Labrador – Island Transmission Link

Marine Water, Sediment, Benthos and Nearshore Habitat Surveys
Potential Electrode Sites

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EXECUTIVE SUMMARY

Nalcor Energy is proposing to develop the Labrador – Island Transmission Link (the Project), a high voltage direct current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula which will include the installation of shoreline electrodes in Labrador and Newfoundland. The Marine Water, Sediment, Benthos, and Nearshore Habitat Surveys reported in this document comprise part of the marine environmental study program completed for the Project Environmental Assessment (EA).

Surveys were completed at L'Anse au Diable on the Labrador coast, on September 30 and October 6 and 7, 2010, and at Dowden's Point in Conception Bay on the Island of Newfoundland, on October 19 and 20, 2010.

Water quality sampling and CTD profiling were completed at both sites. CTD profiles from four sites at each of L'Anse au Diable and Dowden's Point revealed little evidence of gradients in temperature and salinity, with no thermocline. At both sites, field water quality results were generally comparable between sampling stations with narrow ranges in temperature and conductivity, and high dissolved oxygen at supersaturated levels. Salinities in surface samples at Dowden's Point suggested freshwater influence. Values for pH were alkaline within a narrow range for each site. Orthophosphate was the only nutrient detected at both sites being measured at the detection limit. Metals in samples at both sites were low, with only strontium detected in all samples at both sites and boron at all sites at Dowden's Point and three of four sites at L'Anse au Diable. All metals detected at L'Anse au Diable were within Canadian Council of Ministers of the Environment (CCME) limits. At Dowden's Point, mercury was detected in two samples and both exceeded CCME guideline limits, however the guideline is for inorganic mercury while the analytical result was for total mercury. Toluene was the only petroleum hydrocarbon detected and was measured at the detection limit at both sites, but well within the CCME guideline. Water quality data collected in 2010 from both sites has confirmed the pristine nature of the marine environment in the study areas with no evidence of anthropogenic influence on marine water quality.

Sediment samples were successfully collected from subtidal and intertidal sites at L'Anse au Diable while no samples were collected from Dowden's Point, despite considerable sampling effort, due to the coarse nature of substrates. Physical analysis of sediment from L'Anse au Diable demonstrated a sand dominated composition with clay, silt and gravel present in small quantities. Chemical analyses of sediment determined major ions were comparable between subtidal and intertidal locations, organic carbon content was low, while moisture content was higher in subtidal sediments as compared to intertidal sediments. L'Anse au Diable sediments appear to be well washed with the finer particles and organic carbon being removed and settling in depositional environments. Most metals were below detectable levels with only aluminum, iron, and manganese detected in all samples. No CCME (2002) Interim Sediment Quality Guidelines (ISQGs) or Potential Effect Level (PELs) guidelines were exceeded in L'Anse au Diable sediment samples. The absence of clay and low organic content may play a role in the low metal content. Hydrocarbons were not detected in any sample consequently no CCME and PEL guidelines were exceeded. Data for L'Anse au Diable sediments also confirmed the pristine nature of the marine environment in this area.

Benthic samples were collected from subtidal and intertidal zones at L'Anse au Diable. Sediment could not be sampled at Dowden's Point, and consequently no benthic samples were obtained. Samples contained low to moderate abundances while biomass and diversity of organisms were low, with biomass and taxon richness appreciably less in intertidal samples. The benthic community in subtidal samples was dominated by infauna including Polychaetes, Archiannelida, Nemertea, Amphipods and Bivalves, while 99 % of intertidal benthos were small unidentified marine Oligochaetes. Biomass at subtidal sites was an order of magnitude greater than at the intertidal sites and there was also a large difference in taxon richness with subtidal richness (11 to 16 taxa) greater than intertidal richness (two to three taxa). A variety of diversity indices calculated to characterize the benthic community also confirmed a large difference between the subtidal and intertidal benthic community. The benthic community at L'Anse au Diable reflected both the substrate from which samples were collected and the semi-exposed nature of the habitat. The benthic community was dominated by infauna as there was no large substratum for epifauna to attach to and no associated macroflora to provide food and cover.

Nearshore habitat surveys were completed at both sites and focused on assessing habitat characteristics at the Shore Zone level of detail including: (i) backshore; (ii) intertidal zone; and (iii) shallow subtidal zone. At L'Anse au Diable, the bathymetry was irregular, with maximum depth at 8.0 m, and steep bedrock slopes were evident which changed to a plateau of more uniform depth. Substrate types were heterogeneous and consisted of a single substrate type or combinations of two and three substrate types. Bedrock (50.1 %) was extensive throughout the study area while sand (35.3 %) was also well represented. Macroflora were abundant and diverse with coralline red algae, brown algae including filamentous species, filamentous red algae, edible kelp, and sea lettuce well represented. Macroflora distribution was influenced by substrate distribution. The dominant macrofauna observed at L'Anse au Diable were sea urchins, either pale urchin or green urchin, while starfish and sculpin were occasionally observed. Substrate distribution was integrated with macrofloral distribution to define integrated habitat classes for L'Anse au Diable as follows: (i) coarse substrate with macroflora (1.53 ha, 50 %); (ii) coarse substrate with no macroflora (0.03 ha, 1 %); (iii) mixed substrate with macroflora (0.42 ha, 14 %); (iv) mixed substrate with no macroflora (0.03 ha, 1 %); and (v) fine substrate with no macroflora (1.02 ha, 34 %).

Dowden's Point bathymetry was uniform with a trend to increasing depth parallel with the shoreline, with no depressions or hummocks in the seabed topography, and a maximum depth of 5.5 m. The intertidal zone was entirely boulder/cobble habitat while the backshore was a Steep Gravel and Sand Beach with a steep upper slope of eroding glaciofluvial materials. The subtidal substrate was relatively uniform consisting of combinations of boulder, cobble and sand with boulder/cobble the dominant substrate type. There was little diversity in macroflora in the study area with calcareous encrusting red algae and branched red algae of the genus *Lithothamnium* dominating the distribution. Macrofauna observed at Dowden's Point were dominated by green urchin while starfish and blue mussel were occasionally observed. Substrate distribution was integrated with macrofloral distribution to define integrated habitat classes for Dowden's Point as follows: (i) boulder/cobble with macroflora (2.61 ha, 84.3 %); (ii) boulder/cobble with no macroflora (0.04 ha, 1.2 %); (iii) boulder/cobble/sand with macroflora (0.21 ha, 6.8 %); (iv) boulder with macroflora (0.23 ha, 7.6 %); and (v) sand with boulder/cobble with no macroflora (0.01 ha, 0.2 %).

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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 study has been completed with the objective to collect environmental and habitat information in relation to the proposed electrode sites on the Labrador coast of the Strait of Belle Isle and in Conception Bay, Avalon Peninsula, Island of Newfoundland, associated with the proposed HVdc transmission system.

1.1 Project Overview

The proposed Project involves the construction and operation of transmission infrastructure within and between Labrador and the Island of Newfoundland (Figure 1.1). 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.

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FIGURE 1.1

The Labrador - Island Transmission Link Including the Potential Electrode Sites

Project planning and design are currently at a stage of having identified a 2 km wide corridor for the on-land portions of the proposed HVdc transmission line and 500 m wide corridors for the proposed Strait of Belle Isle cable crossings, as well as various alternative corridor segments in particular areas. Study areas have also been identified for the proposed electrodes which are the focus of this report.

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.

Of particular relevance to this study, the proposed HVdc transmission system will include the installation of electrodes, or high capacity grounding systems, in the marine environments of Labrador and Newfoundland. The current Project concept would see the development of two "shore electrodes", one at a location on the Labrador side of the Strait of Belle Isle (L'Anse au Diable) and one in Conception Bay (Dowden's Point). The establishment of these shore electrodes would involve the construction of an in- or near-water (breakwater-like) structure within a small natural or excavated cove or adjacent to the shoreline at the sites, in order to create a small protected marine 'pond' to house the electrode elements.

1.2 Study Purpose and Objectives

The objective of this study was to collect and describe marine environmental and fish habitat data within the proposed sites for shore-based electrodes. The electrode system includes one site on the Labrador coast (L'Anse au Diable) and a second site in Conception Bay, Newfoundland (Dowden's Point). This study included collection of water and sediment quality data, benthic invertebrate community data, and fish habitat information including bathymetry, substrate, macroflora and macrofauna distribution, and backshore characteristics to characterize the marine environment and habitat in the area of the proposed electrode sites. This study, while being focused on the footprint of the proposed electrode sites, is complementary to information gathered in surveys in 2008 and 2009 within the Strait of Belle Isle and shoreline areas (AMEC Earth and Environmental 2010), geophysical surveys in the Strait of Belle Isle in 2007 (Fugro-Jacques Geosurveys Inc. 2010), a literature review of environmental, oceanographic, biological, and fish habitat information in the study area (Sikumiut 2010), and a companion study on marine water and sediment quality and benthic invertebrate communities in the Strait of Belle Isle in 2010 (Sikumiut 2011).

2.0 APPROACH AND METHODS

This study provides marine environmental and fish habitat baseline information for the two proposed electrode sites associated with the HVdc transmission system. The study consisted of field study design and planning, field data and sample collection, laboratory and data analyses, and report preparation. Sampling at the two sites at the Strait of Belle Isle in Labrador and Conception Bay, Newfoundland, included the collection of information on water quality, sediment quality, benthic invertebrate community, bathymetry, substrate distribution, macroflora and macrofauna distribution, and backshore characteristics to contribute to the marine environment baseline information for the two study sites.

2.1 Study Area

The study area for the marine water, sediment, benthos and habitat surveys was focused on the likely footprint of the two proposed electrodes and adjacent areas. The proposed electrode site on the Labrador Coast of the Strait of Belle Isle is a small cove at L'Anse au Diable, between the communities of L'Anse Amour and West Ste. Modeste (Figure 2.1). The proposed electrode site on the Island of Newfoundland is located at Dowden's Point on the south shore of Conception Bay, approximately 3 km northeast of the Holyrood Generating Station (Figure 2.2).

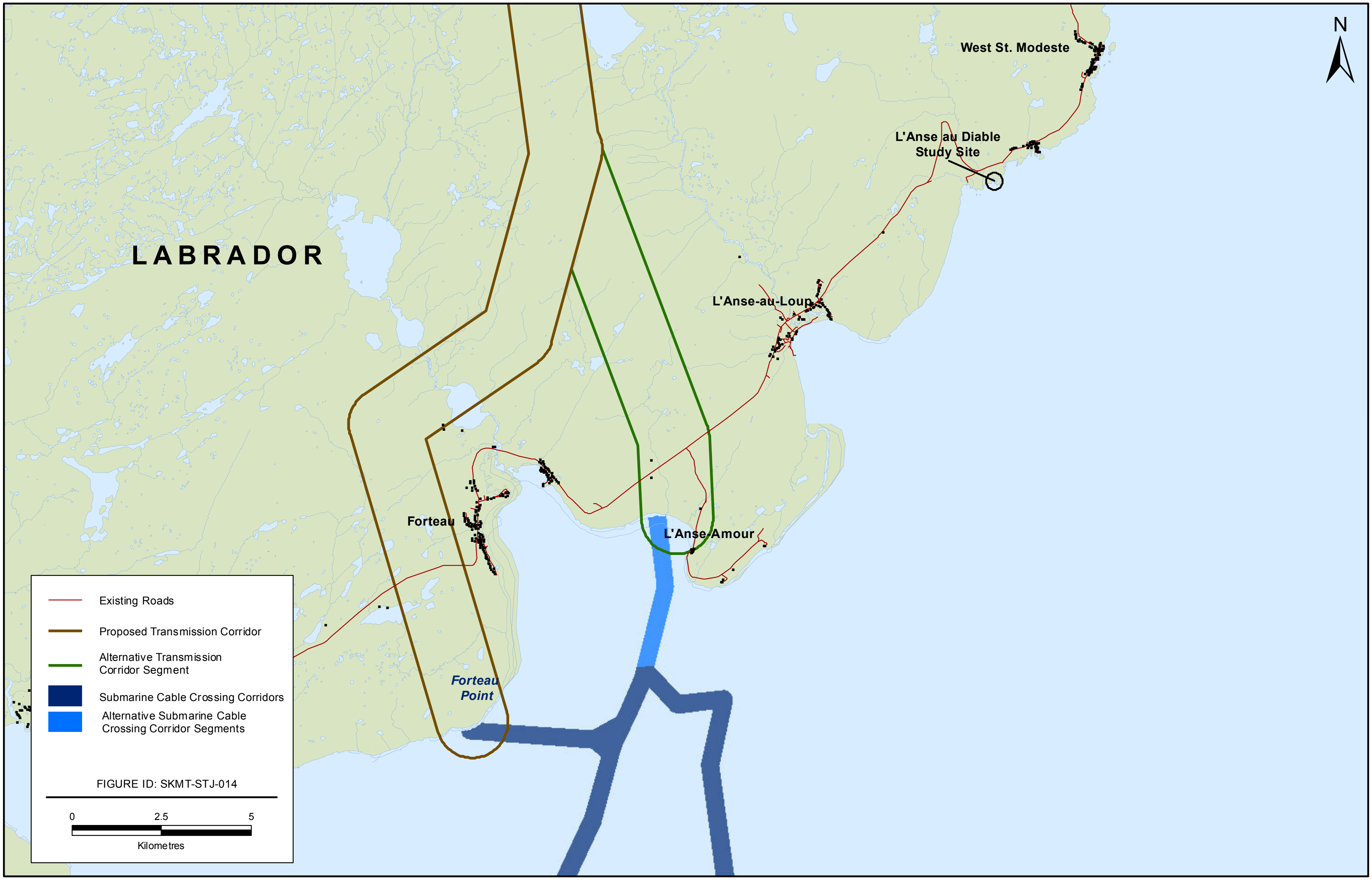

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FIGURE 2.1

L'Anse au Diable Study Site

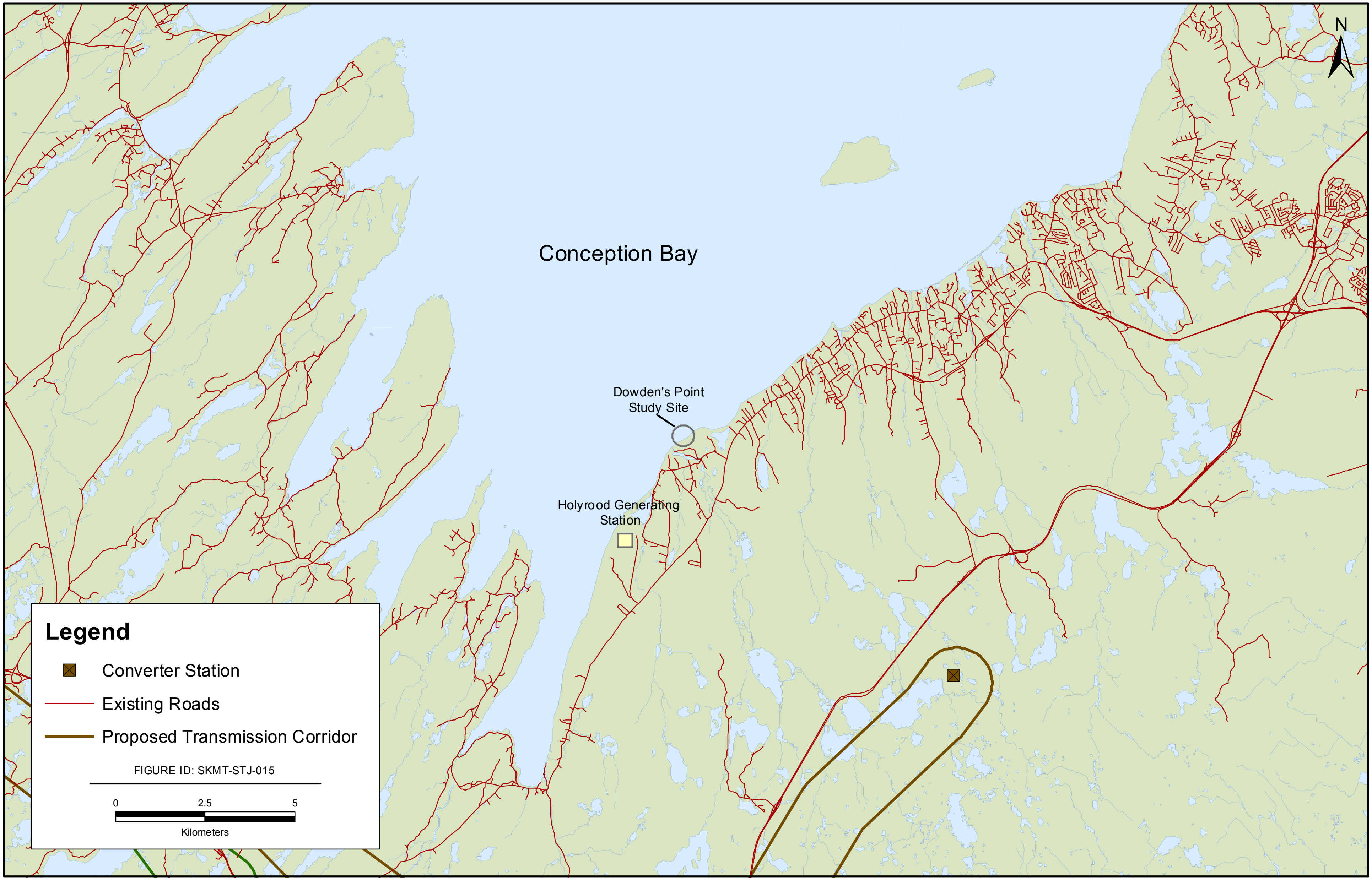

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FIGURE 2.2

Dowden's Point Study Site

2.2 Study Team

The study team (Table 2.1) was led by Larry LeDrew, Project Manager for Client Liaison, Study Logistics, Health and Safety, and Financial Control, and Dave Scruton, as Project Leader for all technical aspects and Lead for report preparation. The field team was led by Narcissus Walsh, with field technical support by Grant Vivian and Kevin Diamond. Field sampling support was completed through the charter of a 7.0 m boat out of L'Anse Amour, Labrador and use of an inflatable zodiac in Conception Bay. Analyses of underwater video was completed by Cynthia Mercer. Data analyses and 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, for client liaison, study logistics, health and safety, and financial control
Dave Scruton, M.E.S.	Senior Scientist	Technical project manager, data analysis, lead for report preparation and review
Narcissus Walsh, B.Sc, B.Ed.	Lead Field Survey Team	Overall study lead for mobilization, implementation and completion of field study components
Grant Vivian, B. Tech	Field Survey Team Member	Field technical support and geomatics specialist; data analyses, graphics and mapping support
Suzanne Thompson, B. Sc.	Biologist	Data analyses and report preparation
Kevin Diamond	Field Survey Team Member	Field technical support, L'Anse au Diable
Cynthia Mercer	Biologist	Underwater video analyses

2.3 Study Design and Planning

The sampling program was planned and conducted in consideration of logistics of sample and data collection (sea state and wave conditions) and the possible influence of tidal cycles on data collection (e.g., bathymetry, video filming of habitat). Existing information for the study areas was reviewed to identify possible sampling constraints related to currents, tides, water depths, and other natural features (AMEC 2010, Sikumiut 2010). Historical weather summaries were consulted in an attempt to schedule the field sampling campaign in consideration of expected weather and sea state conditions (Environment Canada 2010). The Canadian Current and Tide Tables (DFO 2010) were consulted for scheduling purposes with respect to tidal cycles.

The study had four key sub-components including:

a) The collection of water, sediment, and benthic samples at the electrode sites;
b) A bathymetric survey from the shoreline to approximately the 10 m depth contour or the seaward limit of the construction footprint of each site;
c) An underwater video survey from the shoreline to approximately the 10 m depth contour, or the seaward limit of the construction footprint of each site, to characterize and classify marine habitats (substrate and marine plants), and quantify marine fauna; and
d) An assessment of the backshore from the high tide mark to the inland limit of the backshore using standard Fisheries and Oceans Canada (DFO)/Environment Canada criteria.

