPODA	3
Euchone papillosa	POLYCHAETA	4	*Camplyaspis sp.*	CUMACEA	3
Eumida sanquinea	POLYCHAETA	4	*Balanus crenatus*	CIRRIPEDIA	3
Flabelligera affinis	POLYCHAETA	4	Anemone unid.	CNIDARIA	3
Gyptis sp.	POLYCHAETA	4	*Bunodactis stella*	CNIDARIA	3
Harmothoe extenuata	POLYCHAETA	4	Hydroid unid.	CNIDARIA	3
Pectinaria granulata	POLYCHAETA	4	Ascidian sp. B	CHORDATA	3
Spio filicornis	POLYCHAETA	4	Ascidian sp. C	CHORDATA	3
Archiannelid unid	ARCHIANNELIDA	4	Ascidian unid.	CHORDATA	3
Crossaster papposus	ECHINODERMATA	4	Porifera sp. B	PORIFERA	3
Isopod sp. D	ISOPODA	4	Porifera sp. D	PORIFERA	3
Isopod sp. E	ISOPODA	4	Porifera sp. E	PORIFERA	3
Leucon nasicoides	CUMACEA	4	Flatworm sp. A	PLATYHELMINTHES	3
Balanus balanus	CIRRIPEDIA	4	Unidentified Taxon A	MISCELLANEOUS	3
Phascolion strombi	SIPUNCUIDA	4	Unidentified Taxon B	MISCELLANEOUS	3
Ascidia callosa	CHORDATA	4	Foraminifera	MEIOFAUNA/PLANKTON	3
Leucosolenia sp	PORIFERA	4			

Table 3.14 Relative Occurrence of Benthic Taxa, Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Species	Taxon	Occurrence	Species	Taxon	Occurrence
< 25% Distribution					
Astarte borealis	BIVALVIA	2	Chiton sp. A	POLYPLACOPHORA	1
Astarte quadrans	BIVALVIA	2	Chiton unid	POLYPLACOPHORA	1
Bivalve unid.	BIVALVIA	2	Brachiopod sp. B	BRACHIOPODA	1
Cerastoderma pinnulatum	BIVALVIA	2	*Anobothrus gracilis*	POLYCHAETA	1
Chlamys islandicus	BIVALVIA	2	*Arcteobia anticostiensis*	POLYCHAETA	1
Cyclocardia borealis	BIVALVIA	2	*Aricidea catherinae*	POLYCHAETA	1
Gastropod sp. E	GASTROPODA	2	*Aricidea sp. B*	POLYCHAETA	1
Gastropod sp. F	GASTROPODA	2	*Asabellides sp*	POLYCHAETA	1
Margarites costalis	GASTROPODA	2	*Cirratulus sp.*	POLYCHAETA	1
Nudibranch sp. A	GASTROPODA	2	*Diplocirrus? sp.*	POLYCHAETA	1
Chone sp.	POLYCHAETA	2	*Eteone flava?*	POLYCHAETA	1
Cirratulidae unid.	POLYCHAETA	2	*Euchone sp. A*	POLYCHAETA	1
Eteone longa	POLYCHAETA	2	*Eulalia? sp.*	POLYCHAETA	1
Ophelina acuminata	POLYCHAETA	2	*Eumida sp.*	POLYCHAETA	1
Paraonidae sp. C	POLYCHAETA	2	Flabelligeridae	POLYCHAETA	1
Phyllodoce maculata	POLYCHAETA	2	*Glycera dibranchiata*	POLYCHAETA	1
Phyllodocidae sp. A	POLYCHAETA	2	*Levinsenia sp.*	POLYCHAETA	1
Phyllodocidae sp. B	POLYCHAETA	2	Maldanidae	POLYCHAETA	1
Terebellidae unid.	POLYCHAETA	2	Maldanidae sp. A	POLYCHAETA	1
Echinarachnius parma	ECHINODERMATA	2	*Microphthalmus sp.*	POLYCHAETA	1
Pseudopallene discoidea	PYCNOGONIDA	2	*Owenia sp.*	POLYCHAETA	1
Anonyx sp.	AMPHIPODA	2	Paraonidae sp. B	POLYCHAETA	1
Gitanopsis inermis	AMPHIPODA	2	Paraonidae unid	POLYCHAETA	1
Hippomedon sp.	AMPHIPODA	2	*Parougia caeca*	POLYCHAETA	1
Lysianassidae unid	AMPHIPODA	2	*Phyllodoce mucosa*	POLYCHAETA	1
Oedicerotidae sp. A	AMPHIPODA	2	Polychaete sp. A	POLYCHAETA	1
Orchomenella minuta	AMPHIPODA	2	Polychaete sp. B	POLYCHAETA	1
Unciola irrorata	AMPHIPODA	2	Polychaete sp. C	POLYCHAETA	1
Isopod sp. A	ISOPODA	2	Polychaete sp. D	POLYCHAETA	1
Isopod sp. B	ISOPODA	2	Polynoidae unid	POLYCHAETA	1

Table 3.14 Relative Occurrence of Benthic Taxa, Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Species	Taxon	Occurrence	Species	Taxon	Occurrence
< 25% Distribution					
Munna sp.	ISOPODA	2	*Praxillella sp.*	POLYCHAETA	1
Hyas coarctatus	DECAPODA	2	Spionidae	POLYCHAETA	1
Balanus sp.	CIRRIPEDIA	2	*Tharyx sp.*	POLYCHAETA	1
Nemertean sp. B	NEMERTEA	2	Ophiuroid sp. E	ECHINODERMATA	1
Saccoglossus sp.	HEMICHORDATA	2	*Strongylocentrotus sp.*	ECHINODERMATA	1
Boltenia echinata	CHORDATA	2	*Ammothea achelioides*	PYCNOGONIDA	1
Ascidian sp. D	CHORDATA	2	*Nymphon rubrum*	PYCNOGONIDA	1
Ascidian sp. F	CHORDATA	2	Pycnogonid A	PYCNOGONIDA	1
Porifera sp. A	PORIFERA	2	Pycnogonid B	PYCNOGONIDA	1
Astarte undata	BIVALVIA	1	*Acanthonotosoma serratum*	AMPHIPODA	1
Astarte undata	BIVALVIA	1	*Apherusa megalops*	AMPHIPODA	1
Bivalve sp. A	BIVALVIA	1	*Gammaropsis sp.*	AMPHIPODA	1
Bivalve sp. B	BIVALVIA	1	*Leucothoe sp.*	AMPHIPODA	1
Crenella faba	BIVALVIA	1	*Melita denata*	AMPHIPODA	1
Crenella faba	BIVALVIA	1	*Neopleustes pulchellus*	AMPHIPODA	1
Cyclocardia novaeangliae	BIVALVIA	1	*Phoxocephalus holbolli*	AMPHIPODA	1
Musculus niger	BIVALVIA	1	*Pontogeneia inermis*	AMPHIPODA	1
Mya truncata	BIVALVIA	1	*Protomedeia sp.*	AMPHIPODA	1
Thracia myopsis	BIVALVIA	1	*Syrrhoe crenulata*	AMPHIPODA	1
Buccinidae	GASTROPODA	1	*Tryphosa sp.*	AMPHIPODA	1
Colus sp.	GASTROPODA	1	*Unicola sp*	AMPHIPODA	1
Gastropod sp. A	GASTROPODA	1	*Westwoodilla sp.*	AMPHIPODA	1
Gastropod sp. B	GASTROPODA	1	*Munna acanthifera*	ISOPODA	1
Gastropod sp. I	GASTROPODA	1	*Philoscia vittata*	ISOPODA	1
Gastropod sp. K	GASTROPODA	1	Isopod unid.	ISOPODA	1
Lacuna vincta	GASTROPODA	1	Cumacean sp. A	CUMACEA	1
Lepeta caeca	GASTROPODA	1	Shrimp sp. A	DECAPODA	1
Margarites costalis, var. A	GASTROPODA	1	Barnacle unid	CIRRIPEDIA	1
Margarites sp.	GASTROPODA	1	Nemertean sp. A	NEMERTEA	1
Muricidae	GASTROPODA	1	Nemertean sp. C	NEMERTEA	1