The initial study plan and design were 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

For each of the two sites, a study area was delineated, in consultation with Nalcor Energy, based on the proposed footprint of the construction area required for each electrode site. The study areas included a length of coastline and all wetted habitat area from the high tide mark into the shallow subtidal zone to a seaward limit of approximately 10 m depth or less. The study site also extended from the high tide mark to the backshore or inland limit of marine processes (e.g., coastal cliff), above any tidal influence. The marine limit for the surveys were set at the 10 m depth contour as, owing to the design and construction of the electrode sites, it was expected that the footprint would be entirely contained within the 10 m extent.

The survey was conducted to be consistent with the DFO document 'A System for Characterizing and Quantifying Coastal Marine Habitat in Newfoundland and Labrador' (Kelly et al. 2009, draft). This 'system' includes a four level hierarchical approach to coastal marine habitat classification moving from the large scale, general, and descriptive level (ecosystem, ecoregion) to the more small scale, detailed level (Shore Unit, shore zone) requiring site specific characterization. This study was conducted to collect data for the detailed Shore Unit/shore zone level of characterization. The DFO system specified various approaches to data collection and classification of information collected.

The survey of the L'Anse au Diable site was conducted in late September and October 2010. Sampling of water, sediment, and benthos in the subtidal zone was completed during marine surveys in the Strait of Belle Isle (results reported separately, Sikumiut 2011). The field team deployed to Labrador on October 5, 2010, and the nearshore surveys and collection of sediment and benthos in the intertidal zone of L'anse au Diable was completed on October 6 and 7. The survey at Dowden's Point in Conception Bay was completed on October 19 and 20 and the field team were stationed in St. John's and travelled between the two locations each day for this work.

The survey of L'Anse au Diable was completed using a chartered 7.0 m fibreglass speedboat, with 70 hp outboard engine. The boat was launched from shore at L'Anse Amour and the field team travelled to/from L'Anse au Diable each day for the survey work. The chartered vessel was used for sediment sampling, bathymetric survey, and the collection of underwater video for substrate, marine flora and fauna assessment. Water, sediment, and benthic samples were collected on September 30 during the Strait of Belle Isle marine surveys using the 13.7 m longliner chartered for that survey component (Sikumiut 2011). The field team used the longliner for this sampling as the vessel was equipped with sampling gear and was in the vicinity of L'Anse au Diable collecting samples for the companion study. Additional sediment and benthos samples were collected from L'Anse au Diable within the intertidal zone on October 7 from land. For the Dowden's Point survey, a 5.8 m inflatable Mark V HD zodiac with 40 hp outboard motor, equipped with a Honda hauler with Capstan and 5 Hp stroke Honda engine, was used for the deployment of the Van Veen sediment grab and Nisken water sampling bottle. All study components were completed from this boat.

2.5 Water Quality

Water quality samples were collected from selected locations at each electrode site and included measurement of field water quality parameters, and collection of water samples for chemical and hydrocarbon analyses at an analytical laboratory. Methods are detailed in the following sections.

2.5.1 **Site Selection**

The water column at each site at the time of sampling was expected to be thoroughly mixed and, after discussion with Nalcor Energy, four samples were considered sufficient to characterize the spatial variation in water quality at each electrode site. Samples were collected by Niskin bottle at a depth of 1 to 2 m below the water surface at representative locations distributed throughout each site. Sample bottles (n=4 per station), as provided by the contracted analytical laboratory, were used to collect water samples for the required analyses. All water samples were stored in coolers prior to collection of sediment to ensure no cross contamination of samples. After collection, samples were packed and shipped to the contracted analytical laboratory (Maxxam Analytics, Bedford, Nova Scotia), along with Chain of Custody (CoC) forms, within 48 hours of collection.

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

A Sea-Bird Electronics SEACAT SBE-19 CTD meter was used to profile conductivity, temperature, and depth (pressure) at the water quality stations at L'Anse au Diable. The unit measures conductivity from 0 to 9 $S \cdot cm^{-1}$ (resolution of 0.00005 $S \cdot cm^{-1}$) and temperature from -5 to +35 $^{\circ}C$ (resolution of 0.0001 $^{\circ}C$). A YSI 600QS water quality multi-parameter sonde was used to collect conductivity (1 $S \cdot cm^{-1}$), temperature (0.01 $^{\circ}C$), and depth measurements (with measured cable) at the water quality stations at Dowden's Point.

For the L'Anse au Diable stations, the SBE-19 was placed in the water and held at the surface to fully initialize the unit sensors. The unit was then lowered in the water column at an approximate rate of one meter per second. The unit was then retrieved to the surface and connected to an onboard computer (laptop) to download and store the CTD data. For the Dowden's Point stations, the probe of the YSI meter was lowered into the water column and readings were taken at 1 m depth intervals and recorded in a waterproof field notebook.

2.5.3 **Field Measurements**

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

2.5.4 **Laboratory Analysis**

Laboratory analyses of water samples were completed by Maxxam Analytics, Bedford NS, and 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 1999, 2007), where available, 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). Extractable hydrocarbons, including diesel and lube range organics were analyzed using capillary column gas chromatography (flame ionization detector).

Table 2.2 Water Quality Parameters Measured at Electrode Sites in 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
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

Table 2.2 Water Quality Parameters Measured at Electrode Sites in 2010 (Cont'd)

	Units	RDL	CCME Guideline	Analysis Method
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		
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

2.5.5 **Analysis and Interpretation**

The purpose of the water sampling program was to characterize marine water quality at each electrode site. Appropriate descriptive and summary statistics (minimums, maximums, means and standard deviations) were calculated and presented for each parameter at each site.

2.6 Sediment Quality

Sediment sampling was conducted at the two electrode sites during the survey program. Sediment samples were not successfully collected from Dowden's Point, despite repeated attempts, owing to the dominance of coarse substrate material at this site. Sediment samples were successfully collected from L'Anse au Diable, in both the subtidal and intertidal zones, and were analyzed to determine the sediment quality (chemistry and hydrocarbons) and physical characteristics. Detailed methods for the collection and analyses of sediment samples are described in the following sections.

2.6.1 **Site Selection**

After discussion with Nalcor Energy, eight samples were considered sufficient to characterize the sediment chemistry and physical characteristics. Sediment (and benthos) samples were collected from different locations with respect to tidal cycles and wave action: four samples were collected from intertidal sites, and four from subtidal sites.

2.6.2 **Sample Collection**

Two types of grabs were available for sediment sampling including a stainless steel Van Veen grab (30 cm by 30 cm, volume of 13.5 L) and a Shipek sediment grab (20 cm by 20 cm, volume of 3 L). After field testing of both devices, the Van Veen was determined to be more effective and retained a larger volume of sample. Subsequently, the Van Veen grab was used for collection of all sediment and benthic samples at the L'Anse au Diable electrode site (Figure 2.3).

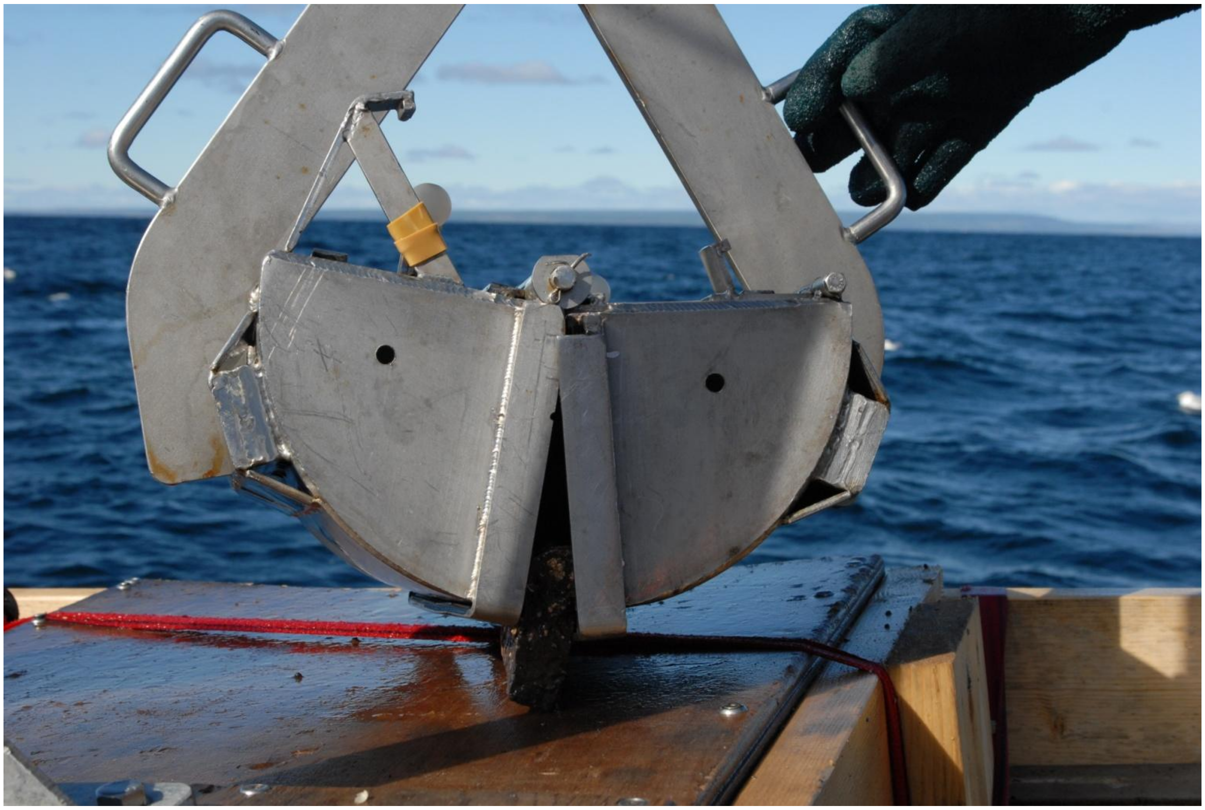


Figure 2.3 Van Veen Sediment Grab with Jaws Held Open by Large Substrate Material

At each sampling site, the survey vessel was maintained in position and the Van Veen grab was primed for release and attached to a 0.95 cm braided rope and Honda hauler system. The sampler was lowered over the side of the vessel and allowed to freefall to the ocean bottom. After closure of the grab, the sample was retrieved, and the grab was opened and examined by the study team to ensure the integrity of the sample. Assessing sample integrity included ensuring the grab did not open during retrieval and determining that the sediment-water interface had not been disturbed. The depth and geo-position of each sample were then recorded.

The grab was then emptied into a 20 liter Rubbermaid™ tub and thoroughly mixed with a stainless steel spoon. Two sub-samples, one each for chemical/hydrocarbon analyses and physical characterization of sediment, were collected in 500 ml 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, along with CoC forms, to the selected analytical laboratory. Sediment sampling was conducted following water sample collection and stored to avoid any cross contamination. Sampling equipment was thoroughly rinsed with sea water between collections.

2.6.3 **Physical Analysis**

Physical characteristics of sediment samples analyzed at the laboratory included classifying the proportion (%) of sample as gravel, sand, silt and clay, based on the Wentworth (1922) substrate scale. A more detailed particle size analysis (PSA) of the silt/clay fraction was also conducted.

To determine the proportion of sample as gravel, sand, silt and clay, organic matter and carbonates were destroyed by hydrogen peroxide. Wet sieving (63 micron mesh sieve) was used to separate the gravel and sand fractions. Samples were 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:

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

2.6.4 **Chemical Analysis**

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 CVAA. Total Organic Carbon (TOC) was also determined using Leco furnace methods. Samples were analyzed for 'available' metals which 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 more biologically relevant for assessing sediment quality.

Sediment samples were also analyzed for TPH and included 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, RDL, 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.

Table 2.3 Sediment Quality Parameters Measured at Electrode Sites September and October 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

Table 2.3 Sediment Quality Parameters Measured at Electrode Sites September and October 2010 (Cont'd)

	Units	RDL	ISQG	PEL	Analysis Method
Inorganics					
Moisture	%	1			
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			
$>C_{16}$-C_{21} Hydrocarbons	$mg{\cdot}kg^{-1}$	10			
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg{\cdot}kg^{-1}$	15			
Modified TPH (Tier1)	$mg{\cdot}kg^{-1}$	20			
Reached Baseline at C_{32}	$mg{\cdot}kg^{-1}$	N/A			
Hydrocarbon Resemblance	$mg{\cdot}kg^{-1}$	N/A			
Surrogate Recovery (%)					
Isobutylbenzene - Extractable	%				
n-Dotriacontane - Extractable	%				
Isobutylbenzene - Volatile	%				

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

2.6.5 Analysis and Interpretation

The purpose of the sediment sampling program was to characterize marine sediment quality at each study site. 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). ISQGs and PELs have been established for several metals that were analyzed for in this study 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.

2.7 Benthic Invertebrates

Collection of benthic invertebrate and sediment samples were attempted from the two electrode sites at the same locations as sediment sampling. Despite repeated attempts, benthic samples were not successfully collected from Dowden's Point owing to the coarse nature of substrates. Eight benthic samples were collected from L'Anse au Diable, four each in the subtidal and intertidal zones, and were analyzed to determine the benthic community characteristics. Detailed methods for the collection and analyses of benthic invertebrate samples are described in the following sections.

2.7.1 **Sample Collection**

The approach to benthic invertebrate sample collection, including quality assurance/quality control (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 the sediment sampling locations and the method of grab deployment and retrieval were as described in Section 2.6.2, Sediment Sample Collection. Upon retrieval, each grab was emptied into a 20 liter Rubbermaid™ 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). For benthic samples collected on September 30, all grabs were transferred to 20 L buckets for processing and field sorting that evening. For benthic samples collected on October 7, sediment grabs were transferred to 20 L buckets immediately and processing and sorting were completed at the laboratory selected for benthic sample analyses.

Field sorting was conducted using a 30 cm by 60 cm, 500 µm mesh, sieving table by elutriating the sample with water flow to suspend organisms that were not readily visible in the sample. The samples were lightly washed with gentle manipulation by the field technicians so as to avoid damage to any of the benthic organisms. Mud and fine sand were washed directly through the sieve while coarser 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 20 L sample buckets. Field sorted samples were preserved in 10 % buffered seawater/formalin.

Benthic samples were kept cool prior to shipment to Envirosphere Consultants Limited, Windsor, Nova Scotia who completed analyses of biological species composition and abundance/biomass 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 EEM programs in Atlantic Canada.

2.7.2 **Laboratory Analyses of Benthic Samples**

2.7.2.1 Sieving of Whole Sediments

Upon arrival at the analytical laboratory, all of the unsorted samples from the L'Anse au Diable intertidal sites were sieved and washed, as described previously, and preserved in 10 % buffered formalin. Within a week to ten days of receipt of samples, all samples were again washed to remove any residual formalin and then transferred to 70 % isopropanol.

2.7.2.2 Sorting and Identification

At the laboratory, 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 -10x magnification, with a final brief check at 16x, with a stereo-microscope. Sorting efficiency was checked by resorting 10 % of samples to ensure 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 (mg) at the time of sorting after blotting to remove surface water. Species abundance and number of taxa were also determined for each sample. For all eight L'Anse au Diable samples, due to the moderate to low abundance of benthic organisms, sub-sampling was not required during identifications.

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 References) 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 EEM programs (Environment Canada 1998) and the Metal Mining EEM Guidance Document (Environment Canada 2002).

A reference collection was developed and archived for possible future use.

2.7.3 **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:
    - Shannon-Wiener Diversity;
    - Pielou's Evenness;
    - McIntosh's Index;

- Simpson's Index; and
- 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 approximately 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 (P) 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.

2.8 Nearshore Habitat Surveys

Nearshore habitat surveys were conducted at each potential electrode site, and included shoreline and backshore surveys, bathymetric surveys and underwater video collection to characterize the subtidal habitat at each site (i.e., substrate, and marine flora) and marine fauna. The methods employed during these surveys are described in the following sections. Surveys were conducted to assess the habitat characteristics at the Shore Zone level of detail (Kelly et al. 2009, draft) which included:

1. Backshore;
2. Intertidal Zone;
3. Shallow Subtidal Zone; and
4. Deep Subtidal Zone.

As a result of the nature and size of the proposed shore electrodes, surveys did not extend into the Deep Subtidal Zone. The major features to be assessed at the Shore Zone Level included:

1. Water depth;
2. Substrate type and class;
3. Macrofloral presence by species/class; and
4. Macrofaunal presence (fish and invertebrates).

2.8.1 **Shoreline and Backshore Survey**

The shoreline and backshore at each electrode site were surveyed using methods described in Kelly et al. (2009, draft) and Catto et al. (1997). The survey delineated Shore Units which were lengths of coastline with similar topography, sediment type, and geomorphic processes. The Shore Units encompassed the area from the limit of the backshore to the high tide mark along the shoreline. Catto et al. (1997) identified 24 different Shore Units, based primarily on geomorphology and substrate type, and descriptors in that document were used to classify the Shore Units for this study (Table 2.4). Due to the relatively small study areas for the shoreline electrode sites, and the scale of the Catto et al. (1997) classification, only a small number of Shore Units were associated with each site.

Table 2.4 Classification of Shore Units

Bedrock Shore Units • Rock Platform • Cliff
Rock and Sediment Shore Units • Gravel Beach on Rock Platform/Cliff • Sand, Gravel Beach on Rock Platform/Cliff • Sand, Gravel Beach on Rock Cliff • Sand Beach on Rock Platform/Cliff
Sediment Shore Units • Gravel Flat/Beach • Sand and Gravel Flat/Beach • Sand Flat/Beach • Mudflats • Estuary and Fringing Lagoon • Boulder Tidal Flat
Man-modified • Seawall • Wharf • Bulkhead • Rip Rap • Slipway

Notes:
Sand beaches: > 90 % sand by volume, > 75 % by mass
Gravel beaches: > 90 % gravel
Sand and gravel beaches: > 30 % and < 70 % sand
Shore units as identified in Catto et al. (1997)

The study team viewed the shoreline from the water and walked the shoreline to record the characteristics of the Shore Units in field notebooks. Features used to delineate the Shore Units included: landform, shore width (m), shore length (m), and slopes (%). Slopes were interpreted from digital images as provided by Nalcor Energy and survey data. Digital photographs were collected to describe and document each electrode study site. The boundaries of each Shore Unit were delineated from interpretation of high quality digital imagery.

2.8.2 **Bathymetry**

A bathymetric survey was conducted at each site using a Marinetek Sonar system which consisted of the sounder, GPS antenna, single beam transducer, power source, and notebook computer for data logging. Data sent to the notebook allowed the user to review, in real time, data including depth, GPS position, magnetic heading, speed, and temperature information.

All depth measurements collected during surveys were reduced to chart datum. To achieve this correction, the time of the survey was recorded and matched with the daily tidal data for L'Anse au Diable (1.4 m) and Dowden's Point (0.2 m). Each recorded depth was converted to chart datum by subtracting the tidal data provided by Canadian Hydrographic Service (CHS) for that day and hour (DFO 2010). It should be noted that for the purpose of navigational safety these data are not to be used for marine navigation.

Data processing involved application of a general process model which included smoothing, transient filtering, and bottom delineation of the raw data. Once all initial processing was complete, the x, y, z data (longitude, latitude, and depth) were exported to a .csv file for additional analysis and modelling in ArcGIS and Golden Software Surfer 8. Kriging was chosen as the preferred processing method for bathymetric modelling. Final maps were created in ArcGIS Version 10.0 using the exported shapefile from Surfer 8, and projected to NAD 83 zone 21 for L'Anse au Diable and NAD 83 zone 22 for Dowden's Point.

2.8.3 **Underwater Video Survey of Marine Habitats (Substrate, Flora and Fauna)**

An underwater marine video survey was completed for each electrode site. The subtidal zone of each electrode site was surveyed consistent with accepted DFO methodology of using substrate and vegetation classes to describe physical habitat features (Bradbury et al. 2001). This method was developed for lacustrine habitat characterization, however the approach and description have been adapted for the DFO Coastal Marine Habitat Classification (Kelly et al. 2009, draft).

The video survey involved the use of an underwater dropped video camera system (Sony VX 2000 digital video camera), with lights, that was enabled to encode GPS position concurrent with the video archiving. A series of continuous transects were conducted at an approximate speed of 1 $km \cdot hr^{-1}$ within each study area. Based on camera orientation and height above the bottom, a field of view of approximately 2 m on either side of the centerline of the transect was recorded. A weight measuring 40 cm was in the field of view to provide a size reference for video interpretation (e.g., substrate).

The towed video system recorded and displayed, in real time, the digital video data and stored the digital video data on a hard drive. Concurrent with the collection and storage of video data, the system recorded time (each second) and GPS position (every two to three seconds). The video was reviewed by the field team in real time to ensure the data collected was acceptable for subsequent analyses and to identify possible locations for other sampling components (e.g., sediment and benthos). If anything noteworthy was observed the field team would slow or stop the boat to collect additional video. At the completion of each survey, the video was backed up and archived on separate digital media (i.e., a portable hard drive) that evening. All data was digitally logged with the necessary metadata information describing the survey details.

The drop video camera tracks for L'Anse au Diable and Dowden's Point are provided in Figures 2.4 and 2.5, respectively. At L'Anse au Diable, a total of 2,998 m of transects were completed comprising 61 minutes of video footage. At Dowden's Point, a total of 2,376 m of transects were completed comprising 62 minutes of video footage.

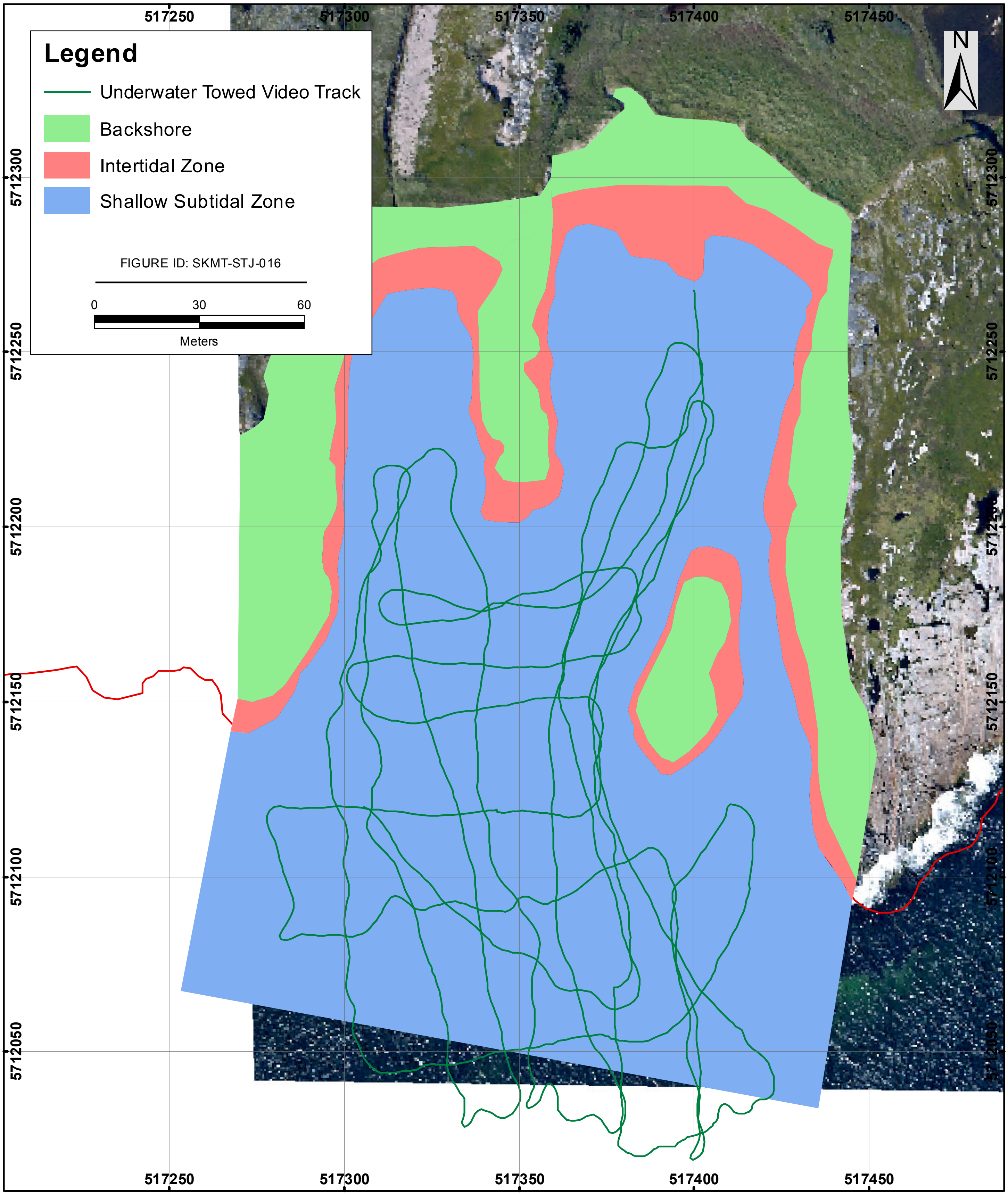


FIGURE 2.4

L'Anse au Diable Underwater Towed Video Track

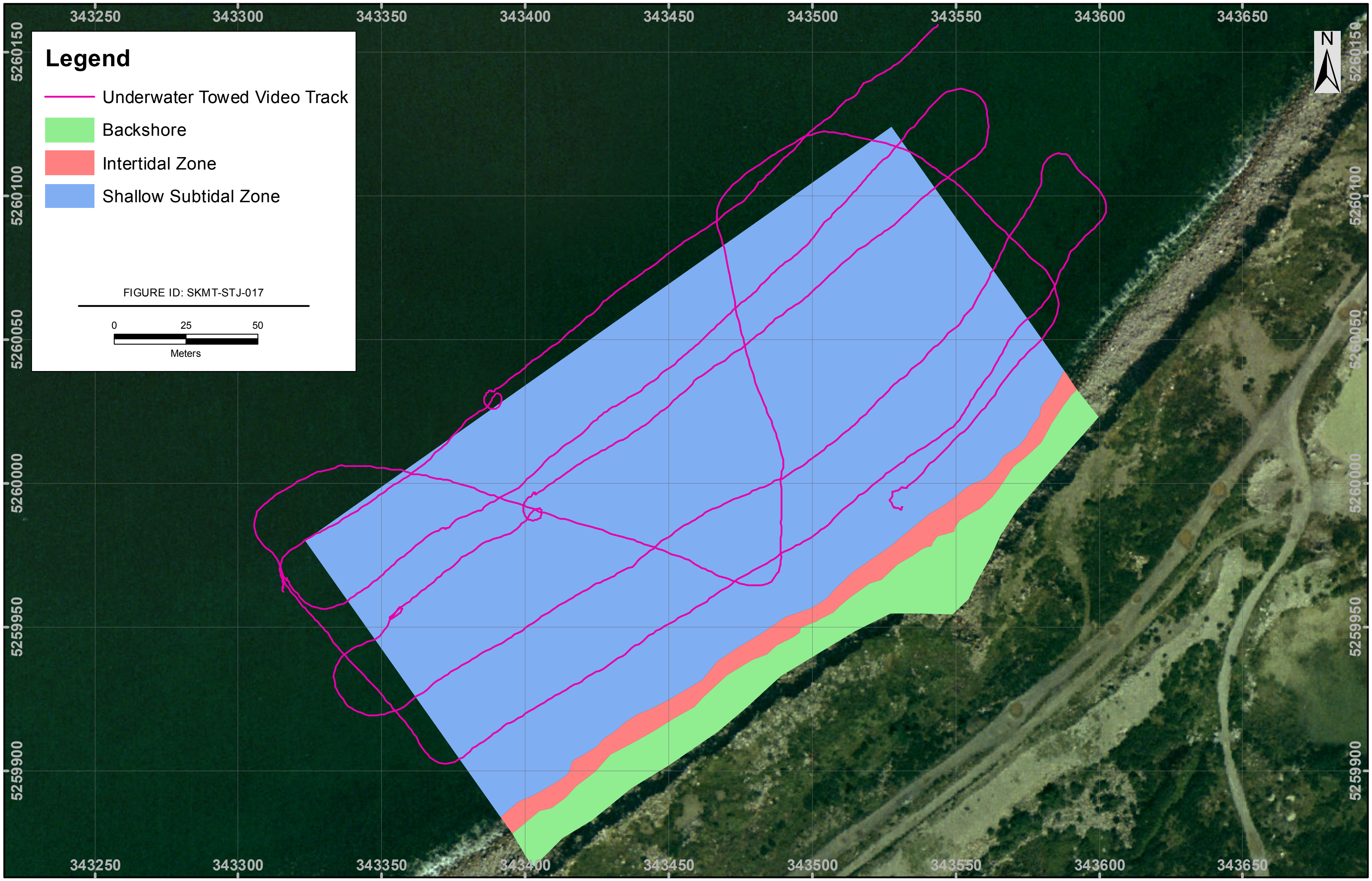


FIGURE 2.5

Dowden's Point Underwater Towed Video Track

2.8.4 **Analyses of Video Footage**

The video footage as collected in the field was subsequently reviewed to characterize and quantify the habitat characteristics. The video was viewed several times by a biologist experienced in the assessment and interpretation of marine habitat characteristics and flora and fauna to be expected in the study sites. The biologist recorded, on a second by second basis, the dominant substrate types, and marine flora and fauna (invertebrates and fish) observed in each frame. Details on approaches used to classify these characteristics are described below.

2.8.4.1 Substrate

Analysis of the video footage followed classification criteria identified by DFO in Kelly et al. (2009, draft). Initially, each video frame was reviewed and characterized as to substrate type and generally each classification was based on combinations of one, two, or three substrate types. Substrate types were determined based on the Wentworth-Udden (Wentworth 1922) size-based classifications in Table 2.5. Initially a large number of substrate classes, which included up to three substrate types, were identified and subsequently several common substrate classes were aggregated into a smaller set of substrate classes amenable for mapping (hereafter referred to as *aggregated* substrate classification).

Table 2.5 Classification of Marine Substrates

Substrate Type[1]	Definition
Bedrock	Continuous solid rock exposed by scouring forces.
Boulder	Rocks greater than 250 mm in diameter.
Rubble	Large rocks ranging from 130 mm – 250 mm in diameter.
Cobble	Rocks ranging from 30 mm – 130 mm.
Gravel	Granule size or coarser, 2 mm – 30 mm.
Sand	Fine deposits ranging from 0.06 mm – 2 mm.
Mud	Material encompassing both silt and clay < 0.06 mm.
Organic/Detritus	Soft material 85 % or more organic materials.

Note [1]: Marine substrates as adapted from Wentworth-Udden (Kelly et al. 2009, draft)

The GPS position of each substrate classes was matched to the time on the video tape to permit mapping of substrate distribution in two dimensions. The data were summarized for both the detailed and aggregated substrate categories, to include the amount of time that it was observed and the percent or relative occurrence (% of total time) at each site.

After mapping of the aggregated substrate classes, the area (ha) of each substrate class was quantified. It is noteworthy that the percentage of each substrate class as determined from time viewed in the video, as opposed to that determined by two-dimensional modelling, may be different as the model assigns substrate values to areas that were not video taped.

2.8.4.2 Macroflora

The macroflora classification was also based on criteria identified in Kelly et al. (2009, draft) which is reproduced in Table 2.6. Where possible, the macroflora observed on the video tape were identified to species, genus, or vegetation class. As for substrate classification, a large number of macrofloral types were initially identified and subsequently, several common species, genera, and types were aggregated to a smaller number of macrofloral classes amenable for mapping (hereafter referred to as *aggregated* macrofloral classification). In many instances several vegetation classes were observed at the same location necessitating the creation of hybrid vegetation classes (e.g., red and green algae), similar to substrate classes being comprised of more than one substrate type.

Table 2.6 Classification of Marine Vegetation

Vegetation Class[1]	**Definition**
Red Algae	Common name or Rhodophyta (e.g., *Chondrus crispus* – Irish moss, *Lithothamium* – coralline algae, *Ptilota, Porphyra, Rhodymenia* – dulse, etc.)
Brown Algae	Common name for the seaweeds of the Laminariales (Phaeophyta), brown alga with a large broad-bladed thallus attached to the substrate by a tough stalk and holdfast (e.g., *Laminaria longicruris* – cabbage kelp, *L. digitata* – finger kelp, *Alaria esculenta* – winged kelp, *Chorda filum* – Mermaid's trusses, *Agarium clathratum, Saccorhiza deratodea*, etc.)
Green Algae	Common name for Chlorophyta (e.g., *Chlamydomonas, Spirogyra, Ulva lactuca* – sea lettuce, *Urospora,* etc.)
Rock Weed	*Fucus sp.* – rock weed, *Ascophyllum nodosum* – knotted wrack
Eelgrass	*Zostera marina* is a green flowering plant (Anthophyta) and is primarily a subtidal species that penetrates to some extent into the intertidal zone. It is common on mud flats, that are exposed at low tide, in estuaries, and shallow, protected bays.
Salt Marsh	Aquatic plants developing on wet soil (e.g., tidal or salt marshes)
Other	Any other type of flora not identified in the above categories

Note [1]: Classification of marine vegetation after Kelly et al. (2009, draft)

As for substrate, GPS position was matched to the time on the video tape to permit mapping of algal distribution in two dimensions. The data were summarized for both the detailed and aggregated macroflora categories, to include the amount of time that it was observed and the percent or relative occurrence (% of total time) at each site.

After mapping of the aggregated macrofloral classes, the area (ha) of each class was quantified. As for substrate, it is noteworthy that the percentage of each macrofloral class, as determined from time viewed in the video and that determined by two-dimensional modelling, may be different.

The relative abundance of each taxon was assessed and described, on a relative ranking scale, as:

- Abundant (A) – numerous (not quantifiable) observations made throughout the study area;
- Common (C) – numerous (not quantifiable) observations made intermittently throughout the study area;

- Occasional (O) – quantifiable observations made intermittently throughout the study area; and
- Uncommon (U) – quantifiable observations made infrequently throughout the study area.

It is important to note that this scale is not quantifiable in most circumstances and the divisions between each rank are relative, as assigned by the video interpreter, and not absolute.

2.8.4.3 Macrofauna

The macrofaunal assessment also followed the approach identified in Kelly et al. (2009, draft). All macrofauna encountered in the video footage were identified to the LPL. Subsequently, the total number of observations for each taxon were summed to determine the relative (%) occurrence of each. Taxa that were extremely abundant, such as the urchin species, were not enumerated and observations were totaled as the amount of time they were observed. As for macroflora, the relative abundance of each taxon was assessed and described on a relative ranking scale, including: Abundant (A); Common (C); Occasional (O); and Uncommon (U).

After reviewing the macrofaunal data, it was determined the data distribution was not amenable to two-dimensional mapping of distributions. This survey was not intended to provide information on habitat utilization that may be required to determine habitat suitability criteria for the purposes of quantification of habitat.

2.8.4.4 Habitat Attribute Mapping

Basemap

For each electrode site, a basemap was developed from high resolution aerial photography and/or Light Detection and Ranging (LiDAR) survey images provided by Nalcor Energy. The basemap was used to delineate broad zones within each study site such as backshore, intertidal and subtidal zones and all other habitat attributes are presented relative to this basemap.

Shoreline and Backshore

The shoreline and backshore at each study site were delineated as Shore Units (Catto et al. 1997) and were mapped in two dimensions. Owing to the relatively small shoreline area at each electrode site, and the scale of definition of Shore Units in Catto et al. (1997), two types of Shore Unit were associated with the L'Anse au Diable site and only one Shore Unit was associated with Dowden's Point. The Shore Units were displayed on the bathymetric map for each site.

Bathymetry

All depth measurements collected during bathymetric surveys were corrected to chart datum. After correction, all bathymetric (x, y, z) data were modelled using Surfer 8 software at 0.5 m contour intervals. The intertidal zone was also displayed on the bathymetric map. The outer (seaward) limit of the intertidal zone was delineated as the chart datum '0 depth', which is defined as the 'lower, low water tide' on Canadian charts. The inner (landward) limit of the intertidal zone was inferred from the 'higher, high water mean tide' values from adjacent tide gauge sites, the slope of the shoreline, and aerial photographs and photographs collected during the surveys.

Substrate

Substrate distribution for each site was mapped and presented in relation to the basemap. Initially the video data were interpreted at a detailed level and these classes were then aggregated into a smaller number of substrate classes for mapping, if necessary. After visualizing the substrate distribution, the Theisen Polygon Analysis approach within ArcGIS (Version 10) was selected as the preferred tool for modelling the substrate distribution within each site. This method is useful for analyzing data that are point input data derived from the results of the video analyses, on a second by second basis. This method develops polygons for each discrete data category to display the two dimensional areal representation of each category. During visualization and initial modelling, it was apparent that a small number of data observations were skewing the mapping product, and these data were manually removed to improve the smoothing and discretization of the substrate class distributions.

Macroflora

The macroflora data was aggregated into macroflora classes and a distribution map was developed from modelling using the Theisen Polygon Analysis approach. A small number of data observations were removed to improve the smoothing and discretization of the macrofloral class distributions. Some macrofloral classes representing a small proportion of the distribution (< 2 %) were removed for mapping purposes only.

Integrated Habitat Map

Finally, for each site the aggregated substrate distribution was integrated with the aggregated macroflora distribution to define integrated habitat classes for the shallow subtidal zone. Owing to the heterogeneity of both attributes at the L'Anse au Diable site, an additional level of substrate aggregation was necessary to provide a reasonable number of habitat classes for mapping. The final integrated habitat map displayed three of the four major zones (footprint of electrode sites did not extend into the Deep Subtidal Zone) required for the Shore Zone level of habitat characterization.

2.9 Quality Management

The study team applied a Quality Management System during the field study components as well as during the analyses of data and preparation of the final report. Quality is achieved through the use of skilled personnel, adequate planning, use of suitable tools and procedures, proper definition of job requirements, rigorous documentation of procedures and data, proper supervision and effective technical direction. This section outlines the specific quality assurance/quality control (QA/QC) techniques utilized by the study team during this study.

2.9.1 **Field Quality Assurance/Quality Control (QA/QC)**

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 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 notebooks and field data sheets into a digital format (e.g., Excel spreadsheet), and duplicated to a USB drive, 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 QA/QC**

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, and 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 procedures followed by Envirosphere Ltd. 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 QA/QC**

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, benthos and nearshore habitat surveys at the potential electrode sites at L'Anse au Diable on the Labrador coast of the Strait of Belle Isle and at Dowden's Point in Conception Bay on the Island of Newfoundland, are presented and summarized below. For organizational purposes, the results are presented separately for each site. The presentation of results are largely descriptive in nature and there is no comparison between sites as data collected were intended to separately describe baseline conditions for each location. Where appropriate, comparison with relevant environmental guidelines are made.