Table 3.14 Relative Occurrence of Benthic Taxa, Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Species	Taxon	Occurrence	Species	Taxon	Occurrence
< 25% Distribution					
Nudibranch sp. B	GASTROPODA	1	Nemertean sp. D	NEMERTEA	1
Nudibranch sp. C	GASTROPODA	1	Nemertean sp. E	NEMERTEA	1
Nudibranch sp. D	GASTROPODA	1	Sipunculid sp. A	SIPUNCUIDA	1
Nudibranch unid	GASTROPODA	1	Sipunculid sp. B	SIPUNCUIDA	1
Odostomia sp.	GASTROPODA	1	Priapulida sp.	PRIAPULIDA	1
Oenopota nobilis	GASTROPODA	1	Alcyonaria sp. B	CNIDARIA	1
Oenopota sp.	GASTROPODA	1	Anemone sp. A	CNIDARIA	1
Onchidoris sp.	GASTROPODA	1	Anemone sp. B	CNIDARIA	1
Polinices immaculatus	GASTROPODA	1	*Boltenia ovifera*	CHORDATA	1
Retusidae	GASTROPODA	1	Ascidian sp. A	CHORDATA	1
Solariella sp.	GASTROPODA	1	Ascidian sp. E	CHORDATA	1
Tachyrhynchus erosus	GASTROPODA	1	Ascidian sp. G	CHORDATA	1
Trichotropis borealis	GASTROPODA	1	Porifera sp. C	PORIFERA	1
Velutina undata	GASTROPODA	1	Calanoid Copepod	MEIOFAUNA/PLANKTON	1
Tonicella marmorea	POLYPLACOPHORA	1	Egg cases	MEIOFAUNA/PLANKTON	1
Tonicella rubra	POLYPLACOPHORA	1			

Note[1]: Occurrence = Number of samples in which taxa was identified

The benthic taxa are listed in order of abundance from all samples in Table 3.15. Similar to relative occurrence, Polychaetes were the dominant group with members of the encrusting, tube building genus *Spirorbis* an order of magnitude greater in abundance than all other benthic taxa. *Spirorbis* spp. were present in high numbers both loose (within the sample) as well as attached to rocks and shell debris. Other abundant Polychaetes included unidentified Sabellidae species and *Exogone hebes* and *Exogone verugera* of feather duster (fan) worms, unidentified translucent worms from Syllidae sp., the tube worm *Chitinopoma serrula*, and the soft bodied *Polycirrus* sp. Dominant Echinoderms included the brittle stars *Ophiura robusta* and O*phiopholis aculeata*. Abundant Amphipods included unidentified shrimp-like species from Stenothoidae and Ischyroceridae. The dominant bivalve was the thick shelled clam *Hiatella arctica*.

Table 3.15 Abundance (total number of organisms) of Benthic Taxa Collected During Benthic Surveys from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

Species	Taxon	Total[1]
Spirorbis spp.	POLYCHAETA	6765
Syllidae unid	POLYCHAETA	811
Ophiura robusta (Ophiuroid sp. B)	ECHINODERMATA	663
Sabellidae unid	POLYCHAETA	609
Stenothoidae unid	AMPHIPODA	403
Exogone hebes	POLYCHAETA	354
Hiatella arctica	BIVALVIA	352
Exogone verugera	POLYCHAETA	328
Ischyroceridae unid	AMPHIPODA	308
Chitinopoma serrula	POLYCHAETA	210
Nematoda	MEIOFAUNA & PLANKTON	175
Ophiopholis aculeata (Ophiuroid sp. A)	ECHINODERMATA	129
Polycirrus sp.	POLYCHAETA	127
Munna fabricii	ISOPODA	112
Saccoglossus sp.	HEMICHORDATA	109
Scypha sp.	PORIFERA	104
Gastropod sp. D	GASTROPODA	95
Exogone dispar	POLYCHAETA	95
Ampharetidae unid	POLYCHAETA	73
Ericthonius rubricornis	AMPHIPODA	72
Harpacticoid Copepod	MEIOFAUNA & PLANKTON	70
Oligochaete sp.	ARCHIANNELIDA	66
Gyptis sp.	POLYCHAETA	64
Foraminifera	MEIOFAUNA & PLANKTON	60
Alcyonaria sp. A	CNIDARIA	59
Hermithiris psittacea	BRACHIOPODA	58
Amphilochus manudens	AMPHIPODA	56
Eurystheus melanops	AMPHIPODA	56
Limatula subauriculata	BIVALVIA	55
Gastropod sp. J	GASTROPODA	55
Cyclocardia novaeangliae	BIVALVIA	51
Balanus crenatus	CIRRIPEDIA	47
Protodrilidae unid.	ARCHIANNELIDA	46

Table 3.15 Abundance (total number of organisms) of Benthic Taxa Collected During Benthic Surveys from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Species	Taxon	Total
Balanus balanus	CIRRIPEDIA	46
Eusirus cuspidatus	AMPHIPODA	41
Thelepus cincinnatus	POLYCHAETA	36
Archiannelid unid	ARCHIANNELIDA	35
Fish Lice	MEIOFAUNA & PLANKTON	35
Tanaid sp. A	TANAIDACEA	34
Ascidia callosa	CHORDATA	32
Euchone sp. A	POLYCHAETA	30
Puncturella noachina	GASTROPODA	29
Maldanidae	POLYCHAETA	29
Ascidian sp. B	CHORDATA	29
Ischnochiton albus	POLYPLACOPHORA	28
Metopa norvegica	AMPHIPODA	28
Pleustidae unid.	AMPHIPODA	28
Chone sp.	POLYCHAETA	27
Nothria conchylega	POLYCHAETA	26
Pholoe minuta	POLYCHAETA	26
Nemertean unid	NEMERTEA	26
Ascidian sp. C	CHORDATA	26
Ophiuroid sp. D	ECHINODERMATA	25
Isopod sp. C	ISOPODA	25
Gastropod unid.	GASTROPODA	24
Maldanidae sp. B	POLYCHAETA	24
Balanus sp.	CIRRIPEDIA	23
Strongylocentrotus droebachiensis	ECHINODERMATA	22
Synidotea nodulosa	ISOPODA	19
Leucosolenia sp	PORIFERA	19
Porifera sp. C	PORIFERA	18
Glycera capitata	POLYCHAETA	17
Crossaster papposus	ECHINODERMATA	17
Isopod sp. E	ISOPODA	17
Eumida sanquinea	POLYCHAETA	16
Gersemia rubiformis	CNIDARIA	16
Polychaete sp. D	POLYCHAETA	15
Strongylocentrotus pallidus	ECHINODERMATA	15
Tiron spiniferum	AMPHIPODA	15
Ascidian unid.	CHORDATA	15
Porifera sp. A	PORIFERA	15
Solariella obscura	GASTROPODA	14
Mediomastus ambiseta	POLYCHAETA	14
Pholoe sp.	POLYCHAETA	14
Phyllodocidae sp. A	POLYCHAETA	14
Spio filicornis	POLYCHAETA	14
Cerastoderma pinnulatum	BIVALVIA	13

Table 3.15 Abundance (total number of organisms) of Benthic Taxa Collected During Benthic Surveys from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010 (Cont'd)

Crenella decussata	BIVALVIA	13
Species	**Taxon**	**Total**
Solariella varicosa	GASTROPODA	13
Ascidian sp. D	CHORDATA	13
Porifera sp. B	PORIFERA	13
Gastropod sp. C	GASTROPODA	12
Solariella obscura	GASTROPODA	12
Cerebratulus sp.	NEMERTEA	12
Anomia squamula	GASTROPODA	11
Euchone papillosa	POLYCHAETA	11
Hydroid unid.	CNIDARIA	11
Chlamys islandicus	BIVALVIA	10
Ophiuroid sp. C	ECHINODERMATA	10

Note[1]: Taxa with an abundance of less than 10 organisms are not included

Abundance, biomass, and selected community measures are provided in Table 3.16. Samples from Strait of Belle Isle stations S-002 to S-015 contained moderate to high abundance, biomass, and diversity of organisms. Total abundance of organisms (number/sample) ranged from 143 (S-005) to 2,878 (S-013) organisms/sample with a mean ± SD of 1,162.3 ± 790.4 (Table 3.16) with stations S-013 (2,878 organisms), S-009 (2003 organisms), S-010 (1,813 organisms), and S-015 (1,611 organisms) having the greatest abundance (Figure 3.4). The high abundance at Station S-013 was related to a variety of Polychaetes, particularly *Spirorbis* spp. which accounted for 76% of all organisms identified from this site.

Biomass (g/sample wet weight) ranged from 1.12 (station S-015) to 274.91 (station S-010) with a mean ± SD of 36.7 ± 76.5 (Table 3.16). Station S-010 had the greatest biomass (274.91 g/sample) which was an order of magnitude greater than the other stations (Figure 3.5). Station S-010 also had the third highest abundance and the greatest taxon richness (Table 3.16). The biomass in station S-010 was related to the bivalve *Hiatella arctica*, the Polychaetes (*Spirorbis* sp., *Sabellidae* spp., and *Syllidae* spp.), worms of the *Saccoglossus* genus, and various sponges (Porifera).

The number of species per sample (Taxon Richness) is the most widely used species richness index and ranged from 29 to 108 with a mean ± SD of 60.1 ± 25.4 (Table 3.16). Highest taxon richness was apparent at Stations S-010, S-009 and S-006 with 108, 97, and 85 species, respectively (Figure 3.6).

The Shannon-Wiener Diversity Index is the most widely used index to describe the proportional abundance of species (Costello et al. 2001) and ranged from 0.48 to 1.39 with a mean ± SD of 0.96 ± 0.29 (Table 3.16). The Shannon-Wiener Diversity Index measures both species numbers and evenness of abundance and is considered an index of biodiversity. Stations S-010, S-009, and S-006 had the higher Shannon-Wiener Diversity Indices of 1.39, 1.23, and 1.22, respectively, and these stations had both higher than average abundance and taxon richness.

Pielou's Evenness Index, constrained to a scale of 0 to 1, ranged from 0.29 to 0.74 with a mean ± SD of 0.55 ± 0.14 (Table 3.16). Pielou's Evenness Index is the most widely used measure of species evenness and also is considered a biodiversity index (Costello et al. 2001). Generally, the Pielou's Evenness Index was similar across stations although stations S-013, S-002, and S-015 had lower than average indices of 0.29, 0.32, and 0.39, respectively. The low Pielou's Evenness Index at stations S-013, and to a lesser extent at stations S-002 and S-015, was related to the dominance of a single taxa, the Polychaete *Spirorbis* spp.

McIntosh's Index, constrained to range from 0 to 1, is an indicator of proportional abundances of species and ranged from 0.23 to 0.74 with a mean ± SD of 0.51 ± 0.17 (Table 3.16). Similarly to Pielou's Evenness Index, the lowest McIntosh's Index was found at stations S-002, S-013, and S-015 with indices of 0.23, 0.24, and 0.32, respectively.

Simpson's Index, constrained to range from 0 (high diversity) to 1 (low diversity), is also an indicator of proportional abundances of species and ranged from 0.08 to 0.61 with a mean ± SD of 0.28 ± 0.18 (Table 3.16). The highest Simpson's Index, indicating the lowest diversity, were found at stations S-013, S-002, and S-015.

Margalef's Index, a commonly used species richness or community diversity index with the higher the index the higher the diversity, ranged from 4.96 to 14.26 with a mean ± SD of 8.52 ± 3.00 (Table 3.16). The highest Margalef's Index was found at stations S-010, S-009, and S-006 with indices of 14.26, 12.63, and 12.01, respectively, similar to the Shannon-Wiener Diversity Index.

Table 3.16 Abundance, Biomass, Taxon Richness, and Community Diversity Indices for Samples Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

Station	Abundance	Biomass (g)	Taxon Richness	Shannon-Wiener Diversity	Pielou's Evenness	Mcintosh's Index	Simpson's Index	Margalef's Index
S-002	778	24.22	34	0.48	0.32	0.23	0.61	4.96
S-003	192	29.07	29	0.81	0.55	0.47	0.32	5.33
S-005	143	3.26	29	1.08	0.74	0.68	0.14	5.64
S-006	1089	9.14	85	1.22	0.63	0.66	0.13	12.01
S-008	956	2.96	55	1.09	0.63	0.62	0.16	7.87
S-009	2003	54.27	97	1.23	0.62	0.60	0.17	12.63
S-010	1813	274.91	108	1.39	0.68	0.74	0.08	14.26
S-011	775	8.13	56	1.04	0.59	0.56	0.22	8.27
S-012	1058	16.81	65	1.09	0.60	0.53	0.24	9.19
S-013	2878	4.64	53	0.51	0.29	0.24	0.59	6.53
S-014	652	11.74	51	0.93	0.55	0.50	0.27	7.72
S-015	1611	1.12	59	0.70	0.39	0.32	0.47	7.85
Mean	**1162.33**	**36.69**	**60.08**	**0.96**	**0.55**	**0.51**	**0.28**	**8.52**
Median	**1007.00**	**10.44**	**55.50**	**1.06**	**0.60**	**0.54**	**0.23**	**7.86**
SD	**790.43**	**76.52**	**25.39**	**0.29**	**0.14**	**0.17**	**0.18**	**3.00**
Min.	**143**	**1.12**	**29**	**0.48**	**0.29**	**0.23**	**0.08**	**4.96**
Max.	**2878**	**274.91**	**108**	**1.39**	**0.74**	**0.74**	**0.61**	**14.26**

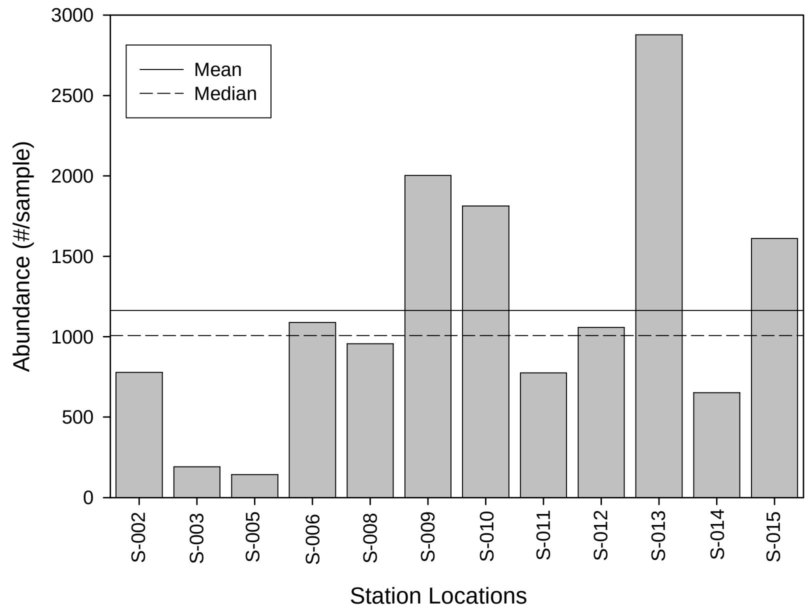

Figure 3.4 Abundance of Benthic Organisms (# organisms/sample) Per Station Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

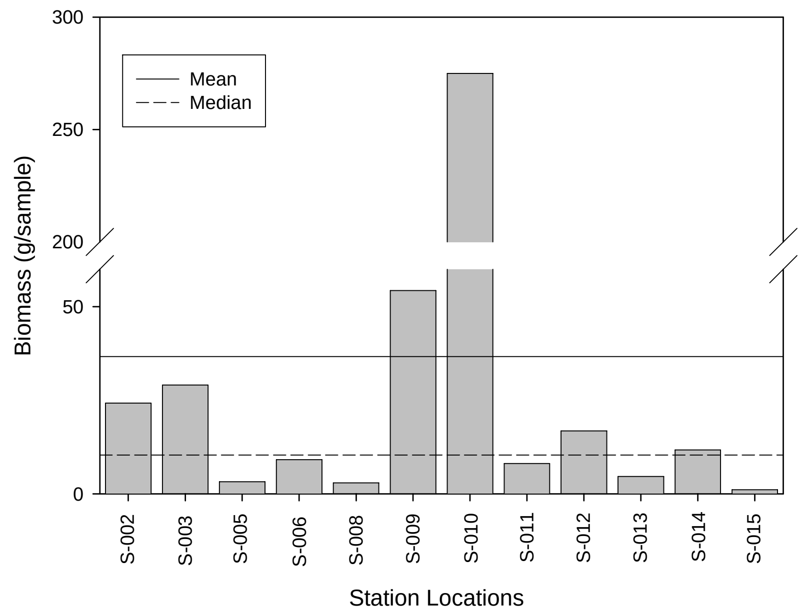

Figure 3.5 Biomass of Benthic Organisms (g/sample) Per Station Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