3.1 L'Anse au Diable

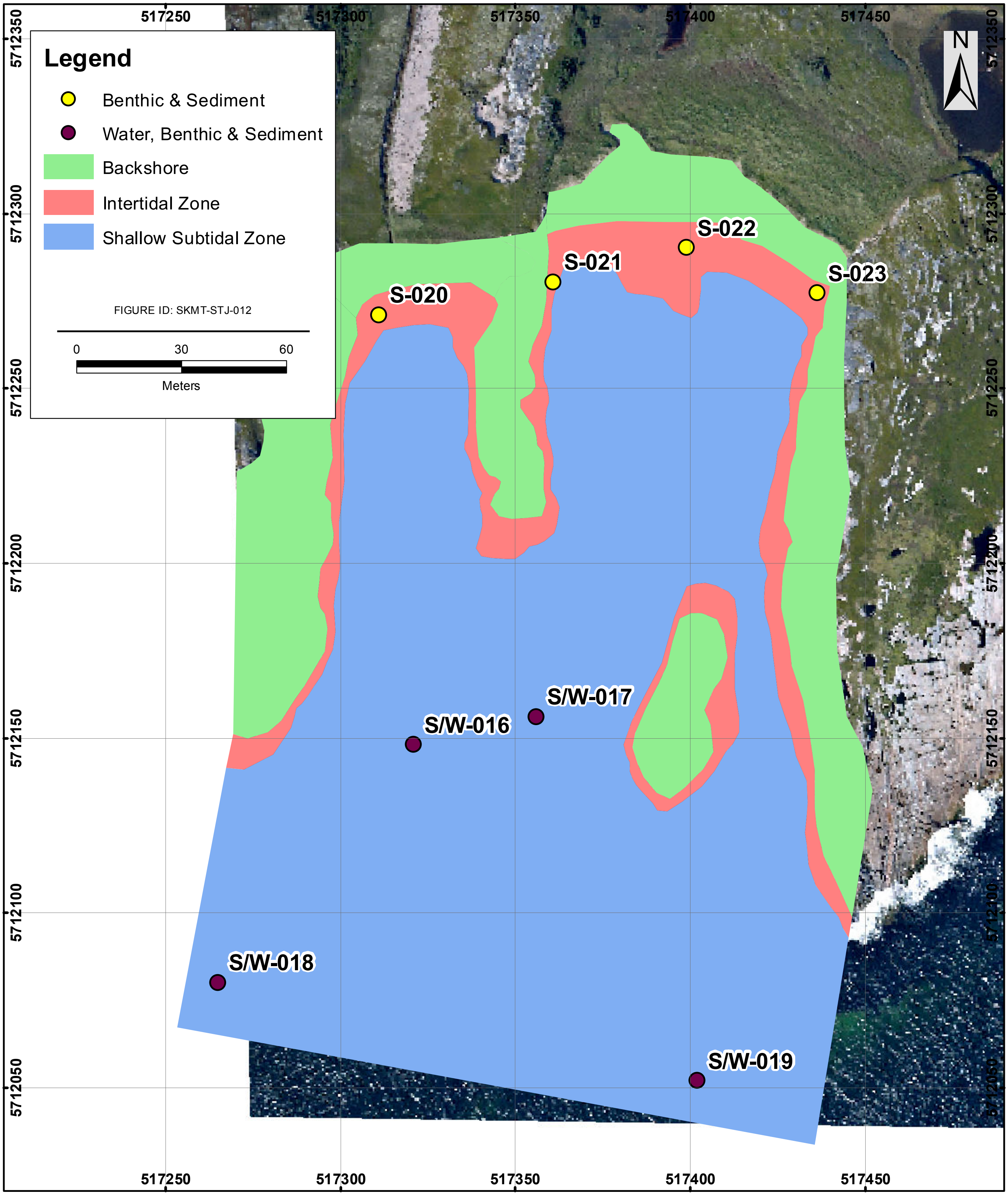
Water, sediment and benthos samples were collected from the subtidal region at L'Anse au Diable on September 30, 2010, while this electrode site was surveyed in detail on October 6 and 7. The results of each of these components are presented below.

3.1.1 Water Quality

Water quality data was collected at four locations within the L'Anse au Diable electrode site (Figure 3.1). Water quality included measurement of selected parameters in the field, and chemical and hydrocarbon analyses at an analytical laboratory. The detailed results of the analyses of these samples are contained in Appendix A. Date, location (in UTMs, Zone 21), and depths of the sampling sites are presented in Table 3.1.

Table 3.1 Summary of Date, Location and Depth of Water Sampling Sites at L'Anse au Diable September 2010

Date	Station ID	Location		Habitat	Depth (m)
		Easting	Northing		
Sept-30-10	W-016	517321	5712148	Subtidal	6.5
Sept-30-10	W-017	517356	5712156	Subtidal	5
Sept-30-10	W-018	517265	5712080	Subtidal	8
Sept-30-10	W-019	517402	5712052	Subtidal	5



nalcor energy

FIGURE 3.1

L'Anse au Diable Sampling Sites

3.1.1.1 Conductivity, Temperature, and Depth (CTD) Profiles

CTD profiles were collected with a Sea-Bird Electronics SEACAT SBE-19 CTD meter at the four water quality stations at L'Anse au Diable. The CTD profiles are displayed in Figure 3.2 (Stations W-016 to W-019).

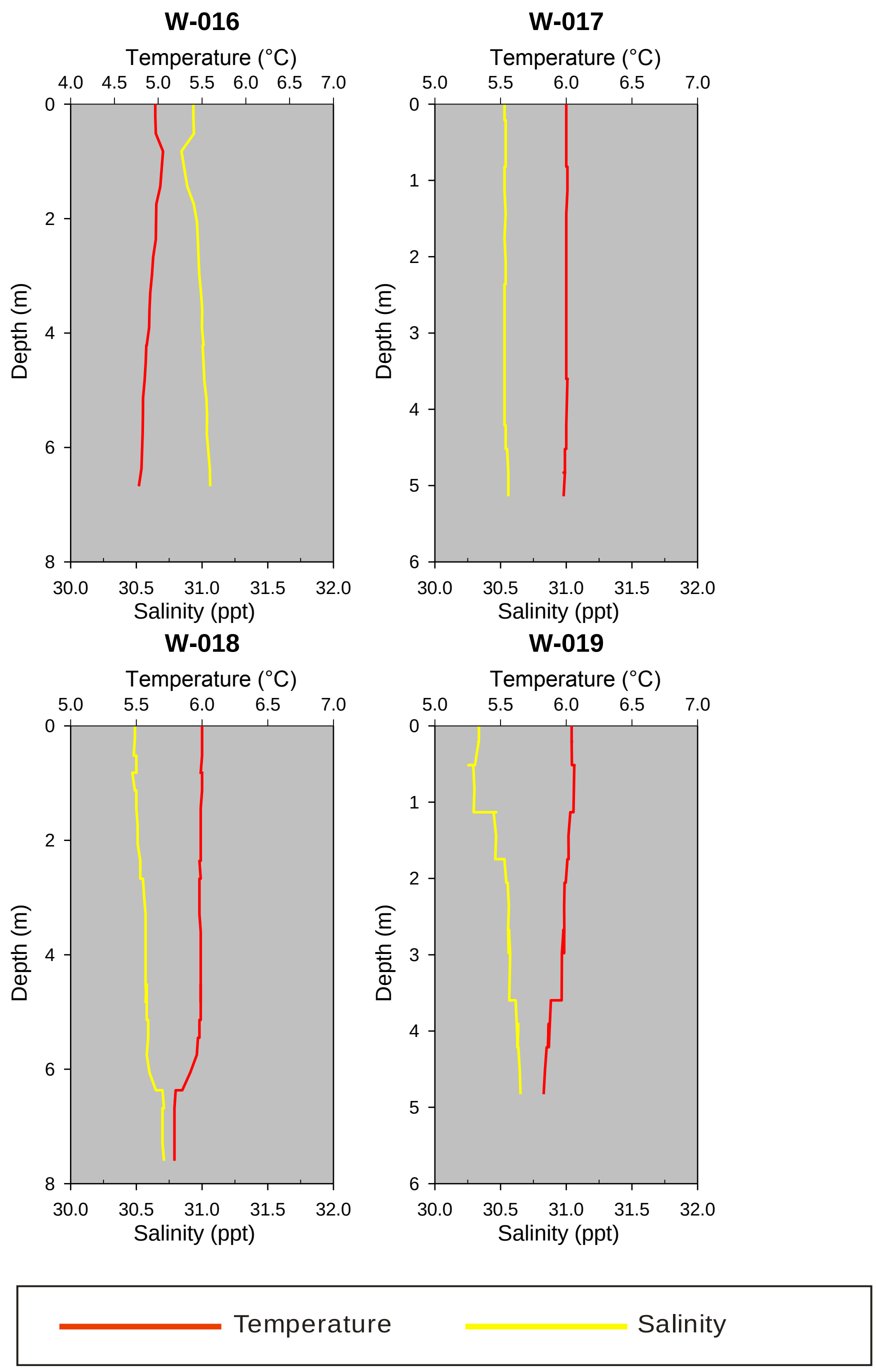


Figure 3.2 CTD Profiles for L'Anse au Diable Stations W-016 to W-019, September 2010

The CTD profiles indicate there is very little evidence of a salinity or temperature gradient with depth, and clearly no thermocline was evident. This was expected owing to the shallow nature of the sampling sites and the fact the water was likely well mixed due to wave and tidal action. Consequently, only one water sample was collected at each site to characterize the water chemistry conditions.

3.1.1.2 Field Water Quality

Field water quality measurements were taken at all sampling stations at L'Anse au Diable on September 30, 2010 and are presented in Table 3.2. Field measurements were taken from the samples collected at or near the surface (1 to 2 m). Field water quality results were generally comparable between sites, with temperatures demonstrating some variability between sites, ranging from 6.80 to 8.47 ˚C. Conductivity values had very little variability, and ranged from 4.71 to 4.77 $S \cdot m^{-1}$, which are typical of seawater. Values for pH were alkaline ranging from 7.96 to 8.11. Dissolved oxygen values varied from 10.49 to 10.63 $mg \cdot L^{-1}$ and were supersaturated (106.3 to 108.7 % saturation). Oxygen reduction potential (ORP) values, an indication of the ability to breakdown contaminants, ranged from 79.3 to 88.5 mV.

Table 3.2 Field Water Quality Measurements for Samples Collected at L'Anse au Diable September 2010

Station ID	Temp. °C	Cond. ($S \cdot m^{-1}$)	pH	DO ($mg \cdot L^{-1}$)	DO (% sat)	ORP (mV)
W-016	8.47	4.77	7.96	10.49	108.7	79.3
W-017	7.30	4.71	8.07	10.58	107.4	82.3
W-018	6.80	4.77	8.11	10.60	106.3	85.8
W-019	7.40	4.73	8.06	10.63	107.3	88.5

3.1.1.3 Laboratory Water Quality

Results of water quality analysis, including statistical summary, for conventional parameters, nutrients, major ions, and metals are presented in Table 3.3, while results of analysis for petroleum hydrocarbons are presented in Table 3.4. Detailed results of laboratory water analysis are presented in Appendix A including sample duplicates and laboratory QA/QC data.

Conventional parameters were similar between all sampling stations. Values for pH were alkaline and ranged from 7.77 to 7.84 with an average of 7.81, well within the CCME guidelines. Very few nutrients were detected in the samples with only orthophosphate detected in three samples, all at the detection limit. Major ions were at levels typical of seawater (Garrison 2010). Metals in samples were also low, with only strontium detected in all samples and boron in three of four samples. All other metals tested for were not detected and no CCME (2002) water quality guidelines were exceeded.

For petroleum hydrocarbons, only toluene was detectable in all of the four samples tested and all values were at the detection limit, and consequently the CCME water quality guideline of 0.215 $mg \cdot L^{-1}$ was not exceeded. All other hydrocarbons were below the reportable detection limit.

Table 3.3 Water Quality Data and Statistical Summary for Conventional Parameters, Nutrients, Major Ions and Metals for Samples Collected from L'Anse au Diable in September 2010

	Units	RDL	CCME Guideline	W-016	W-017	W-018	W-019	Mean	Std. Dev.	Min.	Max.
Conventional Parameters											
pH	pH	N/A	7.0 - 8.7	7.82	7.81	7.77	7.84	7.81	0.03	7.77	7.84
Total Alkalinity	$mg{\cdot}L^{-1}$	5		94	94	94	93	93.8	0.5	93	94
Hardness	$mg{\cdot}L^{-1}$	1		5400	5300	5400	4900	5250.0	238.1	4900	5400
Turbidity	NTU	0.1		0.1	0.2	0.6	0.2	0.28	0.22	0.1	0.6
Conductivity	$\mu S{\cdot}cm^{-1}$	1		42000	42000	42000	41000	41750.0	500.0	41000	42000
Total Suspended Solids	$mg{\cdot}L^{-1}$	1		1	2	1	2	1.5	0.6	1	2
Calculated TDS	$mg{\cdot}L^{-1}$	1		30200	30200	30400	29800	30150.0	251.7	29800	30400
Colour	TCU	5		ND	ND	ND	ND				
Total Organic Carbon	$mg{\cdot}L^{-1}$	5		ND	ND	ND	ND				
Reactive Silica	$mg{\cdot}L^{-1}$	0.5		ND	ND	ND	ND				
Nutrients											
Nitrate + Nitrite	$mg{\cdot}L^{-1}$	0.05		ND	ND	ND	ND				
Nitrite	$mg{\cdot}L^{-1}$	0.01		ND	ND	ND	ND				
Nitrate	$mg{\cdot}L^{-1}$	0.05	16[a]	ND	ND	ND	ND				
Nitrogen	$mg{\cdot}L^{-1}$	0.05		ND	ND	ND	ND				
Total Phosphorous	$\mu g{\cdot}L^{-1}$	10000		ND	ND	ND	ND				
Orthophosphate	$mg{\cdot}L^{-1}$	0.01		0.01	ND	0.01	0.01	0.01	0.00	0.01	0.01
Major Ions											
Total Calcium	$mg{\cdot}L^{-1}$	10		366	358	376	349	362.6	11.5	349	376
Total Magnesium	$mg{\cdot}L^{-1}$	10		1100	1070	1090	983	1060.8	53.3	983	1100
Total Sodium	$mg{\cdot}L^{-1}$	10		9430	9400	9740	9250	9455.0	205.7	9250	9740
Total Potassium	$mg{\cdot}L^{-1}$	10		333	334	346	331	336.0	6.8	331	346
Dissolved Chloride	$mg{\cdot}L^{-1}$	300		17000	17000	17000	16000	16750.0	500.0	16000	17000
Dissolved Sulphate	$mg{\cdot}L^{-1}$	50		2300	2400	2300	2300	2325.0	50.0	2300	2400
Metals											
Total Aluminum	$\mu g{\cdot}L^{-1}$	500		ND	ND	ND	ND				
Total Antimony	$\mu g{\cdot}L^{-1}$	100		ND	ND	ND	ND				

Table 3.3 Water Quality Data and Statistical Summary for Conventional Parameters, Nutrients, Major Ions and Metals for Samples Collected from L'Anse au Diable in September 2010 (Cont'd)

	Units	RDL	CCME Guideline	W-016	W-017	W-018	W-019	Mean	Std. Dev.	Min.	Max.
Total Arsenic	$\mu g \cdot L^{-1}$	100	12.5	ND	ND	ND	ND				
Total Barium	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND				
Total Beryllium	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND				
Total Bismuth	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Boron	$\mu g \cdot L^{-1}$	500		ND	3680	3780	3450	3636.7	169.2	3450	3780
Total Cadmium	$\mu g \cdot L^{-1}$	1.7	0.12	ND	ND	ND	ND				
Total Chromium	$\mu g \cdot L^{-1}$	100	56, 1.5[c]	ND	ND	ND	ND				
Total Cobalt	$\mu g \cdot L^{-1}$	40		ND	ND	ND	ND				
Total Copper	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Iron	$\mu g \cdot L^{-1}$	5000		ND	ND	ND	ND				
Total Lead	$\mu g \cdot L^{-1}$	50		ND	ND	ND	ND				
Total Mercury	$\mu g \cdot L^{-1}$	0.013	0.016[b]	ND	ND	ND	ND				
Total Molybdenum	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Nickel	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Selenium	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Silver	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND				
Total Strontium	$\mu g \cdot L^{-1}$	200		6460	6350	6590	6160	6390.0	182.0	6160	6590
Total Thallium	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND				
Total Tin	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Titanium	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Uranium	$\mu g \cdot L^{-1}$	10		ND	ND	ND	ND				
Total Vanadium	$\mu g \cdot L^{-1}$	200		ND	ND	ND	ND				
Total Zinc	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND				

Notes:

ND - Not Detected

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

Table 3.4 Water Quality Analyses for Petroleum Hydrocarbons for Samples Collected from L'Anse au Diable in September 2010

	Units	RDL	CCME Guideline	W-016	W-017	W-018	W-019
Petroleum Hydrocarbons							
Benzene	$mg \cdot L^{-1}$	0.001	0.11	ND	ND	ND	ND
Toluene	$mg \cdot L^{-1}$	0.001	0.215	0.001	0.001	0.001	0.001
Ethylbenzene	$mg \cdot L^{-1}$	0.001	0.025	ND	ND	ND	ND
Xylene (Total)	$mg \cdot L^{-1}$	0.002		ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg \cdot L^{-1}$	0.01		ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot L^{-1}$	0.05		ND	ND	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot L^{-1}$	0.05		ND	ND	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot L^{-1}$	0.1		ND	ND	ND	ND
Modified TPH (Tier1)	$mg \cdot L^{-1}$	0.1		ND	ND	ND	ND
Reached Baseline at C_{32}	$mg \cdot L^{-1}$	N/A		Yes	Yes	Yes	Yes
Surrogate Recovery (%)							
Isobutylbenzene - Extractable	%			90	91	89	93
n-Dotriacontane - Extractable	%			75	82	78	87
Isobutylbenzene - Volatile	%			100	99	93	107

Notes:
ND - Not Detected
RDL - Reportable Detection Limit
Results relate only to the items tested.

3.1.2 Sediment Quality

Sediment quality data were collected at eight locations within the L'Anse au Diable electrode site, four within the intertidal zone and four in the shallow subtidal zone (Figure 3.1). The four subtidal sediment sampling sites were co-located with the water sampling sites. For the purposes of organization, and owing to differences in substrate characteristics, the sediment quality results from the intertidal and subtidal zones are presented separately. Sediment quality assessment included chemical and hydrocarbon analyses as well as physical characterization (particle size analyses) at an analytical laboratory. Date, depths, locations (in UTMs, Zone 21), and substrate description of the sampling sites are listed in Table 3.5. Intertidal sampling location UTMs were adjusted to match the datum of the high resolution digital image provided by Nalcor Energy. The detailed results of the analysis of these samples are contained in Appendix A.

Table 3.5 Date, Locations, Depths, and Substrate Description of the Sampling Sites at L'Anse au Diable September and October 2010

Date	Station ID	Depth[1]	Location		Habitat	Substrate Description
			Easting	Northing		
Subtidal Sites						
Sept-30-10	S-016	5.0	517321	5712148	Subtidal	Sand with some shell fragments
Sept-30-10	S-017	3.7	517356	5712156	Subtidal	Sand with some shell fragments and woody debris
Sept-30-10	S-018	5.0	517265	5712080	Subtidal	Sand with some shell fragments
Sept-30-10	S-019	3.0	517402	5712052	Subtidal	Sand with some shell fragments and woody debris
Intertidal Sites						
Oct-07-10	S-020	n/a	517307	5712279	Intertidal	Sand with some shell fragments
Oct-07-10	S-021	n/a	517353	5712279	Intertidal	Sand with seaweed
Oct-07-10	S-022	n/a	517399	5712298	Intertidal	Sand with seaweed
Oct-07-10	S-023	n/a	517445	5712279	Intertidal	Sand with seaweed

[1]Note: Sediment samples in the intertidal zone were collected at low tide

3.1.2.1 Physical Analysis of Sediment

Substrate composition (i.e., gravel, sand, silt or clay) for each sample is presented in Figure 3.3, while a more detailed analysis of sediment composition (i.e., the Phi scale) is presented in Figure 3.4. The physical analysis of sediment demonstrated that all samples were dominated by sand with fractions from 94 to 99 %. There were small amounts of clay in all samples, 0.4 to 1.2 %, while gravel was only apparent in three samples (one subtidal, two intertidal) and silt was only apparent in two samples (both at 0.2 %), one in each of the subtidal and the intertidal zones. Analyses on the Phi scale indicated that the intertidal samples, on average, were marginally coarser than the subtidal samples, perhaps due to washing and sorting by wave action. Results of physical analysis of sediment samples are presented in Appendix A, including sample duplicates and laboratory QA/QC data.