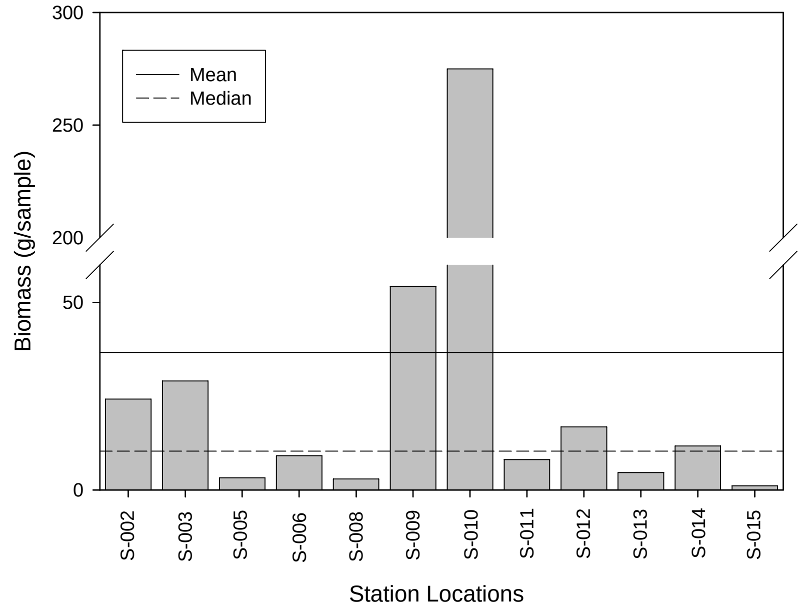

Figure 3.6 Taxon Richness of Benthic Organisms (# taxa/sample) Per Station Collected from the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors October 2010

4.0 DISCUSSION AND CONCLUSIONS

The results of the Strait of Belle Isle marine water, sediment, and benthos surveys in 2010 are discussed in relation to the descriptive characteristics of the samples collected. Water and sediment characteristics are discussed in relation to CCME guidelines for the Protection of Aquatic Life and the potential for demonstration of anthropogenic influences. The water, sediment and benthos are then further discussed in relation to available historical information for these characteristics.

4.1 Water Quality

CTD profiles were successfully obtained from 14 stations while water samples were successfully collected from all 15 stations, with three samples taken from different depths, with the exception of one station where only two samples were collected owing to the shallow depth. Field water quality measurements were taken at all stations from the surface sample. Field water quality results were generally comparable between sites, with temperatures demonstrating some variability between sites, ranging from 5.99 to 10.91 ˚C. Conductivity values ranged from 4.72 to 4.87 $S \cdot m^{-1}$, which are near typical of seawater. Values for pH were alkaline ranging from 7.89 to 8.15. Dissolved oxygen values varied from 9.64 to 11.51 $mg \cdot L^{-1}$ and were supersaturated (102.3 to 114.9% saturation).

Water samples were analyzed at a laboratory for conventional parameters, nutrients, major ions, metals and petroleum hydrocarbons. Although water samples were collected from different depths, noticeable differences were not evident between depths at each sampling station suggesting the water masses were well mixed despite some thermal stratification. Conventional parameters were similar between all sampling stations and at all depths. pH was alkaline and ranged from 7.78 to 7.91 with an average of 7.85 which is well within the CCME guidelines. Seawater is more enriched in dissolved ions than freshwater and this is most apparent in the dominant ions, sodium and chloride, but also in other major cations (calcium, magnesium, and potassium) and anions (bicarbonate alkalinity and sulphate).

Very few nutrients were detected in the samples, with orthophosphate (n=30) detected in the most samples and nitrate (n=7) and total phosphorous (n=12) detected in a few samples at low levels. Most nutrients are terrestrial in origin, finding their way to oceans via riverine and atmospheric pathways. The low marine nutrient content is consistent with the pristine nature of the marine environment in the study area. Nutrients levels can vary with depth with low nutrients at the surface, where they are used in biological production, and higher values at depths where they are liberated through decomposition. There was no apparent trend in nutrient levels with depth which likely is also evidence of the highly mixed waters in this region.

Metals in samples were also low, with only boron and strontium detected in all samples while most metals were not detected in any samples including aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, silver, thallium, tin, titanium, uranium, vanadium and zinc. Mercury and lead were detected in two samples each, while selenium was detected in only one sample.

Laboratory water quality results for trace elements/metals were evaluated in relation to national guidelines for the Protection of Aquatic Life, as developed by the CCME (CCME 1999, CCME 2007), and there were no exceedences for any parameters tested. For petroleum hydrocarbons, only toluene was detectable in any of the samples tested (n=33) and all values were well within the CCME water quality guideline of 0.215 $mg \cdot L^{-1}$. All other hydrocarbons were below the RDL. The presence of hydrocarbons in the marine environment can reflect natural sources (e.g., oil seeps) and also anthropogenic inputs from commercial and recreational boating activity. Water quality data collected in 2010 has confirmed the pristine nature of the marine environment in the study area and there is no evidence of any anthropogenic influence on marine water quality for metals and hydrocarbons.

While the 2010 marine water quality program had extensive and essentially equally distributed spatial coverage, these samples/measurements represent a single 'point in time' and may exhibit variability in some parameters on a temporal scale, including inter-annual, seasonal, and diel variations. Seawater temperatures for example would vary considerably in relation to climatic conditions, tides and currents, and other influences. The Strait of Belle Isle region is strongly influenced by currents and tides, with currents following the main axis of the Strait and velocity highest at the surface and decreasing with depth (Sikumiut 2010).

Variations in total salinity and in temperature cause variations in the density of seawater leading to layering or stratification, from warm to colder water, as the water depth increases. Water in the Strait of Belle Isle has been reported to be stratified as a two layer system in summer with more homogeneous conditions in fall and winter (Sikumiut 2010). In summer, the surface layer can extend to a depth of 50 to 60 m, with average temperatures between 10 and 11˚C, while bottom temperatures can range between -0.4 and 3.5˚C under stratification. Fall and winter conditions are colder and saltier with one homogeneous layer forming in October. It is apparent that this water sampling campaign, being conducted from September 26 to 30, was completed while the water column was well stratified.

4.2 Sediment Quality

A total of seven sediment samples were collected from locations along the submarine cable corridors in the Strait of Belle Isle during the 2010 marine surveys. Sampling was attempted at seven other sampling stations and after a sequence of unsuccessful grab attempts, sampling was ceased due to unsuitable substrate conditions (larger substrate material or bedrock with few associated fines). This is consistent with similar survey work in the Strait of Belle Isle where finer sediment materials have also been difficult to obtain (e.g., AMEC 2010). Analysis of sediment demonstrated the coarse nature of the sediments analyzed which consisted mainly of rubble, cobble, gravel and fine shell material. The larger material was sieved from the samples and only the gravel and finer material was subject to physical and chemical analyses. The gravel component dominated the samples representing from 45 to 79% (mean ± SD; 61.7 ± 11.6%) of the material. Sand ranged from 16 to 51% (mean ± SD; 33.7 ± 11.9%), clays from 2.8 to 6.8% (mean ± SD; 4.4 ± 1.5%) while silt was virtually non-existent averaging less than 0.2% and being absent in four of seven samples. Detailed sediment size analyses also revealed the coarse nature of the sediments with most of the material being coarser than -2 on the Phi scale (4 mm).

Previous sediment sampling programs in the Strait of Belle Isle determined that the overburden on the seabed was composed of a layer of shells/shell fragments overlying sand, gravel, cobbles, and boulders (SNC-Lavalin 1980). Acoustic classification determined 90 percent of the seabed was comprised of coarser material including pebbles, cobbles, and boulders. In the few places where finer materials has accumulated, sand and gravel waves were evident suggesting the bottom material was fairly mobile, indicative of strong bottom currents (Fugro 2010). AMEC (2010) also examined substrate in the study area corridors in 2008 using drop video and determined the predominant substrate categories were coarse-small (gravel, cobble) and coarse-large (bedrock, boulder, rubble, totaling 84%. Very few fines (1.9%) were evident and they were restricted to depths of less than 50 m. Shells were also an important substrate component (10.4%)

Chemical analyses of sediment included analysis for major ions, metals, total organic carbon, moisture content, and petroleum hydrocarbons. The cations calcium, ranging from 180,000 to 400,000 $mg \cdot kg^{-1}$ (mean ± SD; 268,571.4 ± 79,252.5 $mg \cdot kg^{-1}$), and to a lesser extent magnesium, ranging from 3,800 to 8,800 $mg \cdot kg^{-1}$ (mean ± SD; 5,014.29 ± 1,812.39 $mg \cdot kg^{-1}$), were very high reflecting the contribution of shell fragments to the finer sediment fractions. Organic carbon content was low ranging from 2 to 20 $g \cdot kg^{-1}$ (mean ± SD; 6.47 ± 6.13 $g \cdot kg^{-1}$), which is further evidence of the lack of fine materials in the sediments in the study area. Moisture content ranged from 17 to 28% (mean ± SD; 23.29 ± 3.99%). Most metals tested for were below detectable levels. Only aluminum, iron, manganese and strontium were detected in all samples, while lead (n=3), vanadium (n=2) and barium (n=1) were also detected. No CCME (2002) ISQGs or PELs Guidelines for the Protection of Aquatic Life were exceeded in sediment samples collected in the Strait of Belle Isle. It is also worth noting that trace metals and other contaminant levels in marine sediments are commonly related to sediment particle size and to organic carbon content (Halcrow et al. 1973). The low proportion of clays and organic matter in the sediments from the Strait of Belle Isle would make them less apt to bind and retain metals.