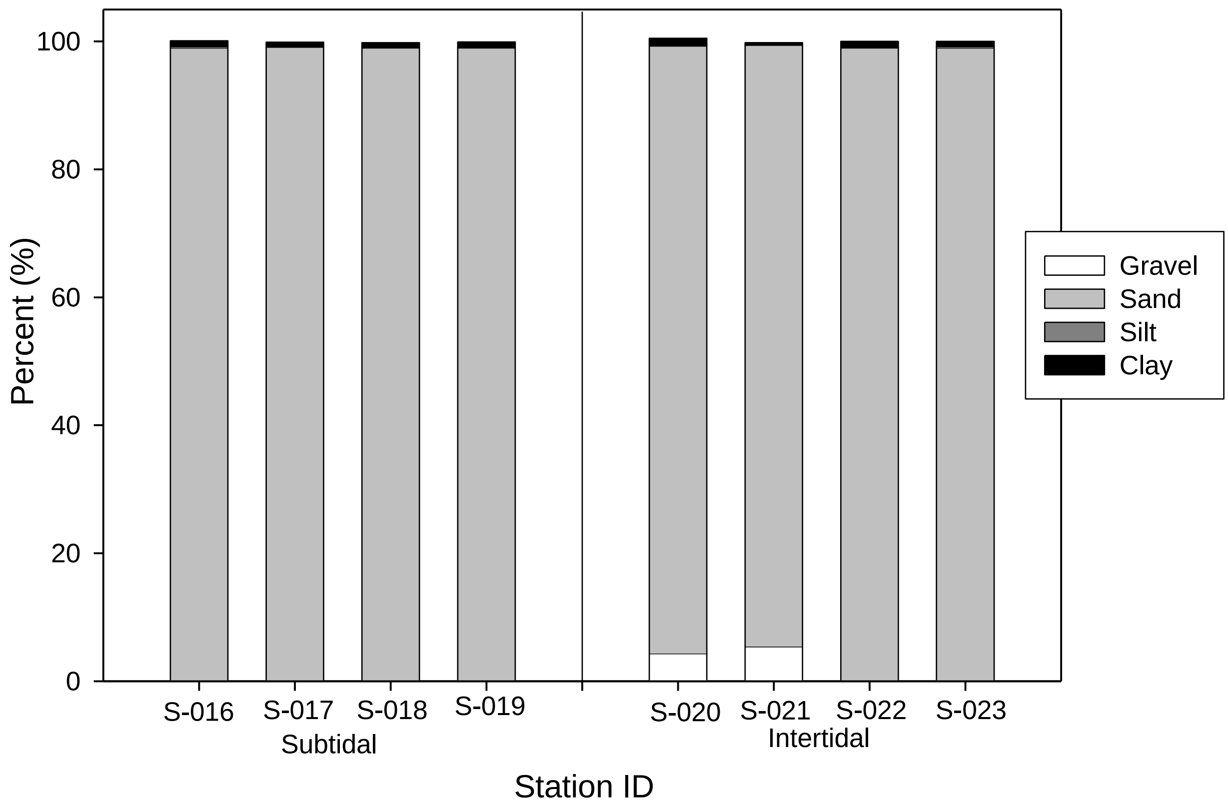


Figure 3.3 Particle Size Analysis (after Wentworth 1922) of Sediment Samples Collected from L'Anse au Diable September and October 2010

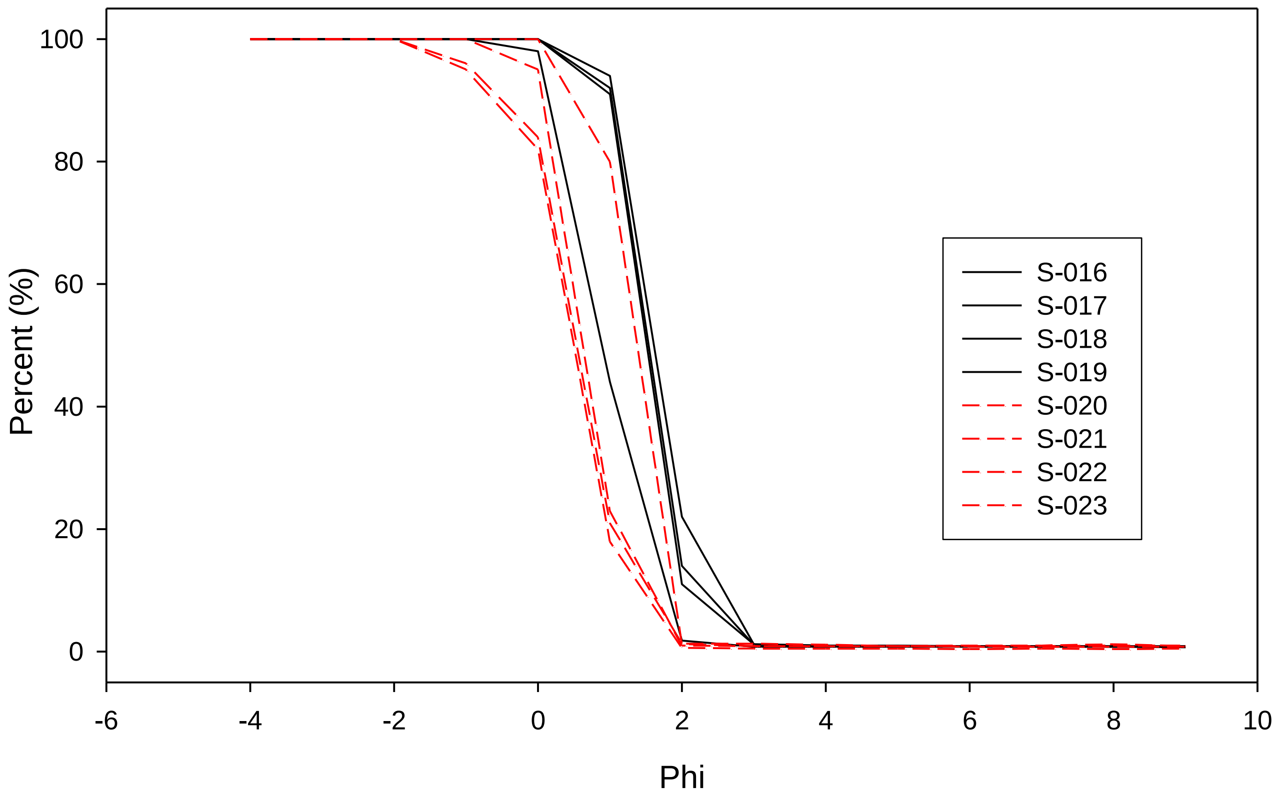


Figure 3.4 Particle Size Analysis (Phi Scale) of Sediment Samples Collected form L'Anse au Diable September and October 2010

3.1.2.2 Chemical Analysis of Sediment

Results of chemical analyses of sediment including analyses for major ions, metals, total organic carbon and moisture content, with summary statistics, are presented in Tables 3.6 and 3.7 for the subtidal and intertidal samples, respectively. Results of analysis of sediment for petroleum hydrocarbons are provided in Tables 3.8 and 3.9, for the subtidal and intertidal samples, respectively. Detailed results of all chemical analysis of sediment samples are presented in Appendix A, including sample duplicates and laboratory QA/QC data.

Chemical analyses of sediment determined that major ions were slightly higher in the subtidal samples and potassium was only measured in the subtidal samples. Organic carbon content was low ranging from 0.3 to 0.4 $g \cdot kg^{-1}$ in the intertidal samples, being undetected in two samples, while organic carbon in the subtidal samples ranged from 0.4 to 0.5 $g \cdot kg^{-1}$. Moisture content was slightly higher in the subtidal samples, ranging from 17 to 19 %, as compared to a range of 8 to 19 % in the intertidal samples. For metals, only aluminum, iron, and manganese were measured in all samples while thallium was detected in one sample in the intertidal zone. Strontium was detected in one sample and vanadium in all four samples within subtidal zone samples. All other metals tested were undetected. No CCME (2002) ISQGs or PELs for the protection of aquatic life were exceeded in sediment samples collected at L'Anse au Diable. Hydrocarbons were not detected in any samples.

Table 3.6 Sediment Analysis and Statistical Summary for Major Ions, Metals, Total Organic Carbon and Moisture from L'Anse au Diable Subtidal Samples, September 2010

	Units	RDL	ISQG	PEL	S-016	S-017	S-018	S-019	Mean	Std. Dev.	Min.	Max.
Major Ions												
Available Calcium	$mg \cdot kg^{-1}$	100			690	2000	560	570	955.0	699.2	560.0	2000.0
Available Magnesium	$mg \cdot kg^{-1}$	100			480	360	450	340	407.5	68.0	340.0	480.0
Available Phosphorous	$mg \cdot kg^{-1}$	100			ND	ND	ND	ND				
Available Potassium	$mg \cdot kg^{-1}$	100			140	140	230	150	165.0	43.6	140.0	230.0
Available Sodium	$mg \cdot kg^{-1}$	100			3000	2200	2700	1800	2425.0	531.5	1800.0	3000.0
Available Sulphur	$mg \cdot kg^{-1}$	500			ND	ND	ND	ND				
Metals												
Available Aluminum	$mg \cdot kg^{-1}$	10			200	180	240	240	215.0	30.0	180.0	240.0
Available Antimony	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Arsenic	$mg \cdot kg^{-1}$	2	7.24	41.6	ND	ND	ND	ND				
Available Barium	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND				
Available Beryllium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Bismuth	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Boron	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND				
Available Cadmium	$mg \cdot kg^{-1}$	0.3	0.7	4.2	ND	ND	ND	ND				
Available Chromium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Cobalt	$mg \cdot kg^{-1}$	1			ND	ND	ND	ND				
Available Copper	$mg \cdot kg^{-1}$	2	18.7	108	ND	ND	ND	ND				
Available Iron	$mg \cdot kg^{-1}$	50			1200	830	1100	1200	1082.5	174.8	830.0	1200.0
Available Lead	$mg \cdot kg^{-1}$	0.5	30.2	112	ND	ND	ND	ND				
Available Lithium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Manganese	$mg \cdot kg^{-1}$	2			4	3	4	4	3.8	0.5	3.0	4.0
Available Mercury	$mg \cdot kg^{-1}$	0.1	0.13	0.7	ND	ND	ND	ND				
Available Molybdenum	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Nickel	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				

Table 3.6 Sediment Analysis and Statistical Summary for Major Ions, Metals, Total Organic Carbon and Moisture from L'Anse au Diable Subtidal Samples, September 2010 (Cont'd)

	Units	RDL	ISQG	PEL	S-016	S-017	S-018	S-019	Mean	Std. Dev.	Min.	Max.
Available Rubidium	mg·kg^{-1}	2			ND	ND	ND	ND				
Available Selenium	mg·kg^{-1}	1			ND	ND	ND	ND				
Available Silver	mg·kg^{-1}	0.5			ND	ND	ND	ND				
Available Strontium	mg·kg^{-1}	5			ND	6	ND	ND	6.0	n/a	6.0	6.0
Available Thallium	mg·kg^{-1}	0.1			ND	ND	ND	ND				
Available Tin	mg·kg^{-1}	2			ND	ND	ND	ND				
Available Uranium	mg·kg^{-1}	0.1			ND	ND	ND	ND				
Available Vanadium	mg·kg^{-1}	2			4	2	3	3	3.0	0.8	2.0	4.0
Available Zinc	mg·kg^{-1}	5	124	271	ND	ND	ND	ND				
Organic Carbon												
Organic Carbon	g·kg^{-1}	0.2			0.4	0.4	0.5	0.4	0.4	0.0	0.4	0.5
Inorganics												
Moisture	%	1			19	17	19	19	18.5	1.0	17.0	19.0

Notes:

ND - Not Detected

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

Table 3.7 Sediment Analysis and Statistical Summary for Major Ions, Metals, Total Organic Carbon and Moisture from L'Anse au Diable Intertidal Samples, October 2010

	Units	RDL	ISQG	PEL	S-020	S-021	S-022	S-023	Mean	Std. Dev.	Min.	Max.
Major Ions												
Available Calcium	$mg \cdot kg^{-1}$	100			210	900	150	230	372.5	353.3	150.0	900.0
Available Magnesium	$mg \cdot kg^{-1}$	100			210	160	210	180	190.0	24.5	160.0	210.0
Available Phosphorous	$mg \cdot kg^{-1}$	100			ND	ND	ND	ND				
Available Potassium	$mg \cdot kg^{-1}$	100			ND	ND	ND	ND				
Available Sodium	$mg \cdot kg^{-1}$	100			880	500	910	750	760.0	186.7	500.0	910.0
Available Sulphur	$mg \cdot kg^{-1}$	500			ND	ND	ND	ND				
Metals												
Available Aluminum	$mg \cdot kg^{-1}$	10			170	260	180	170	195.0	43.6	170.0	260.0
Available Antimony	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Arsenic	$mg \cdot kg^{-1}$	2	7.24	41.6	ND	ND	ND	ND				
Available Barium	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND				
Available Beryllium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Bismuth	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Boron	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND				
Available Cadmium	$mg \cdot kg^{-1}$	0.3	0.7	4.2	ND	ND	ND	ND				
Available Chromium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Cobalt	$mg \cdot kg^{-1}$	1			ND	ND	ND	ND				
Available Copper	$mg \cdot kg^{-1}$	2	18.7	108	ND	ND	ND	ND				
Available Iron	$mg \cdot kg^{-1}$	50			620	740	650	670	670.0	51.0	620.0	740.0
Available Lead	$mg \cdot kg^{-1}$	0.5	30.2	112	ND	ND	ND	ND				
Available Lithium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Manganese	$mg \cdot kg^{-1}$	2			2	3	3	2	2.5	0.6	2.0	3.0
Available Mercury	$mg \cdot kg^{-1}$	0.1	0.13	0.7	ND	ND	ND	ND				
Available Molybdenum	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Nickel	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Rubidium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				

Table 3.7 Sediment Analysis and Statistical Summary for Major Ions, Metals, Total Organic Carbon and Moisture from L'Anse au Diable Intertidal Samples, October 2010 (Cont'd)

	Units	RDL	ISQG	PEL	S-020	S-021	S-022	S-023	Mean	Std. Dev.	Min.	Max.
Available Selenium	$mg \cdot kg^{-1}$	1			ND	ND	ND	ND				
Available Silver	$mg \cdot kg^{-1}$	0.5			ND	ND	ND	ND				
Available Strontium	$mg \cdot kg^{-1}$	5			ND	ND	ND	ND				
Available Thallium	$mg \cdot kg^{-1}$	0.1			0.1	ND	ND	ND	0.1	N/A	0.1	0.1
Available Tin	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Uranium	$mg \cdot kg^{-1}$	0.1			ND	ND	ND	ND				
Available Vanadium	$mg \cdot kg^{-1}$	2			ND	ND	ND	ND				
Available Zinc	$mg \cdot kg^{-1}$	5	124	271	ND	ND	ND	ND				
Organic Carbon												
Organic Carbon	$g \cdot kg^{-1}$	0.2			0.3	0.4	ND	ND	0.4	0.1	0.3	0.4
Inorganics												
Moisture	%	1			17	8	19	16	15.0	4.8	8.0	19.0

Notes:

ND - Not Detected

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

Table 3.8 Sediment Analysis for Hydrocarbons from L'Anse au Diable Subtidal Samples, September 2010

Petroleum Hydrocarbons	**Units**	**RDL**	**S-016**	**S-017**	**S-018**	**S-019**
Benzene	$mg\cdot kg^{-1}$	0.003	ND	ND	ND	ND
Toluene	$mg\cdot kg^{-1}$	0.03	ND	ND	ND	ND
Ethylbenzene	$mg\cdot kg^{-1}$	0.01	ND	ND	ND	ND
Xylene (Total)	$mg\cdot kg^{-1}$	0.05	ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg\cdot kg^{-1}$	3	ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg\cdot kg^{-1}$	10	ND	ND	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg\cdot kg^{-1}$	10	ND	ND	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg\cdot kg^{-1}$	15	ND	ND	ND	ND
Modified TPH (Tier1)	$mg\cdot kg^{-1}$	20	ND	ND	ND	ND
Reached Baseline at C_{32}	$mg\cdot kg^{-1}$	N/A	NA	NA	NA	NA
Hydrocarbon Resemblance	$mg\cdot kg^{-1}$	N/A	NA	NA	NA	NA
Surrogate Recovery (%)						
Isobutylbenzene - Extractable	%		95	96	98	96
n-Dotriacontane - Extractable	%		104	100	120	111
Isobutylbenzene - Volatile	%		105	105	114	114

Table 3.9 Sediment Analysis for Hydrocarbons from L'Anse au Diable Intertidal Samples, September 2010

Petroleum Hydrocarbons	**Units**	**RDL**	**S-020**	**S-021**	**S-022**	**S-023**
Benzene	$mg\cdot kg^{-1}$	0.003	ND	ND	ND	ND
Toluene	$mg\cdot kg^{-1}$	0.03	ND	ND	ND	ND
Ethylbenzene	$mg\cdot kg^{-1}$	0.01	ND	ND	ND	ND
Xylene (Total)	$mg\cdot kg^{-1}$	0.05	ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg\cdot kg^{-1}$	3	ND	ND	ND	ND
$>C_{10}$-C_{16} Hydrocarbons	$mg\cdot kg^{-1}$	10	ND	ND	ND	ND
$>C_{16}$-C_{21} Hydrocarbons	$mg\cdot kg^{-1}$	10	ND	ND	ND	ND
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg\cdot kg^{-1}$	15	ND	ND	ND	ND
Modified TPH (Tier1)	$mg\cdot kg^{-1}$	20	ND	ND	ND	ND
Reached Baseline at C_{32}	$mg\cdot kg^{-1}$	N/A	NA	NA	NA	NA
Hydrocarbon Resemblance	$mg\cdot kg^{-1}$	N/A	NA	NA	NA	NA
Surrogate Recovery (%)						
Isobutylbenzene - Extractable	%		91	91	95	90
n-Dotriacontane - Extractable	%		94	91	97	95
Isobutylbenzene - Volatile	%		107	99	101	100

3.1.3 Benthic Invertebrates

All eight sites at L'Anse au Diable sampled for sediment were successfully sampled for benthic invertebrates. 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 3.10. Four sites in the subtidal zone were sampled on September 30, 2010 and four sites in the intertidal zone were sampled on October 7, 2010. Sub-sampling was not required by the benthic laboratory as the quantity and diversity of benthic organisms was relatively low. For the purposes of organization, and owing to differences in benthic community, the benthic results from the intertidal and subtidal zones are presented separately.

Table 3.10 Sediment Characteristics and Benthic Community Collected During Benthos Surveys from L'Anse au Diable October 2010

Sample	Field Sediment Assessment	Laboratory Assessment of Sediment and Organism Community Description
Subtidal Samples		
S-016	Sand with some shell fragments	Shell debris, encrusting bryozoans, foraminifers, *Spirorbis* spp., echinoderms and crustaceans.
S-017	Sand with some shell fragments and woody debris	Sandy with shell fragments and sea urchin spines with a sand lance (fish), as well as crustaceans and polychaetes.
S-018	Sand with some shell fragments	Sandy with some shelly and woody debris. Abundant amphipods as well as polychaetes present.
S-019	Sand with some shell fragments and woody debris	Sandy with some shelly debris and small polychaetes present.
Intertidal Samples		
S-020	Sand with some shell fragments	Sandy with some shelly and woody debris, as well as amphipods and polychaetes.
S-021	Sand with seaweed	Sand with shell fragments, sea urchin spines, foraminifers and polychaetes.
S-022	Sand with seaweed	Seaweed present as well as polychaetes and amphipods.
S-023	Sand with seaweed	Seaweed and sand in sample with occasional polychaetes visible.