The concentration of metals in marine sediments is dependent on local geology, particle size, amount of organic matter, anthropogenic influence, and the dynamics of transportation, deposition, and erosion (AMAP 1979). The distribution of heavy metals among the various environmental compartments is dynamic and driven by multiple processes, both natural and anthropogenic, and concentrations tend to increase from water to sediment to biota. In the 2010 water and sediment data there is no evidence of anthropogenic influence on these compartments in the study area. In the northern Arctic and other relatively pristine areas, metals occur in marine ecosystems as a result of natural sources due to geochemical cycling processes and metal levels in these environments are generally considered background levels (AMAP 1979).

Hydrocarbons were detected in only two samples and those detected were in low concentrations with no CCME or PEL guidelines exceeded. Potential sources of hydrocarbons in marine sediments are diverse and include natural sources (e.g., biogenic sources and petroleum seeps) and anthropogenic sources (e.g., offshore exploration and production, fuel transportation and storage facilities, sewage input, and commercial and recreational boat traffic, combustion sources). Generally, consistent with the water quality results, hydrocarbons in marine sediments confirmed the pristine nature of the marine environment in the study area and there is virtually no evidence of any anthropogenic input.

4.3 Benthic Invertebrates

Twelve sites were successfully sampled for benthos and sediment grabs mostly consisted of coarse material, including pebbles, cobbles and rubble and considerable shell material. Samples contained moderate to high abundance, biomass, and diversity of organisms and five of 12 samples were sub-sampled owing to the large number of organisms in the sample. Abundance ranged from 143 to 2,878 organisms/sample with six stations (50%) exceeding 1,000 organisms per sample. Biomass (g/sample wet weight) ranged from 1.12 to 274.91 g/sample with six samples (50%) exceeding 10 g/sample. There was no correlation between abundance and biomass as several larger taxa and/or individuals were not equally distributed in samples. Abundance and biomass estimates were considered semi-quantitative at best as the volume of sample retained for benthic analyses was variable between stations.

A total of 14,303 organisms representing 308 different taxa at various taxonomic levels (species, genus, family, order, class) were recovered from the samples and the benthic community was dominated by Polychaetes (69.1%), followed by Amphipods (7.5%), Echinoderms (6.3%), Bivalves (3.7%), meiofauna and plankton (2.5%), Gastropods (2.2%), Isopods (1.4%) and Porifera (1.3%). Abundant taxa, occurring in 75% or more samples, included Polychaetes, including *Spirorbis* spp., found in all samples, *Exogone hebes* and unidentified *Sabellidae* sp. found in 10 samples, and unidentified *Syllidae* sp. (10 samples). Brittle stars (*Ophiopholis aculeate* and *Ophiura robusta*) were found in all 12 samples as were hard coral. The hard shelled clam, *Hermithiris psittacea* was found in 11 samples. Other abundant taxa included unidentified Stenothidae *sp.*, Ischyroceridae*,* Harpacticoid copepods, the bivalve *Limatula subauriculata*, white northern chiton *Ischnochiton albus*, colonial bryozoans sp., and small nematode meiofauna. Common Taxa, found in 50 to 75% of the samples, included several polychaetes, amphipods, bivalves, isopods , ribbon worms (Tanaidacea), corals, sponges, and various meiofauna including fish lice and Ostracoda.

The dominant taxa were members of the encrusting, tube building genus *Spirorbis*, which were an order of magnitude greater in abundance than all other benthic taxa and these organisms were present both loose (within the sample) as well as attached to rocks and shell debris. Other important Polychaetes included unidentified Sabellidae species and *Exogone hebes* and *Exogone verugera*, unidentified Syllidae sp., *Chitinopoma serrula*, and *Polycirrus* sp. Dominant Echinoderms included the brittle stars *Ophiura robusta* and O*phiopholis aculeata*. Abundant Amphipods included unidentified Stenothoidae sp. and Ischyroceridae sp. The dominant bivalve was the thick shelled clam *Hiatella arctica*.

A variety of diversity indices were calculated to characterize the benthic community. Taxon Richness as the number of species per sample ranged from 29 to 108 with all but three stations exceeding 50 taxa per sample. The Shannon-Wiener Diversity Index ranged from 0.48 to 1.39 while Pielou's Evenness Index, ranged from 0.29 to 0.74. McIntosh's Index ranged from 0.23 to 0.74 while Simpson's Index ranged from 0.08 to 0.61. Margalef's Index, a commonly used species richness or community diversity index with the higher the index the higher the diversity, ranged from 4.96 to 14.26. The various indices were relatively similar across stations with the exception of stations 2, 13 and 15 which had generally the lower Pielou's Evenness Index and lowest McIntosh's Index and the highest Simpson's Index.

Benthic invertebrates including both infaunal (in the seafloor) and epifaunal (on the seafloor or attached to it and objects) organisms were collected during the October 2010 survey. Fisheries and Oceans Canada (DFO 1997) has previously determined the Strait of Belle Isle to be an Important Area (IA) in terms of benthic invertebrates during the identification of Ecologically and Biologically Significant Areas (EBSAs) in the Gulf of St. Lawrence. Generally, Sikumiut (2010) in reviewing available environmental and biological data sources for the Strait of Belle Isle found that existing benthic data was generally lacking for the region. Chabot et al. (2007) compiled data from various sources, mostly for data from DFO Scientific Multispecies surveys conducted by DFO research vessels from 2000 to 2006. Invertebrates captured within the Strait of Belle Isle Study Area include 20 species of shrimp, species from the soft coral family Alcyoniidae, anemones (Anthozoa), sponges (Porifera), tunicates (Ascidiacea), sea stars (Asteroidea), Gorgonocephalidae, Ophiuridae, sea urchins, as well as various bivalve and crab species (Chabot et al. 2007). These data are not comparable to data collected during this survey as the survey trawl would only capture invertebrates on the surface of the seabed or the water column just above the bottom also potentially explaining the dominance of shrimp species.

Ardisson and Bourgel (1992) looked at invertebrates species present at moored navigational buoys throughout the Gulf of St. Lawrence and within the study area over a 12 year period (1974 to 1985). The benthic fauna were dominated by sessile organisms including bivalve molluscs *Mytilus edulis, Hiatella arctica*, Hydrozoa species (*Obelia longissima, O. geniculata*), *Tubularia larynx*, and crustacean species (*Balanus crenatus, Semibalanus balanoides*).

Recently, AMEC Earth and Environmental (2010) conducted macrofaunal surveys using drop video (2008) and diver guided mobile video (2009) along the corridors of the proposed submarine cable crossings in 2008 and 2009 and found 35 and 20 taxa, respectively. Data were analyzed to determine percent occurrence and relative abundance. For the 2008 marine survey, starfish (*Asterias sp.*), pale urchin (*Strongylocentrotus pallidus*) and hydroids (numerous species) were the most widely distributed, while in the 2009 surveys perwinkle (*Littorina sp*.) were the most widely distributed. These data should be considered complementary to the benthic community data determined from sediment grabs in this study. The AMEC study, using video, could only identify the large epifaunal species occurring on the sediment surface while the survey results presented in this report also included infauna from the top 15 to 20 cm of the sediment.

4.4 Summary

In summary, the water and sediment quality in the Strait of Belle Isle proposed submarine cable crossing corridors indicated a pristine environment, with no evidence of any anthropogenic influence. The water column was stratified with respect to temperature and salinity in the deeper stations but not at the stations adjacent to the Newfoundland and Labrador coasts. The benthic community was abundant and diverse, containing both epifauna and infauna, and reflected the heterogeneity of substrate material.

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APPENDIX A

Water and Sediment Quality Data

NOTE: In the interests of efficiency and brevity, these detailed Laboratory Data Sheets have not been reproduced and printed in this submission. These have been provided to Fisheries and Oceans Canada, and are available as requested and required from Nalcor Energy.

APPENDIX B

Benthic Invertebrate Data

Table B-I . Benthic Invertebrates Raw Data for the Strait of Belle Isle Proposed Submarine Cable Crossing Corridors

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Percent Processed	**100%**	**100%**	**100%**	**100%**	**100%**	**66.67%**	**100%**	**33.33%**	**40%**	**28.57%**	**100%**	**33.33%**
SPECIES												
MOLLUSCA												
BIVALVIA												
Astarte borealis	0	0	0	0	1	0	0	0	0	0	0	2
Astarte quadrans	0	1	0	0	0	0	0	0	0	0	0	3
Astarte undata	2	0	0	0	0	0	0	0	0	0	0	0
Astarte undata?	0	0	0	0	0	0	0	0	0	1	0	0
Bivalve sp. A	1	0	0	0	0	0	0	0	0	0	0	0
Bivalve sp. B	0	0	0	0	0	1	0	0	0	0	0	0
Bivalve unid.	0	0	0	0	0	4	0	0	0	0	0	1
Cerastoderma pinnulatum	12	1	0	0	0	0	0	0	0	0	0	0
Chlamys islandicus	0	0	0	0	0	1	9	0	0	0	0	0
Crenella decussata	1	0	1	3	0	0	1	0	0	0	2	5
Crenella faba	0	1	0	0	0	0	0	0	0	0	0	0
Crenella? *faba*	0	0	0	0	0	0	0	0	0	0	0	2
Crenella glandula	1	0	0	3	0	0	1	0	2	0	0	0
Cyclocardia borealis	0	1	0	0	0	4	0	0	0	0	0	0
Cyclocardia novaeangliae	0	0	1	2	9	24	4	1	0	0	4	6
Cyclocardia novaeangliae?	0	0	0	0	0	0	0	0	0	0	1	0
Hiatella arctica	1	0	0	0	1	21	303	0	4	0	2	20
Limatula subauriculata	0	0	1	4	8	19	3	3	2	10	0	5
Liocyma fluctuosa	0	0	0	0	0	0	0	0	0	0	0	0
Modiolus modiolus	0	0	0	0	0	0	0	0	0	0	0	0
Musculus niger	0	0	0	0	0	0	2	0	0	0	0	0
Mya truncata	0	0	0	0	0	0	0	2	0	0	0	0
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0	0
Thracia myopsis	0	0	0	1	0	0	0	0	0	0	0	0
GASTROPODA												
Anomia squamula	0	0	0	0	0	5	0	3	1	1	1	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Boreotrophan truncatus	0	0	0	1	0	1	4	0	0	0	0	0
Buccinidae?	0	2	0	0	0	0	0	0	0	0	0	0
Colus sp.	0	0	0	0	0	0	1	0	0	0	0	0
Gastropod sp. A	0	1	0	0	0	0	0	0	0	0	0	0
Gastropod sp. B	0	0	0	0	6	0	0	0	0	0	0	0
Gastropod sp. C	0	0	0	2	0	7	0	0	0	0	1	2
Gastropod sp. D	0	0	0	1	0	0	0	1	0	1	0	92
Gastropod sp. E	0	0	0	0	0	0	1	0	1		0	0
Gastropod sp. F	0	0	0	0	0	1	0	1	0	0	0	0
Gastropod sp. G	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod sp. H	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod sp. I	0	0	0	0	0	0	1	0	0	0	0	0
Gastropod sp. J	0	0	0	0	0	6	0	0	0	30	0	19
Gastropod sp. K	0	0	0	0	0	0	0	0	0	0	0	1
Gastropod unid.	0	0	1	0	0	9	6	0	0	0	0	8
Lacuna vincta	1	0	0	0	0	0	0	0	0	0	0	0
Lepeta caeca	0	0	0	0	0	1	0	0	0	0	0	0
Margarites costalis	0	0	0	0	0	0	0	0	0	3	1	0
Margarites costalis, var. A	0	0	0	0	0	1	0	0	0	0	0	0
Margarites sp.	0	0	1	0	0	0	0	0	0	0	0	0
Moelleria costulata	1	1	0	0	0	1	0	0	0	0	0	0
Muricidae	0	0	0	0	0	0	4	0	0	0	0	0
Nudibranch sp. A	0	0	0	1	0	0	2	0	0	0	0	0
Nudibranch sp. B	0	0	0	1	0	0	0	0	0	0	0	0
Nudibranch sp. C	0	0	0	0	0	0	0	1	0	0	0	0
Nudibranch sp. D	0	0	0	0	0	2	0	0	0	0	0	0
Nudibranch unid	0	0	0	0	0	0	1	0	0	0	0	0
Odostomia? sp.	0	0	0	0	3	0	0	0	0	0	0	0
Oenopota nobilis	0	0	0	0	0	0	0	1	0	0	0	0
Oenopota sp.	0	0	0	2	0	0	0	0	0	0	0	0
Onchidoris? sp.	0	0	0	0	0	0	0	2	0	0	0	0
Polinices immaculatus	0	0	0	0	0	0	1	0	0	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Puncturella noachina	0	0	0	2	2	12	7	2	0	1	1	2
Retusidae	0	0	0	0	0	1	0	0	0	0	0	0
Solariella obscura	0	0	1	0	0	0	0	0	9	0	1	3
Solariella obscura?	0	0	0	4	0	3	0	5	0	0	0	0
Solariella varicosa	0	0	0	3	0	0	0	1	3	0	1	5
Solariella sp.	0	0	0	0	0	0	3	0	0	0	0	0
Tachyrhynchus erosus	0	0	0	0	0	1	0	0	0	0	0	0
Trichotropis? borealis	0	0	0	0	1	0	0	0	0	0	0	0
Velutina undata	0	0	0	0	0	0	0	0	0	0	1	0
POLYPLACOPHORA												
Ischnochiton albus	0	0	1	1	0	9	2	4	2	5	3	1
Tonicella marmorea	2	0	0	0	0	0	0	0	0	0	0	0
Tonicella rubra	2	0	0	0	0	0	0	0	0	0	0	0
Chiton sp. A	0	0	0	0	0	0	1	0	0	0	0	0
Chiton unid	0	0	0	0	0	0	2	0	0	0	0	0
BRACHIOPODA												
Glaciarcula spitzbergensis	0	0	0	0	0	0	1	0	1	1	0	0
Hermithiris psittacea	6	1	0	2	5	14	3	16	4	1	4	2
Brachiopod sp. B	0	2	0	0	0	0	0	0	0	0	0	0
ANNELIDA												
POLYCHAETA												
Ampharetidae unid	3	1	0	21	17	2	4	21	2	1	1	0
Anobothrus gracilis	0	0	0	1	0	0	0	0	0	0	0	0
Arcteobia anticostiensis	0	0	1	0	0	0	0	0	0	0	0	0
Aricidea catherinae	1	0	0	0	0	0	0	0	0	0	0	0
Aricidea sp. B	0	0	0	0	5	0	0	0	0	0	0	0
Asabellides? sp	0	0	0	0	0	2	0	0	0	0	0	0
Capitella capitata	0	0	0	0	0	0	0	0	0	0	0	0
Capitellidae unid	0	0	0	0	0	0	0	2	1	3	0	0
Chaetozone? sp.	0	0	0	0	0	0	0	0	0	0	0	0
Chitinopoma serrula	0	0	0	24	1	111	55	0	12	0	0	7
Chone sp.	0	0	0	0	0	11	0	0	16	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Cirratulidae unid.	0	0	0	1	0	0	3	0	0	0	0	0
Cirratulus sp.	0	0	0	0	0	0	0	1	0	0	0	0
Diplocirrus? sp.	0	0	0	0	0	1	0	0	0	0	0	0
Eteone flava?	0	0	0	0	0	0	1	0	0	0	0	0
Eteone longa	0	0	0	1	0	0	0	0	0	1	0	0
Euchone papillosa	0	0	0	4	0	1	0	0	5	1	0	0
Euchone sp. A	30	0	0	0	0	0	0	0	0	0	0	0
Eulalia? sp.	0	0	0	0	0	0	0	0	0	1	0	0
Eumida sanquinea	0	0	0	0	0	6	7	0	2	0	0	1
Eumida sp.	0	0	0	0	0	0	0	1	0	0	0	0
Exogone dispar	0	0	1	0	0	3	0	54	24	0	13	0
Exogone hebes	7	1	0	0	115	50	6	8	31	66	18	52
Exogone verugera?	0	3	7	0	36	95	0	0	19	168	0	0
Flabelligera affinis	1	0	0	1	0	0	1	3	0	0	0	0
Flabelligeridae?	0	0	0	0	0	1	0	0	0	0	0	0
Glycera capitata	0	0	0	1	4	0	0	2	5	0	0	5
Glycera dibranchiata	0	0	0	0	1	0	0	0	0	0	0	0
Gyptis sp.	0	0	0	0	0	2	10	0	7	0	0	45
Harmothoe extenuata	2	0	0	5	0	1	1	0	0	0	0	0
Heteromastus filiformis	0	0	0	0	0	0	0	0	0	0	0	0
Levinsenia? sp.	4	0	0	0	0	0	0	0	0	0	0	0
Maldanidae	0	0	0	0	29	0	0	0	0	0	0	0
Maldanidae sp. A	0	1	0	0	0	0	0	0	0	0	0	0
Maldanidae sp. B	2	0	2	14	0	0	0	0	5	1	0	0
Maldanidae sp. C	0	0	0	0	0	0	0	0	0	0	0	0
Mediomastus ambiseta	2	0	0	10	0	0	2	0	0	0	0	0
Microphthalmus sczelkoweii	0	0	0	0	0	0	0	0	0	0	0	0
Microphthalmus sp.	0	0	0	0	0	0	0	0	0	3	0	0
Nereis sp.	1	0	0	0	0	2	1	0	0	0	0	0
Nothria conchylega	0	0	1	3	1	13	0	1	1	4	2	0