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.

A total of 561 and 844 benthic organisms were identified from the four subtidal and intertidal stations, respectively. The benthic community collected from subtidal samples was dominated by Polychaetes (241 organisms, 43.0 %), followed by Archiannelida (152 organisms, 27.1 %), Nemertea (94 organisms, 16.8 %), Amphipods (66 organisms, 11.8 %), Bivalves (7 organisms, 1.2 %), and one fish. In the intertidal samples, small unidentified marine Oligochaetes of the Group Archiannelida accounted for 835 organisms or 99 % of the benthos in these samples.

Table 3.11 and 3.12 presents the relative occurrence of benthic taxa in the L'Anse au Diable subtidal and intertidal stations, respectively. In the subtidal samples, a total of 33 taxa were identified and five occurred in all samples including the Polychaetes *Scoloplos acutus* and *Spio filicornis*, unidentified small marine Oligochaeta, a small unidentified Nemertean, and the Amphipod *Psammonyx terranovae*. The Polychaetes *Heteromastus filiformis* and *Ophelina acuminata* and an Archiannelid of the Protodrilidae family were identified from three stations. All other taxa were found in one or two stations. In the intertidal samples, a total of only six taxa were identified and only small unidentified marine Oligochaetes were evident in all samples and an unidentified Nemertean in two samples.

Table 3.11 Relative Occurrence of Benthic Taxa Collected During Benthos Surveys from Subtidal Sites at L'Anse au Diable September 2010

Species	Taxon	Occurrence[1]
Scoloplos acutus	POLYCHAETA	4
Spio filicornis	POLYCHAETA	4
Marine Oligochaeta	ARCHIANNELIDA	4
Psammonyx terranovae	AMPHIPODA	4
Nemertean sp. D	NEMERTEA	4
Heteromastus filiformis	POLYCHAETA	3
Ophelina acuminata	POLYCHAETA	3
Protodrilidae unid.	ARCHIANNELIDA	3
Capitella capitata	POLYCHAETA	2
Microphthalmus sczelkoweii	POLYCHAETA	2
Archiannelid unid	ARCHIANNELIDA	2
Nemertean sp. A	NEMERTEA	2
Liocyma fluctuosa	BIVALVIA	1
Modiolus modiolus	BIVALVIA	1
Mya truncata	BIVALVIA	1
Mytilus edulis	BIVALVIA	1
Chaetozone sp.	POLYCHAETA	1
Eteone longa	POLYCHAETA	1
Gyptis sp.	POLYCHAETA	1

Note [1]: Occurrence as the number of samples in which the taxon was identified.

Table 3.11 Relative Occurrence of Benthic Taxa Collected During Benthos Surveys from Subtidal Sites at L'Anse au Diable September 2010 (Cont'd)

Species	Taxon	Occurrence[1]
Levinsenia sp.	POLYCHAETA	1
Maldanidae sp. C	POLYCHAETA	1
Paradoneis sp.	POLYCHAETA	1
Polychaete sp. E	POLYCHAETA	1
Pygospio elegans	POLYCHAETA	1
Travisia sp.	POLYCHAETA	1
Anonyx sp.	AMPHIPODA	1
Calliopius laeviusculus	AMPHIPODA	1
Corophium sp.	AMPHIPODA	1
Oediceros saginatus	AMPHIPODA	1
Cerebratulus sp.	NEMERTEA	1
Nemertean unid	NEMERTEA	1
Priapulida sp.	PRIAPULIDA	1
Ammodytes sp.	FISH	1

Note [1]: Occurrence as the number of samples in which the taxon was identified.

Table 3.12 Relative Occurrence of Benthic Taxa Collected During Benthos Surveys from Intertidal Sites from L'Anse au Diable October 2010

Species	Taxon	Occurrence[1]
Marine Oligochaete	ARCHIANNELIDA	4
Nemertean unid	NEMERTEA	2
Gastropod sp. G	GASTROPODA	1
Gastropod sp. H	GASTROPODA	1
Calliopius laeviusculus	AMPHIPODA	1
Gammarus oceanicus	AMPHIPODA	1

Note [1]: Occurrence as the number of samples in which the taxon was identified.

The benthic taxa are listed in order of abundance in Table 3.13 and 3.14 in the subtidal and intertidal samples, respectively. In the subtidal samples, similar to the relative occurrence, unidentified small marine Oligochaeta, Polychaetes *Scoloplos acutus* and *Spio filicornis,* a small unidentified Nemertean species, and the Amphipod *Psammonyx terranovae* accounted for 71 % of the organisms identified. Other organisms with a minimum of 10 individuals included the Polychaetes *Ophelina acuminata, Heteromastus filiformis, Capitella capitata,* and *Travisia* sp., unidentified Archiannelids, and unidentified Nemerteans. In the intertidal samples, as previously indicated, small unidentified Marine Oligochaetes accounted for 99 % of the benthos in these samples.

Table 3.13 Abundance (Total # of Organisms) of Benthic Taxa Collected During Benthos Surveys from Subtidal Sites at L'Anse au Diable September 2010

Species	Taxon	Total
Marine Oligochaete	ARCHIANNELIDA	118
Scoloplos acutus	POLYCHAETA	85
Nemertean sp. D	NEMERTEA	67
Spio filicornis	POLYCHAETA	66
Psammonyx terranovae	AMPHIPODA	61
Ophelina acuminata	POLYCHAETA	33
Archiannelid unid	ARCHIANNELIDA	29
Nemertean unid	NEMERTEA	19
Heteromastus filiformis	POLYCHAETA	12
Travisia sp.	POLYCHAETA	12
Capitella capitata	POLYCHAETA	10
Levinsenia sp.	POLYCHAETA	7
Protodrilidae unid.	ARCHIANNELIDA	5
Chaetozone sp.	POLYCHAETA	4
Cerebratulus sp.	NEMERTEA	4
Nemertean sp. A	NEMERTEA	4
Mytilus edulis	BIVALVIA	3
Microphthalmus sczelkoweii	POLYCHAETA	3
Polychaete sp. E	POLYCHAETA	3
Modiolus modiolus	BIVALVIA	2
Anonyx sp.	AMPHIPODA	2
Liocyma fluctuosa	BIVALVIA	1
Mya truncata	BIVALVIA	1
Eteone longa	POLYCHAETA	1
Gyptis sp.	POLYCHAETA	1
Maldanidae sp. C	POLYCHAETA	1
Paradoneis sp.	POLYCHAETA	1
Pygospio elegans	POLYCHAETA	1
Calliopius laeviusculus	AMPHIPODA	1
Corophium sp.	AMPHIPODA	1
Oediceros saginatus	AMPHIPODA	1
Priapulida sp.	PRIAPULIDA	1
Ammodytes sp.	FISH	1
Total		**561**

Table 3.14 Abundance (Total # of Organisms) of Benthic Taxa Collected During Benthos Surveys from Intertidal Sites at L'Anse au Diable October 2010

Species	Taxon	Total
Marine Oligochaete	ARCHIANNELIDA	835
Nemertean unid	NEMERTEA	5
Gastropod sp. G	GASTROPODA	1
Gastropod sp. H	GASTROPODA	1
Calliopius laeviusculus	AMPHIPODA	1
Gammarus oceanicus	AMPHIPODA	1
Total		**844**

Abundance, biomass, and selected community measures are provided in Table 3.15 and due to the differences in benthic community, these metrics have been calculated separately for the subtidal and intertidal communities. Subtidal samples had a moderate abundance (#/sample) from 110 to 189 organisms (mean ± Std. Dev. of 140.0 ± 35.8) while intertidal samples ranged from 35 to 398 organisms (mean ± Std. Dev. of 211.0 ± 177.1) and there was greater variability in the intertidal samples (Figure 3.5). The high abundance at two stations in the intertidal zone was related to small unidentified marine Oligochaetes.

Biomass (g/sample wet weight) ranged from 0.84 to 2.45 (mean ± Std. Dev. of 1.66 ± 0.78) at the subtidal sites which was an order of magnitude greater than at the intertidal sites (range of 0.04 to 0.47, mean ± Std. Dev. of 0.16 ± 0.21) (Table 3.15, Figure 3.6). Similarly, there was a large difference in taxon richness (# taxa/sample) between samples from the two locations with subtidal richness ranging from 11 to 16 taxa (mean ± Std. Dev. of 14.3 ± 2.4) and intertidal richness ranging from two to three taxa (mean ± Std. Dev. of 2.5 ± 0.6) (Table 3.15, Figure 3.7).

The Shannon-Wiener Diversity Index, the most widely used index to describe the proportional abundance of species (Costello et al. 2001), ranged from 0.78 to 0.94 (mean ± Std. Dev. of 0.87 ± 0.07) and from 0.01 to 0.09 (mean ± Std. Dev. of 0.05 ± 0.04) in the subtidal and intertidal zones, respectively.

Pielou's Evenness Index, constrained to a scale from 0 to 1, is the most widely used measure of species evenness and a biodiversity index (Costello et al. 2001), and ranged from 0.73 to 0.82 (mean ± Std. Dev. of 0.76 ± 0.04) and from 0.03 to 0.19 (mean ± Std. Dev. of 0.11 ± 0.09) in the subtidal and intertidal zones, respectively.

McIntosh's Index, constrained to a scale from 0 to 1, is an indicator of proportional abundances of species and ranged from 0.59 to 0.68 (mean ± Std. Dev. of 0.62 ± 0.04) and from 0.003 to 0.05 (mean ± Std. Dev. of 0.02 ± 0.02) in the subtidal and intertidal zones, respectively.

Simpson's Index, constrained to range from 0 (high diversity) to 1 (low diversity), is also an indicator of proportional abundances of species, ranged from 0.15 to 0.22 (mean ± Std. Dev. of 0.19 ± 0.03) and from 0.91 to 1.00 (mean ± Std. Dev. of 0.96 ± 0.04) in the subtidal and intertidal zones, respectively.

Margalef's Index, a commonly used species richness or community diversity index with the higher the index the higher the diversity, ranged from 2.10 to 3.02 (mean ± Std. Dev. of 2.69 ± 0.40) and from 0.17 to 0.45 (mean ± Std. Dev. of 0.31 ± 0.12) in the subtidal and intertidal zones, respectively.

Table 3.15 Abundance, Biomass, Taxon Richness and Benthic Diversity Indices for Benthos from Subtidal and Intertidal Sites at L'Anse au Diable September and October 2010

Sample Number	Abundance[1]	Biomass[2]	Taxon Richness[3]	Shannon-Wiener Diversity	Pielou's Evenness Index	McIntosh's Index	Simpson's Index	Margalef's Index
Subtidal Sites								
S-016	189	0.84	16	0.894	0.742	0.63	0.173	2.862
S-017	117	2.45	11	0.778	0.747	0.589	0.216	2.1
S-018	110	1.16	14	0.935	0.815	0.676	0.151	2.766
S-019	144	2.18	16	0.878	0.729	0.591	0.21	3.018
Mean	**140.0**	**1.66**	**14.25**	**0.87**	**0.76**	**0.62**	**0.19**	**2.69**
Median	**130.5**	**1.67**	**15.00**	**0.89**	**0.74**	**0.61**	**0.19**	**2.81**
Std. Dev.	**35.8**	**0.78**	**2.36**	**0.07**	**0.04**	**0.04**	**0.03**	**0.40**
Min.	**110.0**	**0.84**	**11.00**	**0.78**	**0.73**	**0.59**	**0.15**	**2.10**
Max.	**189.0**	**2.45**	**16.00**	**0.94**	**0.82**	**0.68**	**0.22**	**3.02**
Intertidal Sites								
S-020	87	0.06	3	0.092	0.193	0.051	0.911	0.448
S-021	324	0.47	3	0.025	0.053	0.01	0.982	0.346
S-022	35	0.07	2	0.056	0.187	0.034	0.944	0.281
S-023	398	0.04	2	0.008	0.025	0.003	0.995	0.167
Mean	**211.0**	**0.16**	**2.50**	**0.05**	**0.11**	**0.02**	**0.96**	**0.31**
Median	**205.5**	**0.07**	**2.50**	**0.04**	**0.12**	**0.02**	**0.96**	**0.31**
Std. Dev.	**177.1**	**0.21**	**0.58**	**0.04**	**0.09**	**0.02**	**0.04**	**0.12**
Min.	**35.0**	**0.04**	**2.00**	**0.01**	**0.03**	**0.00**	**0.91**	**0.17**
Max.	**398.0**	**0.47**	**3.00**	**0.09**	**0.19**	**0.05**	**1.00**	**0.45**

Note: [1] Abundance - # organisms/sample

[2] Biomass - g/sample

[3] Taxon Richness - taxa/sample

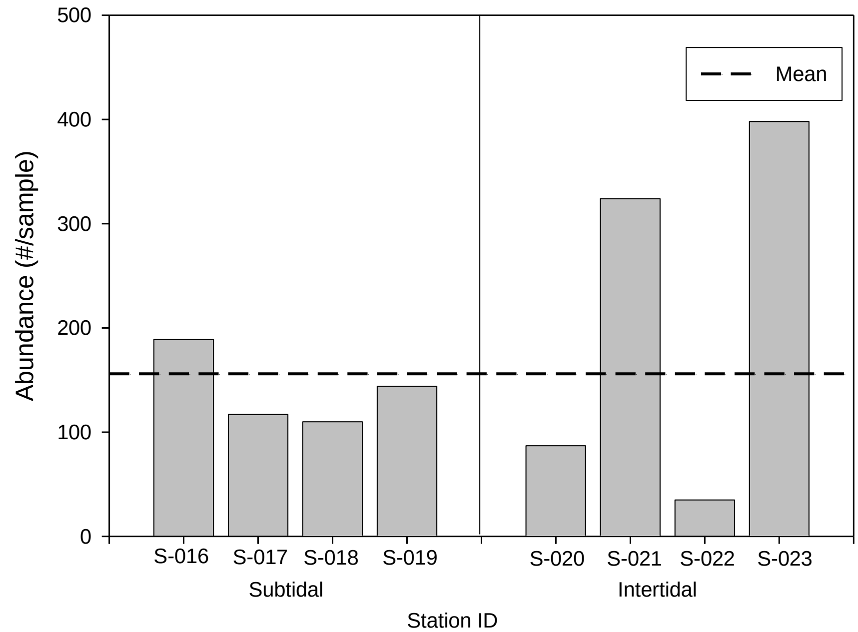


Figure 3.5 Abundance of Benthic Taxa (# Organisms/Sample) Collected from L'Anse au Diable Samples, September and October 2010

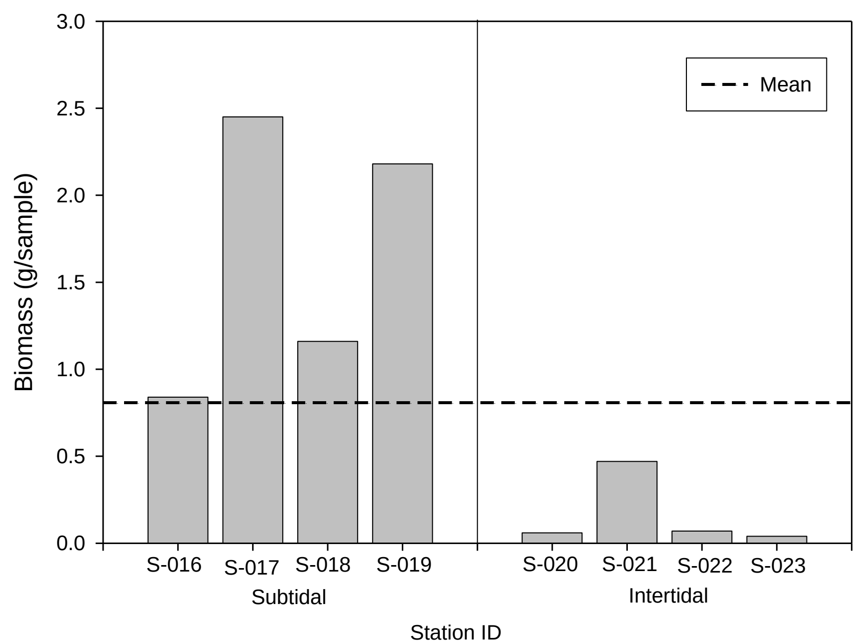


Figure 3.6 Biomass of Benthic Taxa (g/sample) Collected from L'Anse au Diable Samples, September and October 2010

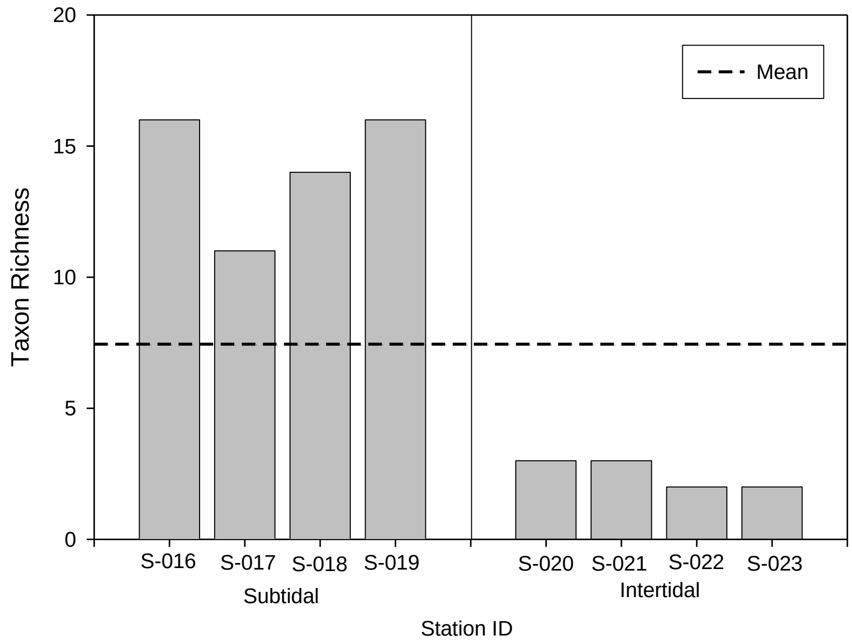


Figure 3.7 Taxon Richness of Benthic Organisms (# taxa/sample) Collected from L'Anse au Diable Samples, September and October 2010

3.1.4 Nearshore Habitat Surveys

Nearshore habitat surveys assessed the habitat characteristics at the Shore Zone level of detail (Kelly et al. 2009, draft) including: (i) backshore; (ii) intertidal zone; and (iii) shallow subtidal zone. The deep subtidal zone was not surveyed as the footprint of the potential electrode site does not extend into this zone. The major features assessed and presented in the following sections included: (i) water depth (bathymetry); (ii) substrate type and distribution; (iii) macroflora class and distribution; (iv) macrofauna presence; and (v) integrated habitat class distribution.