Ophelina acuminata	1	0	0	0	3	0	0	0	0	0	0	0
Owenia? sp.	0	0	1	0	0	0	0	0	0	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Paradoneis? sp.	0	0	0	0	0	0	0	0	0	0	0	0
Paraonidae sp. B	0	0	0	0	0	0	5	0	0	0	0	0
Paraonidae sp. C	0	0	0	0	0	0	0	0	1	1	0	0
Paraonidae unid	0	0	0	7	0	0	0	0	0	0	0	0
Parougia caeca	0	0	0	0	0	0	1	0	0	0	0	0
Pectinaria granulata	1	3	0	1	0	0	0	0	0	0	1	0
Pherusa sp.	0	0	0	1	1	2	0	1	0	2	1	0
Pholoe minuta	0	0	0	4	7	0	1	3	0	7	2	2
Pholoe sp.	0	0	0	0	0	7	4	0	3	0	0	0
Phyllodoce maculata?	0	0	0	0	0	1	3	0	0	0	0	0
Phyllodoce mucosa?	8	0	0	0	0	0	0	0	0	0	0	0
Phyllodocidae sp. A	0	0	0	0	0	11	0	3	0	0	0	0
Phyllodocidae sp. B	0	3	0	0	0	0	0	0	1	0	0	0
Polychaete sp. A	0	1	0	0	0	0	0	0	0	0	0	0
Polychaete sp. B	0	0	0	1	0	0	0	0	0	0	0	0
Polychaete sp. C	0	0	0	1	0	0	0	0	0	0	0	0
Polychaete sp. D	0	0	0	0	0	0	0	0	0	0	15	0
Polychaete sp. E	0	0	0	0	0	0	0	0	0	0	0	0
Polychaete unid	0	0	0	2	0	2	0	0	0	1	0	0
Polycirrus sp.	0	1	0	33	0	0	14	0	12	61	6	0
Polynoidae unid	0	0	0	0	0	0	0	0	0	0	0	1
Praxillella? sp.	0	0	0	0	0	0	1	0	0	0	0	0
Pygospio? *elegans*	0	0	0	0	0	0	0	0	0	0	0	0
Sabellidae unid	0	1	0	55	37	147	198	74	8	1	52	36
Scoloplos acutus	0	0	0	0	0	0	0	0	0	0	0	0
Spio filicornis	0	0	0	0	0	2	9	0	1	0	2	0
Spionidae	0	0	0	0	0	1	0	0	0	0	0	0
Spirorbis spp.	604	102	40	273	340	782	172	337	500	2196	320	1099
Syllidae unid	0	0	6	218	35	82	121	40	32	127	86	64
Terebellidae unid.	0	0	0	0	0	0	3	0	2	0	0	0
Tharyx sp.	0	0	0	1	0	0	0	0	0	0	0	0
Thelepus cincinnatus	0	1	1	0	0	13	4	0	17	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Travisia? sp.	0	0	0	1	0	0	2	0	3	0	0	0
ARCHIANNELIDA												
Archiannelid unid	0	0	2	4	28	0	0	0	1	0	0	0
Protodrilidae unid.	0	0	0	0	0	4	5	0	14	2	7	14
MARINE OLIGOCHAETE	0	0	0	4	53	1	0	0	1	0	0	7
ECHINODERMATA												
Crossaster papposus	0	0	0	4	0	1	0	0	2	10	0	0
Echinarachnius parma	1	0	0	0	1	0	0	0	0	0	0	0
Ophiopholis aculeata (Ophiuroid sp. A)	7	26	1	21	2	12	21	6	21	7	4	1
Ophiura robusta (Ophiuroid sp. B)	53	21	10	144	79	98	14	59	75	61	28	21
Ophiuroid sp. C	0	0	1	5	0	0	4	0	0	0	0	0
Ophiuroid sp. D	0	0	0	0	3	8	4	0	7	3	0	0
Ophiuroid sp. E	0	0	0	0	0	0	0	0	0	0	0	5
Psolus phantapus	0	1	0	0	1	0	2	1	0	0	0	1
Strongylocentrotus droebachiensis	10	6	0	6	0	0	0	0	0	0	0	0
Strongylocentrotus pallidus	0	0	3	0	0	2	0	0	8	1	0	1
Strongylocentrotus sp.	0	0	0	0	0	0	0	2	0	0	0	0
ARTHROPODA												
CHELICERATA												
PYCNOGONIDA												
Ammothea? *achelioides*	0	0	0	1	0	0	0	0	0	0	0	0
Nymphon rubrum	0	0	0	9	0	0	0	0	0	0	0	0
Pseudopallene? *discoidea*	0	0	0	1	0	0	1	0	0	0	0	0
Pycnogonid A	0	0	0	0	0	0	1	0	0	0	0	0
Pycnogonid B	0	0	0	0	0	0	1	0	0	0	0	0
CRUSTACEA												
AMPHIPODA												
Acanthonotosoma serratum?	0	0	0	0	0	0	0	1	0	0	0	0
Amphilochus manudens	0	0	0	4	0	13	1	4	5	21	7	1
Anonyx sp.	0	0	0	2	0	0	0	0	1	0	0	0
Apherusa megalops	0	0	0	0	0	0	0	0	0	0	2	0
Calliopius laeviusculus	0	0	0	0	0	0	0	0	0	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Caprellidae unid.	0	0	0	0	1	0	2	0	1	0	0	0
Corophium? sp.	0	0	0	0	0	0	0	0	0	0	0	0
Ericthonius rubricornis	0	0	28	9	0	8	11	12	3	0	1	0
Eurystheus melanops	0	0	0	15	2	2	16	8	5	7	1	0
Eusirus cuspidatus	0	0	1	0	1	39	0	0	0	0	0	0
Gammaropsis? sp.	0	5	0	0	0	0	0	0	0	0	0	0
Gammarus oceanicus	0	0	0	0	0	0	0	0	0	0	0	0
Gitanopsis inermis	0	0	0	0	0	1	0	1	0	0	0	0
Guernea nordenskjoldi	0	0	0	6	0	0	0	1	0	0	0	2
Hippomedon sp.	0	0	0	0	0	0	0	0	0	4	1	0
Ischyroceridae unid	0	0	13	26	25	15	171	19	26	3	5	5
Leucothoe sp.	0	0	0	0	0	0	0	0	0	0	0	1
Lysianassidae unid	0	0	0	0	0	0	0	5	0	0	1	0
Melita denata	0	0	0	0	0	0	0	0	1	0	0	0
Metopa norvegica	0	0	9	0	1	2	1	0	15	0	0	0
Neopleustes pulchellus	0	0	0	0	0	0	1	0	0	0	0	0
Oediceros saginatus	0	0	0	0	0	0	0	0	0	0	0	0
Oedicerotidae sp. A	0	0	0	1	0	0	2	0	0	0	0	0
Orchomenella minuta?	0	0	0	0	0	0	2	0	0	0	1	0
Phoxocephalus holbolli	0	0	0	1	0	0	0	0	0	0	0	0
Pleustidae unid.	0	0	0	5	0	0	20	0	0	0	3	0
Pontogeneia inermis	2	0	0	0	0	0	0	0	0	0	0	0
Protomedeia sp.	0	0	0	0	0	0	3	0	0	0	0	0
Psammonyx terranovae	0	0	0	0	0	0	0	0	0	0	0	0
Stenothoidae unid	0	1	3	43	63	23	135	30	65	20	18	2
Syrrhoe crenulata	0	0	0	0	0	0	0	0	0	0	0	1
Tiron spiniferum	0	0	0	0	4	1	1	1	3	1	3	1
Tryphosa sp.	0	0	0	0	0	0	0	0	0	0	0	1
Unciola irrorata	0	0	0	0	0	0	0	1	7	0	0	0
Unicola sp							0	0	1	0	0	0
Westwoodilla sp.	0	0	0	0	2	0	0	0	0	0	0	0
Amphipod unid	0	0	0	0	1	3	1	0	0	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
ISOPODA												
Isopod sp. A	0	0	0	2	0	0	1	0	0	0	0	0
Isopod sp. B	0	0	0	1	1	0	0	0	0	0	0	0
Isopod sp. C	0	0	0	1	0	1	0	2	16	3	0	2
Isopod sp. D	0	0	0	1	1	0	0	2	0	0	1	0
Isopod sp. E	0	0	0	0	0	0	0	4	2	2	0	9
Munna acanthifera?	0	0	0	3	0	0	0	0	0	0	0	0
Munna fabricii	0	0	0	16	3	16	50	5	10	2	10	0
Munna sp.	0	1	0	0	0	1	0	0	0	0	0	0
Philoscia vittata	0	1	0	0	0	0	0	0	0	0	0	0
Pleurogonium spinosissmum	0	0	0	1	1	2	1	0	1	0	0	3
Synidotea nodulosa	0	0	0	0	1	1	11	4	2	0	0	0
Isopod unid.	0	0	0	0	0	0	0	1	0	0	0	0
CUMACEA												
Camplyaspis sp.	0	0	0	0	0	1	1	0	0	2	0	0
Cumacean sp. A	0	0	0	4	0	0	0	0	0	0	0	0
Leucon nasicoides	0	0	0	3	0	2	0	1	0	1	0	0
DECAPODA												
Hyas coarctatus	0	0	1	0	1	0	0	0	0	0	0	0
Shrimp sp. A	0	0	0	0	0	0	1	0	0	0	0	0
TANAIDACEA												
Tanaid sp. A	0	0	0	0	2	4	4	5	3	15	1	0
CIRRIPEDIA												
Balanus balanus	0	0	0	0	2	29	12	0	0	0	3	0
Balanus crenatus	0	0	0	0	2	3	42	0	0	0	0	0
Balanus sp.	0	0	0	0	2	0	21	0	0	0	0	0
Barnacle unid	0	0	0	0	0	2	0	0	0	0	0	0
NEMERTEA												
Cerebratulus sp.	2	0	0	3	1	1	0	0	2	3	0	0
Nemertean sp. A	1	0	0	0	0	0	0	0	0	0	0	0
Nemertean sp. B	0	1	0	0	0	0	0	0	0	1	0	0
Nemertean sp. C	0	0	0	0	0	0	7	0	0	0	0	0

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
Nemertean sp. D	0	0	0	0	0	0	0	0	0	0	1	0
Nemertean sp. E	0	0	0	0	0	0	0	0	0	0	1	0
Nemertean unid	4	0	0	0	0	1	1	3	15	0	0	2
SIPUNCUIDA												
Phascolion strombi	0	0	1	3	1	3	0	0	0	0	0	0
Sipunculid sp. A	0	0	0	0	0	0	0	0	0	2	0	0
Sipunculid sp. B	0	0	0	0	0	0	2	0	0	0	0	0
PRIAPULIDA	0	0	0	1	0	0	0	0	0	0	0	0
CNIDARIA												
Alcyonaria sp. A	0	0	0	2	1	42	10	0	0	0	3	1
Alcyonaria sp. B	1	0	0	0	0	0	0	0	0	0	0	0
Anemone sp. A	0	0	0	1	0	0	0	0	0	0	0	0
Anemone sp. B	0	0	0	0	0	0	1	0	0	0	0	0
Anemone unid.	0	0	0	0	0	0	3	1	0	0	0	1
Bunodactis stella	0	0	0	1	0	0	1	0	1	0	0	0
Edwardsia elegans	0	0	0	1	0	0	1	0	2	3	0	1
Gersemia rubiformis	0	0	3	2	0	6	4	0	0	1	0	0
Hydroid unid.	0	0	0	1	0	0	9	1	0	0	0	0
HEMICHORDATA												
Saccoglossus? sp.	0	0	0	0	0	1	108	0	0	0	0	0
CHORDATA												
Ascidia callosa	0	0	0	0	0	21	5	0	0	0	1	5
Boltenia echinata	0	0	0	0	0	3	5	0	0	0	0	0
Boltenia ovifera?	0	0	0	0	0	0	3	0	0	0	0	0
Ascidian sp. A	0	0	0	0	0	1	0	0	0	0	0	0
Ascidian sp. B	0	0	0	0	0	19	1	0	0	0	0	9
Ascidian sp. C	0	0	0	0	0	10	12	0	0	0	0	4
Ascidian sp. D	0	0	0	0	0	8	0	0	0	0	0	5
Ascidian sp. E	0	0	0	0	0	1	0	0	0	0	0	0
Ascidian sp. F	0	0	0	1	0	0	1	0	0	0	0	0
Ascidian sp. G	0	0	0	0	0	0	0	0	0	1	0	0
Ascidian unid.	0	0	0	1	0	13	0	0	0	0	0	1

	S-002	S-003	S-005	S-006	S-008	S-009	S-010	S-011	S-012	S-013	S-014	S-015
PORIFERA												
Leucosolenia sp	0	0	0	3	0	7	8	0	0	0	0	1
Scypha sp.	0	0	0	5	1	48	35	0	0	3	5	7
Porifera sp. A	0	0	0	0	0	10	5	0	0	0	0	0
Porifera sp. B	0	0	0	0	0	7	5	0	0	0	1	0
Porifera sp. C	0	0	0	0	0	0	18	0	0	0	0	0
Porifera sp. D	0	0	0	1	0	0	6	0	0	0	1	0
Porifera sp. E	0	0	0	0	0	5	1	0	0	0	0	1
PLATYHELMINTHES												
Flatworm sp. A	0	0	0	0	1	0	3	0	3	0	0	0
MISCELLANEOUS												
Unidentified Taxon A	0	0	0	3	0	0	1	1	0	0	0	0
Unidentified Taxon B	0	0	0	0	0	2	1	0	0	0	0	4
FISH												
Ammodytes sp.	0	0	0	0	0	0	0	0	0	0	0	0
MEIOFAUNA & PLANKTON												
Bryozoa (Present/Absent)	P	P	A	P	P	P	P	A	A	P	P	P
Calanoid Copepod	0	0	0	0	0	1	0	0	0	0	0	0
Harpacticoid Copepod	0	0	1	9	0	9	9	3	4	8	2	25
Egg cases	0	0	0	0	0	P	0	0	0	0	0	0
Fish Lice	0	1	0	3	2	7	17	0	0	4	1	0
Hydrachnidia	0	0	0	1	0	3	0	1	0	0	2	0
Ostracoda	0	1	1	2	0	1	0	1	0	0	0	1
Nematoda	0	0	2	14	17	52	70	4	4	2	10	0
Foraminifera	0	0	1	26	33	0	0	0	0	0	0	0
Hard Coral (Present/Absent)	P	P	P	P	P	P	P	P	P	P	P	P

APPENDIX C

Study Photographs


Figure C.1 Substrate with encrusting benthic invertebrates including fan worms, barnacles


Figure C.2 Shipek sampler used during the sediment and benthic surveys


Figure C.3 Bivalve mollusc sampled in benthic surveys


Figure C.4 Benthic grab with red soft coral species

Figure C. 5 Benthic grab with large substrate containing encrusting organisms such as barnacles

Figure C.6 Benthic grab with large substrate encrusted with corraline algae

Figure C.7 Sediment grab for site S-011. Typical shell substrate material

Figure C. 8 Large substrate (cobble) from benthic grab including scallops and brittle stars

Figure C.9 Post-processed benthic grab with brittle stars and a sea urchin

Figure C.10 Van Veen Grab with substrate, benthic organisms including a large scallop

Figure C.11 Encrusted invertebrates on cobble/shell substrate

Figure C.12 Benthic samples preserved in 10% buffered formalin prior to shipment to the laboratory for analyses

Figure C.13 Van Veen grab filled with typical sand substrate

Figure C.14 Sediment grab from Van Veen demonstrating the high density of benthic invertebrates

Figure C.15 Demonstrating various species of bivalves in a benthic grab during processing of sample

Figure C.16 Post-processed benthic sample on sieve containing fine sediment