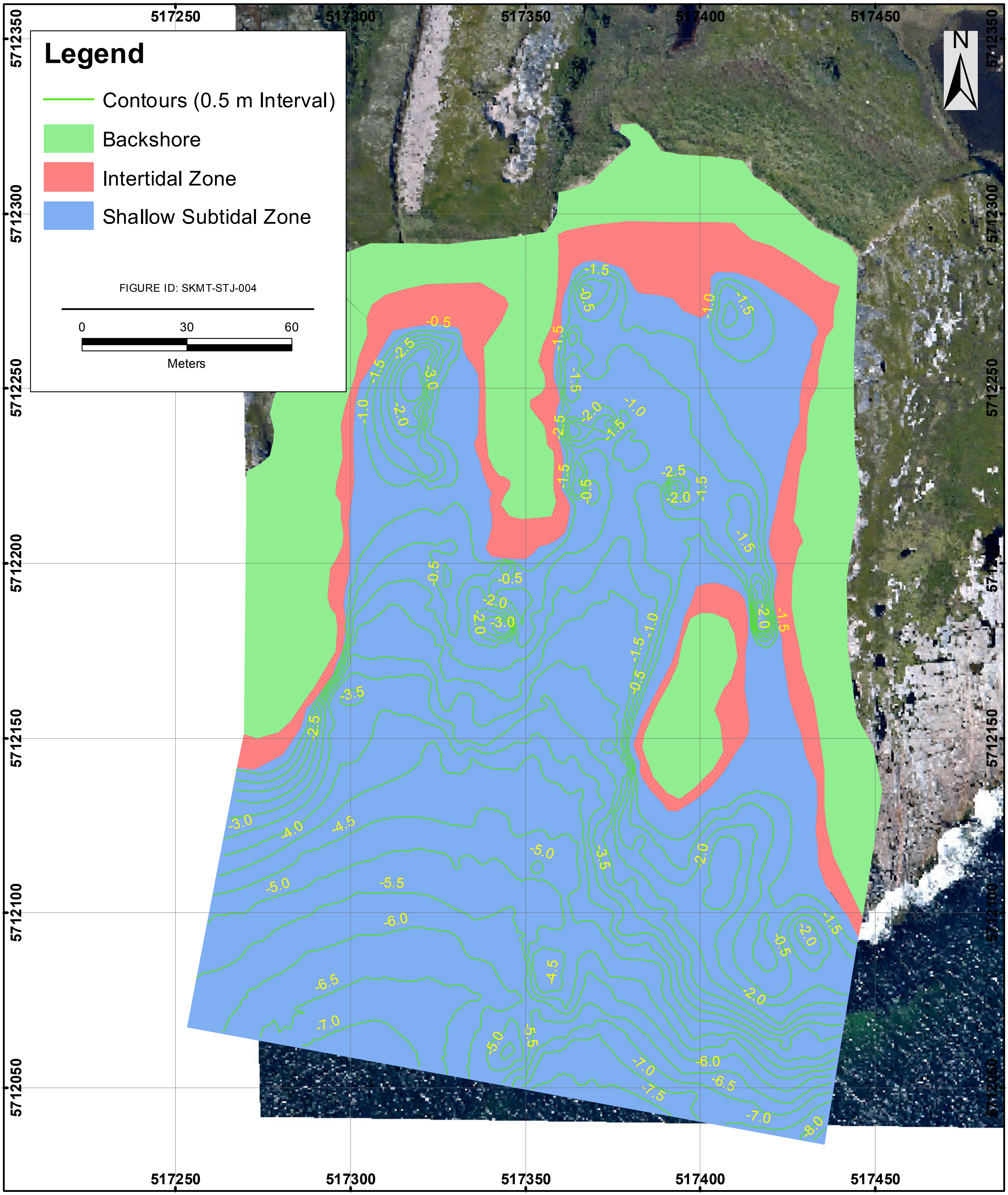
3.1.4.1 Overview

The L'Anse au Diable electrode site is located in the Labrador South Ecoregion (Kelly et al., 2009 draft) along the Labrador coast of the Strait of Belle Isle, and is described as an open coast marine ecosystem. An ice pack will develop by late December in the area and Arctic ice and ice bergs are extensive in the Strait of Belle Isle resulting in considerable ice scour. Tidal data from DFO's tide gauge at Battle Harbour (Easting 595536, Northing 5791622) indicate a mean tidal amplitude of 0.91 m and high tide amplitude of 1.37 m with a mean water level of 0.94 m (DFO 2010). The current adjacent to L'Anse au Diable flows parallel to the shore in a southwesterly direction and tidal currents in the Strait are very strong. The outer coastline at L'Anse au Diable would be considered semi-exposed, with the inner embayment sheltered and oriented away from prevailing winds, and considered as semi-protected. The maximum fetch from the south would be 30 km and 20 km from the southeast (i.e., the Newfoundland shoreline). The site would be considered stable in nature with respect to sediment transport with rock platforms sheltering two stable sand beaches. The L'Anse au Diable electrode site is located along the

Labrador side of the Strait of Belle Isle and could be considered representative for that area with rugged bedrock dominated shorelines with the occasional sheltered embayments with gravel and/or sand beaches.

3.1.4.2 Bathymetry

The depth distributions from the bathymetric survey were modelled and mapped in two-dimensions and presented in Figure 3.8. The maximum depth apparent in the study area was 8.0 m and 2.26 ha (74 %) were within 5.0 m depth. Several areas within the inner coves contained steep bedrock slopes which then changed to a plateau of more uniform depth. Outside of the inner cove the sea bed slopes more regularly into the shallow subtidal zone, two small plateaus are present. Several of these bathymetric features were linked to substrate distribution which in turn played a role in macroflora and, to a lesser extent, macrofaunal distributions.



nalcor energy

FIGURE 3.8

L'Anse au Diable Bathymetry and Backshore, Intertidal and Subtidal Zones

3.1.4.3 Intertidal and Backshore Zones

The demarcation between the intertidal and subtidal zones was determined from the mean tidal range from the tide gauge at Battle Harbour, from interpretation of the digital image for the site, and from observations and photos taken during the survey (Figure 3.8). A total of 0.42 ha of the study area is within the intertidal zone, with 0.24 ha consisting of bedrock extending from the Rock Platform backshore to the water's edge, and 0.18 ha of sand extending from the Sand/Flat Beach backshore to the water's edge (Figure 3.9).

Similarly, two types of backshore were identified extending from the intertidal zone to the inland extent of possible marine processes which was interpreted from the digital image for the site and photographs taken during the survey (Figures 3.10 and 3.11). The total backshore area for L'Anse au Diable was 0.93 ha, including 0.71 ha of Rock Platform and 0.22 ha of Sand/Flat Beach.

Figure 3.9 Sand Beach Intertidal Zone

Figure 3.10 Sand Flat/Beach and Rock Platform Backshore Zone

Figure 3.11 Narrow Intertidal Zone Adjacent to Rock Platform Backshore

3.1.4.4 Substrate Distribution

The distribution of substrate types as determined from underwater video analyses for L'Anse au Diable is presented in Table 3.16. The substrate types identified were either a single substrate type or combinations of two and three substrate types. Overall, L'Anse au Diable contained a very heterogeneous mix of substrate types and, owing to the large number of substrate combinations observed, the data were aggregated into a smaller number of substrate classes for two-dimensional modelling and mapping (Table 3.17). Bedrock/boulder was the dominant aggregated substrate class (42.1 %), followed by sand (34.8 %), cobble/boulder/sand (9.3 %), sand/boulder/cobble/pebble (7.4 %), boulder/cobble/sand (5.6 %), and finally boulder (0.8 %).

Within the subtidal zone, there were areas of bedrock structures with steep slopes which then changed to a plateau containing boulder, cobble, and sandy regions. At the base of the bedrock structure, the substrate typically changed from sand to boulder. Sandy substrates were usually rippled with some larger ripples apparent with slightly higher crests, although the majority of the ripples were shallow. This suggests some current on the seabed over the sandy substrates.

Table 3.16 Detailed Substrate Classes Identified in the Underwater Video from L'Anse au Diable October 2010

Substrate Type/Class[1]	Time Viewed (s)	Percent (%)
Bedrock/Boulder	1521	42.06
Sand	1257	34.76
Cobble/Sand	250	6.91
Sand/Cobble	127	3.51
Boulder/Sand	107	2.96
Cobble/Boulder/Sand	52	1.44
Boulder/Cobble	49	1.36
Boulder/Cobble/Sand	48	1.33
Sand/Boulder	41	1.13
Sand/Pebble	29	0.8
Boulder	28	0.77
Cobble/Boulder	26	0.72
Sand/Cobble/Boulder	23	0.64
Sand/Boulder/Cobble	19	0.53
Sand/Pebble/Cobble	16	0.44
Sand/Cobble/Pebble	14	0.39
Cobble/Pebble	9	0.25
Total Time Viewed/Percent	**3616**	**100**

Note [1]: Dominant substrate is identified first, followed by the next most important substrate type, followed by the third (if applicable)

Table 3.17 Aggregated Substrate Classes Identified in the Underwater Video from L'Anse au Diable October 2010

Substrate Class[1]	Time Viewed (s)	Percent (%)
Bedrock/Boulder	1521	42.06
Sand	1257	34.76
Cobble/Boulder/Sand	337	9.32
Sand/Boulder/Cobble/Pebble	269	7.44
Boulder/Cobble/Sand	204	5.64
Boulder	28	0.77
Total Time Viewed/Percent	**3616**	**100**

Note [1]: Dominant substrate is identified first, followed by the next most important substrate type, followed by the third and fourth (if applicable)

The observations of the six aggregated substrate classes were modelled and mapped in two-dimensions in Figure 3.12. The total area (ha) represented by each substrate class in the study area is provided in Table 3.18. The largest substrate class is bedrock/boulder (50.1 %) which is extensively distributed throughout the study site. Sand (35.3 %) is also a large substrate class and there are two extensive patches associated with the inner cove beaches and another large expanse in the southwest quadrant of the study area. There is considerable heterogeneity in substrate distribution on the western side of the small island within the study site.

Table 3.18 Area (ha) for Aggregated Substrate Classes as Mapped from the Underwater Video from L'Anse au Diable October 2010

Substrate Class[1]	Area (ha)	Percent (%)[2]
Bedrock/Boulder	1.52	50.10
Sand	1.07	35.30
Cobble/Boulder/Sand	0.16	5.29
Boulder/Cobble/Sand	0.14	4.64
Sand/Boulder/Cobble/Pebble	0.12	3.96
Boulder	0.02	0.71

Note [1]: Dominant substrate is identified first, followed by the next most important substrate type, followed by the third and fourth (if applicable)
Note [2]: The percent of each substrate class, by area, is different from percent by observation, due to the modelling algorithm

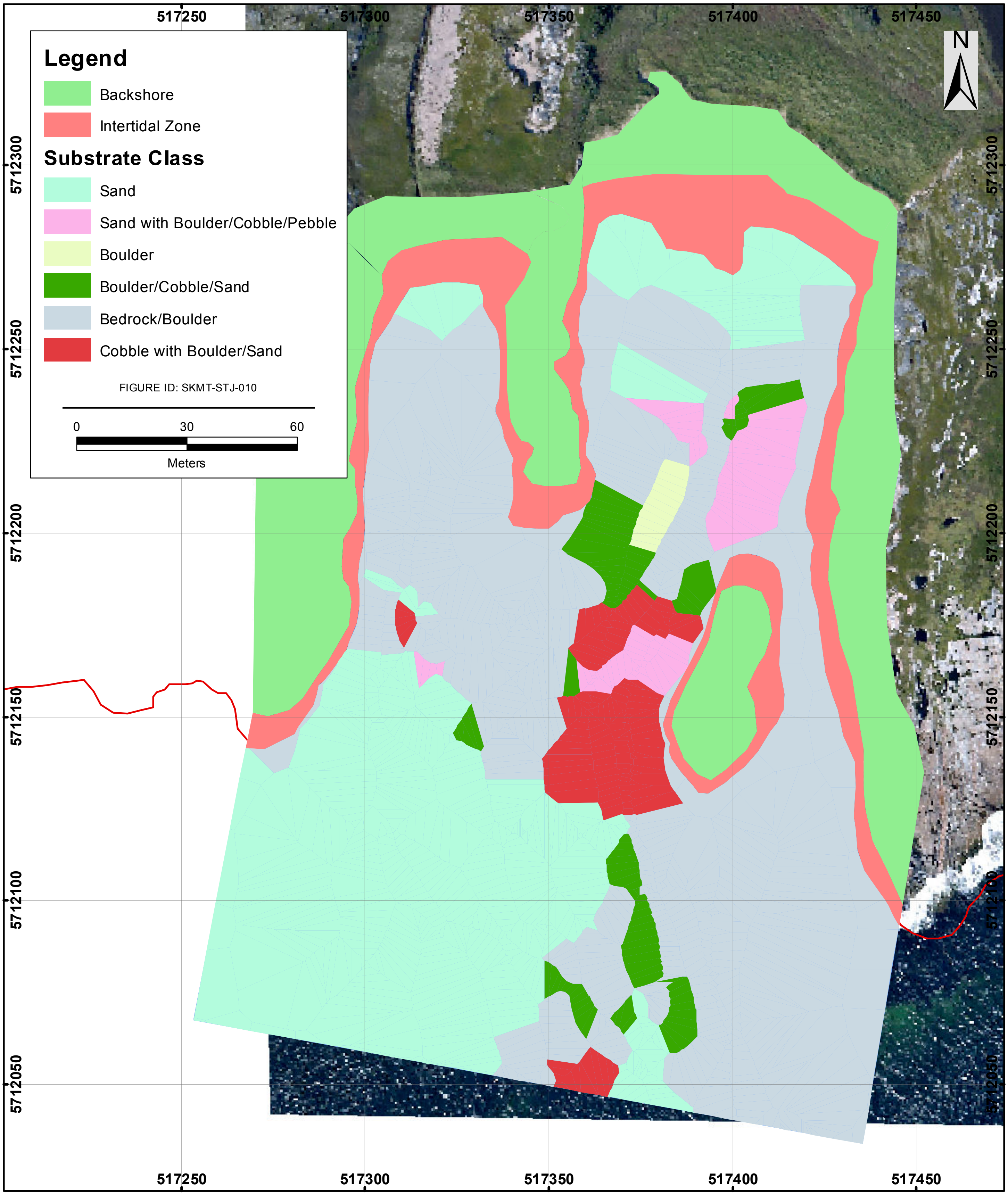


FIGURE 3.12

L'Anse au Diable Substrate Distribution

3.1.4.5 Macrofloral Distributions

Table 3.19 provides a detailed listing of the macroflora types identified in the underwater video. The macroflora were identified to species and/or genus where possible, although this was not always possible owing to the resolution of the video related to elevation from the bottom and/or vessel speed. Overall there was an abundance and diversity of macroflora and, owing to the large number of types identified, and the varying levels of taxonomic description, the data were aggregated into a smaller number of macrofloral classes for two-dimensional modelling and mapping (Table 3.20). The aggregated classes consisted of the major algal types (red, brown, and green) and various combinations of the types as they frequently occurred together.

Table 3.19 Detailed Macrofloral Types Identified in the Underwater Video from L'Anse au Diable October 2010

Taxa	Common name	Macrofloral Type	Time Viewed (s)	Percent (%)
Calcareous encrusting Rhodophyta sp.	Coralline algae	Red Algae	1374	19.81
Alaria esculenta	edible kelp	Brown Algae	951	13.71
Ulva sp.	sea lettuce	Green Algae	858	12.37
Ptilota sp. *Ptilota serrata*	red fern	Red Algae	680	9.81
Agarum cribrosum	sea colander	Brown Algae	545	7.86
Encrusted coraline algae, *Phymatolithon* sp.	Coralline red algae	Red Algae	504	7.27
Laminaria digitata	finger kelp	Brown Algae	503	7.25
Palmaria palmata	dulse	Red Algae	430	6.20
Brown filamentous algae	sour weed	Brown Algae	376	5.42
Red filamentous algae	Red algae	Red Algae	272	3.92
Fucus sp.	Brown algae	Brown Algae	199	2.87
Laminaria saccharina	sugar kelp	Brown Algae	135	1.95
Desmarestia sp.	sour weed	Brown Algae	36	0.52
Lithothamnium sp.	Crustose algae	Red Algae	35	0.50
unidentified green seaweed	n/a	Green Algae	17	0.25
other unidentified	n/a	n/a	20	0.29
Total Time Viewed/Percent			**6935**	**100.00**

Table 3.20 Aggregated Macrofloral Classes Identified in the Underwater Video from L'Anse au Diable October 2010

Macrofloral Type	Taxa	Time Viewed (s)	Percent (%)
Red algae	Encrusted coralline algae – various Rhodophyta sp., *Phymatolithon* sp., various red filamentous algae, *Lithothamnium* sp. (Crustose algae), Ptilota sp., *Ptilota serrata* (red fern), *Palmaria palmata* (dulse)	236	10.42

Table 3.20 Aggregated Macrofloral Classes Identified in the Underwater Video from L'Anse au Diable October 2010 (Cont'd)

Macrofloral Type	Taxa	Time Viewed (s)	Percent (%)
Brown Algae	*Alaria esculenta* (edible kelp), various brown filamentous algae (sour weed), *Agarum cribrosum* (sea Colander), *Laminaria digitata* (finger kelp), *Fucus* sp., *Laminaria saccharina* (sugar kelp), *Desmarestia* sp. (sour weed)	284	12.54
Green Algae	*Ulva* sp. (sea lettuce)	49	2.16
Red/Brown Algae	Combinations of red and brown algae	880	38.85
Red/Green Algae	Combinations of red and green algae	169	7.46
Brown/Green Algae	Combinations of brown and green algae	138	6.09
Red/Brown/Green Algae	Combinations of all three dominant macrofloral types	509	22.47
	Total Time Viewed/Percent	**2,265**[1]	**100.00**

Note [1]: Total time viewed is less that in Table 3.19 as macroalgal types were observed together at many locations.

The dominant macrofloral type was the coralline red algae (27.1 %) with various Rhodophyta species apparent and members of the genus *Phymatolithon* particularly apparent. Brown algae (25.9 %) were similarly important and included various filamentous species, sea colander, finger kelp, sugar kelp, and various *Fucus* and *Desmarestia* species. Various red algae including filamentous species, dulse, red fern, and other *Lithothamnium* and *Ptilota* species comprised 20.4 % of the macroflora observed. The brown algae edible kelp and sea lettuce in the green algae group comprised 13.7 % and 12.4 % of the observed macroflora, respectively. The single dominant taxon was the edible kelp, *Alaria esculenta*.

The distribution of macroflora was influenced by substrate distribution. Most of the bedrock, boulder, and to a lesser extent cobble had algal growth on their surface which was chalky white to pink to purple in colour and was subsequently identified as calcareous encrusting coralline red algae. The sea colander, *Agarum cribrosum* was most frequently observed on the vertical side of bedrock and in crevices within the bedrock. Most of the other seaweed species were associated with the bedrock, boulder, and cobble substrate. There were no macroflora observed in association with the sandy substrates.

The distribution of macroflora classes was modelled and mapped in two-dimensions in Figure 3.13. It was also important to include areas without macroflora in the modelled distributions. The total area (ha) represented by each macrofloral class in the study area is provided in Table 3.21. The two smallest classes, red algae alone (1.7 %) and green algae alone (0.5 %), were removed from the model owing to the low representation. The largest class was No Macroflora (36.1 %) and this distribution was highly correlated to the distribution of sand substrates. Red and brown algae (23.0 %) was also important and the distribution of this class was more patchy but highly associated with bedrock/boulder substrates. Combinations of all three algae types were also well represented (18.7 %) and the distribution of this class was most closely associated with bedrock/boulder.

Table 3.21 Area (ha) Containing Aggregated Macrofloral Classes as Mapped from the Underwater Video from L'Anse au Diable October 2010

Macrofloral Class	Area (ha)	Percent (%)[1]
No algae	1.10	36.10
Red and brown algae	0.70	22.96
Red/brown/green algae	0.57	18.72
Brown algae	0.30	9.78
Red and green algae	0.23	7.71
Brown and green algae	0.08	2.52
Red algae	0.05	1.68
Green algae	0.02	0.53

[1]Note: The percent of each macrofloral class, by area, is different from percent by observation, due to the modelling algorithm.

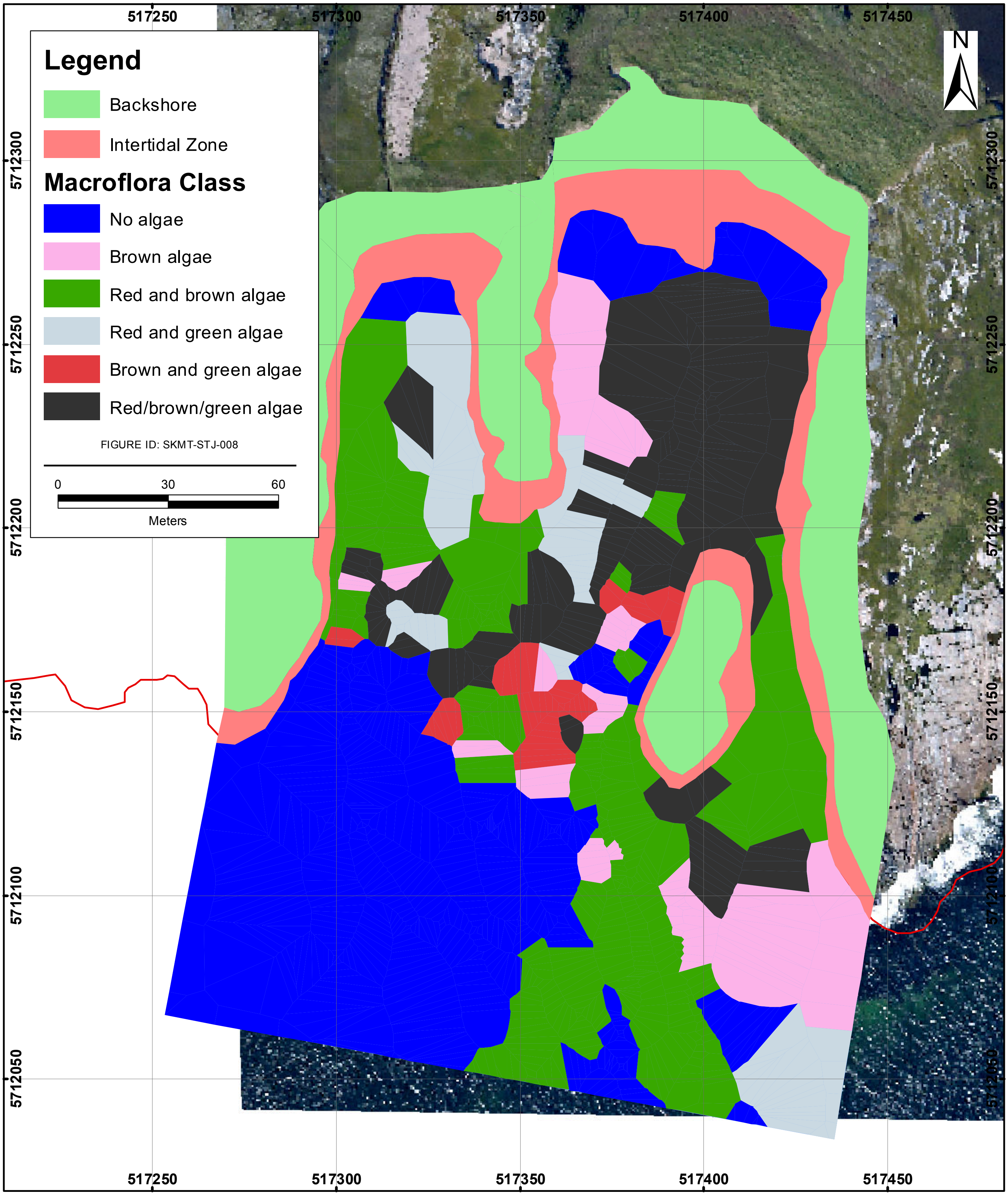


FIGURE 3.13

L'Anse au Diable Macroflora Distribution

3.1.4.6 Macrofauna Distributions

The macrofauna observed in the underwater video for L'Anse au Diable in 2010 are listed in Table 3.22. The dominant fauna were the sea urchins, either *Strongylocentrotus pallidus* (pale urchin), or *S. droebachiensis* (green urchin). Identification to species was difficult but it is likely both species were well represented. The sea urchins were abundant, and where present, they were numerous, and no attempt was made to enumerate them. With the exception of sea urchins, echinoderms were occasional within the study area and there were a total of 41 starfish observed, including 28 polar sea star and 13 of the *Asterias* species. Eleven sculpin were observed, most likely shorthorn sculpin (*Myoxocephalus scorpius*), and these were considered occasional in the study area. Obviously some fish species are mobile and they may have avoided the video camera due to the lights, noise, and other disturbances. One snow crab (*Chionoecetes opilio*) was observed as were two unidentified fish. The macrofaunal observations, other than sea urchins, were too few to map and the only important habitat association was the absence of sea urchins with sandy substrates.

Table 3.22 Macrofauna Taxa Observed in the Underwater Video from L'Anse au Diable

Taxa	Common Name	Time (s) or Number Viewed
Strongylocentrotus pallidus and/or *S. droebachiensis*	Pale urchin and/or green urchin	813 s [1]
Leptasterias polaris	Polar sea star	28
Asterias sp.	Starfish	13
Myoxocephalus sp.	Sculpin	11
Chionoecetes opilio	Snow crab	1
Unidentified fish species	n/a	2

Note [1]: Urchin species too numerous to count

3.1.4.7 Habitat Distributions

The aggregated substrate distribution was integrated with the aggregated macroflora distribution to define integrated habitat classes for the shallow subtidal zone. The heterogeneity of both attributes at the L'Anse au Diable site required that an additional level of substrate aggregation be completed to reduce the number of habitat classes for mapping. This aggregation collapsed the six substrate classes into three (Table 3.23).

Table 3.23 Additional Aggregation of Substrate Classes for Habitat Integration and Mapping

Final Aggregated Substrate Class	Substrate Class
Coarse substrate – bedrock, boulder	Bedrock/Boulder
	Boulder
Mixed substrate – boulder, cobble, pebble, sand	Cobble/Boulder/Sand
	Boulder/Cobble/Sand
	Sand/Boulder/Cobble/Pebble
Fine substrate - sand	Sand

The habitat classes developed from integration of substrate and macrofloral distributions in the subtidal zone, and the area (ha) of each as determined from modelling and mapping, are provided in Table 3.24.

Table 3.24 Area (ha) Containing Integrated Habitat Classes as Mapped from the Underwater Video from L'Anse au Diable

Integrated Habitat Class	Area (ha)	Percent (%)
Coarse substrate with Macroflora	1.53	50.0
Coarse substrate with No Macroflora	0.03	1.0
Mixed substrate with Macroflora	0.42	14.0
Mixed substrate with No Macroflora	0.03	1.0
Fine substrate with No Macroflora	1.02	34.0

An integrated habitat map (Figure 3.14) is presented including three zones for shore zone habitat characterization including:

1. Backshore (two classes);
2. Intertidal Zone (two classes); and
3. Shallow Subtidal Zone (five classes).

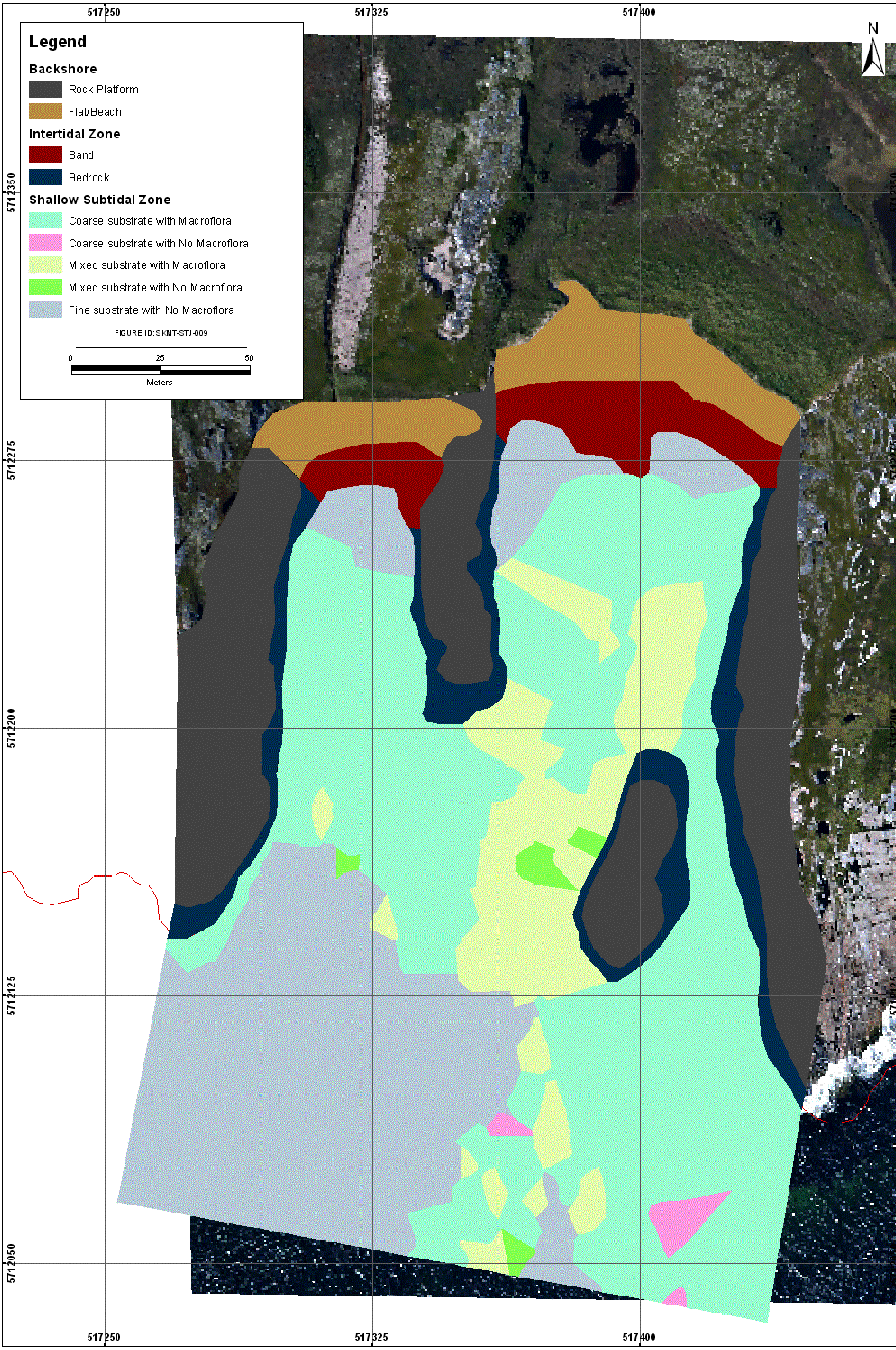


FIGURE 3.14

L'Anse au Diable Habitat Distribution

3.2 Dowden's Point

The Dowden's Point electrode site was surveyed on October 19 and 20, 2010 including water sampling and nearshore habitat surveys. No sediment or substrate material were able to be collected at this site, and consequently there are no results for sediment quality or benthic community. The results of the water sampling is presented in Section 3.2.1, followed by the nearshore habitat surveys in Section 3.2.2.

3.2.1 **Water Quality**

Water quality data was collected at four locations within the Dowden's Point electrode site (Figure 3.15). Water quality included measurement of selected parameters in the field, and chemical and hydrocarbon analyses at an analytical laboratory. CTD profiles were also created from data collected with a YSI meter. The detailed results of the analysis of these samples are contained in Appendix A. Depths and locations (in UTMs, Zone 22) of the sampling sites are listed in Table 3.25.

Table 3.25 Summary of Date, Location and Depth of Water Sampling Sites at Dowden's Point, October 2010

Date	Station ID	Location		Habitat	Depth (m)
		Easting	Northing		
Oct-19-10	W-020	343365	5259958	Subtidal	4.0
Oct-19-10	W-021	343418	5260025	Subtidal	4.4
Oct-19-10	W-022	343509	5260029	Subtidal	3.3
Oct-19-10	W-023	343530	5260104	Subtidal	4.0

3.2.1.1 Conductivity, Temperature, and Depth (CTD) Profiles

CTD profiles were collected with a YSI meter at the four water quality stations at the Dowden's Point electrode site. The CTD profiles are displayed in Figure 3.16 (Stations W-020 to W-023).

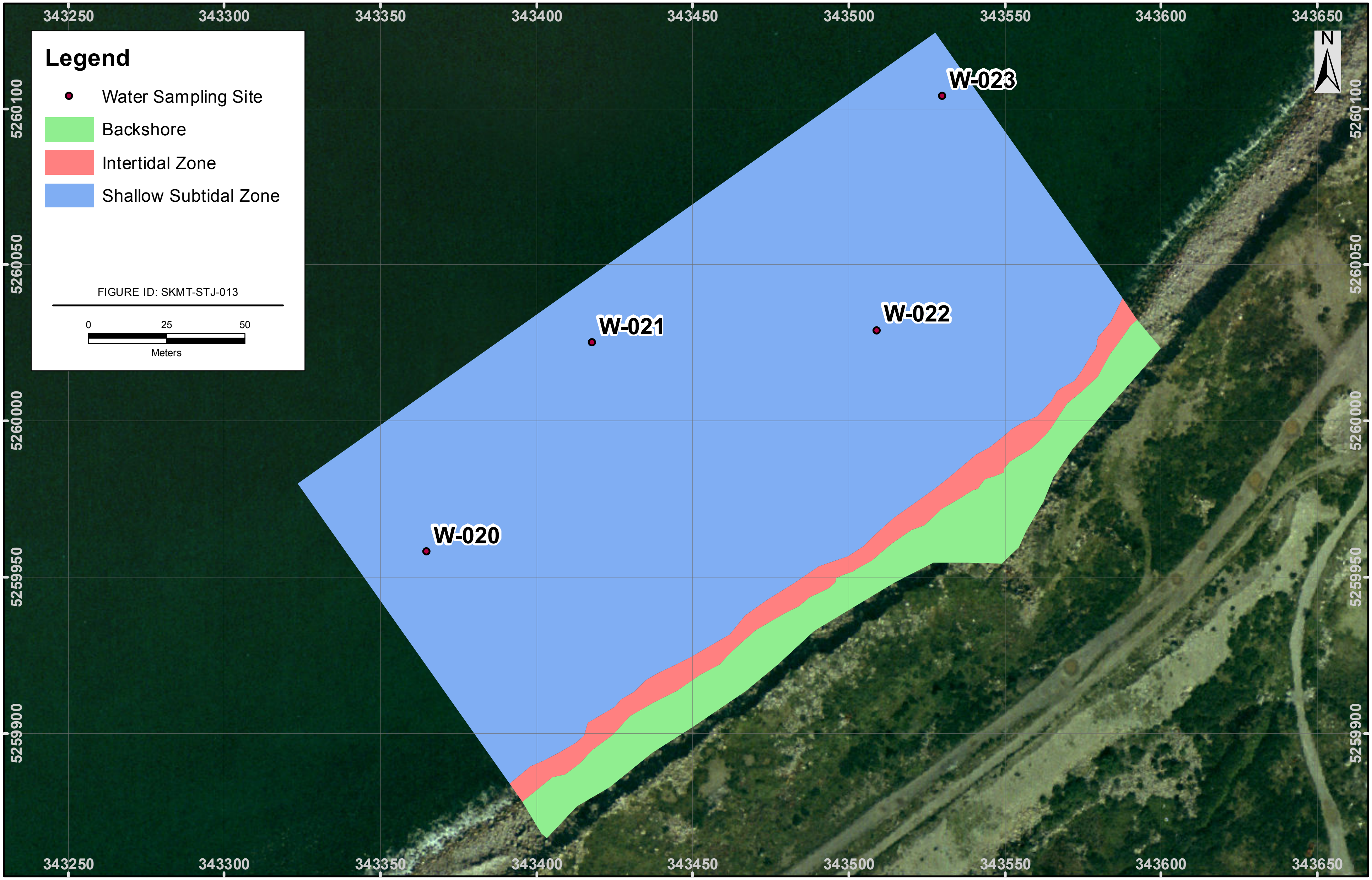


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FIGURE 3.15

Dowden's Point Sampling Sites

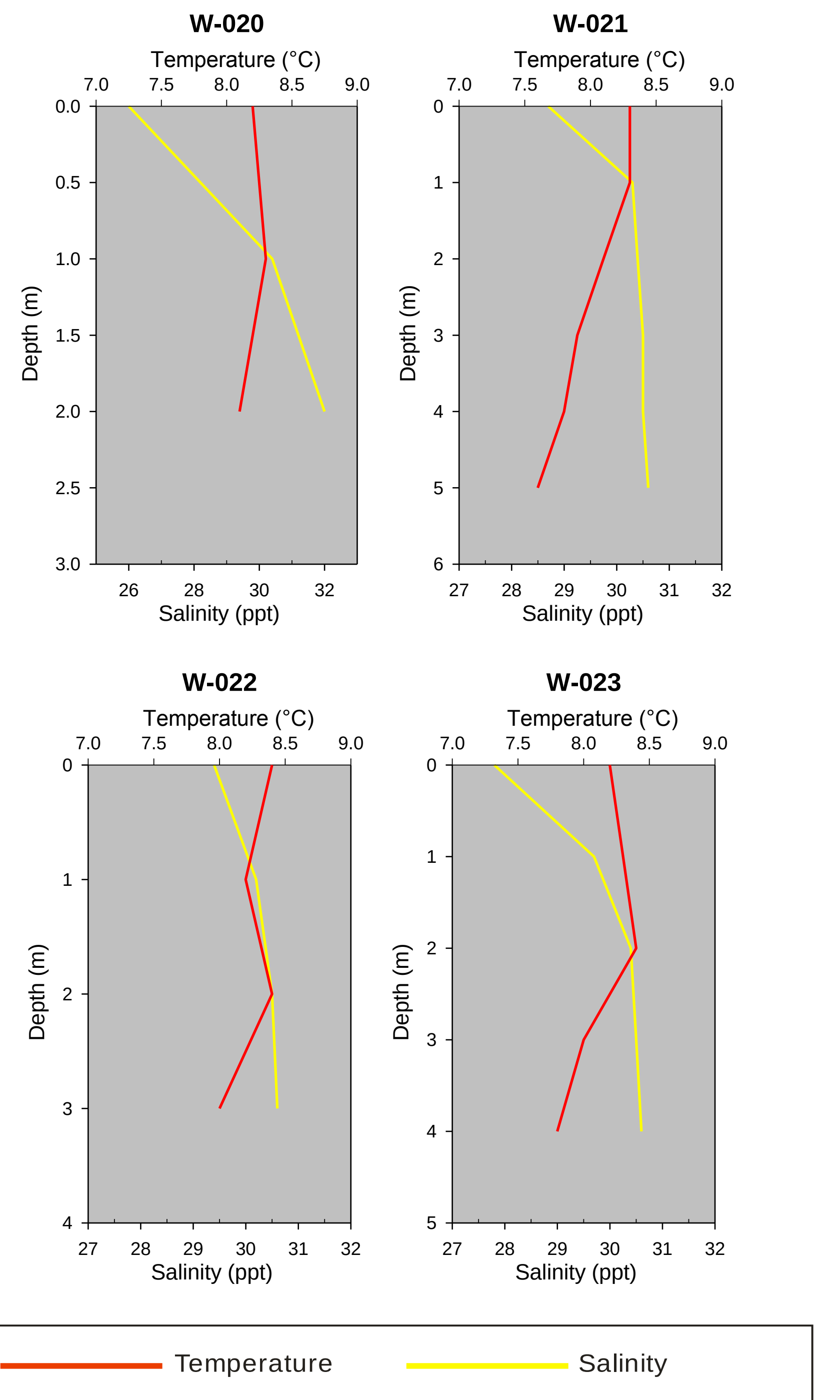

Figure 3.16 CTD Profiles for Dowden's Point Stations W-020 to W-023, October 2010

The CTD profiles indicate there was evidence of a modest salinity gradient with depth. The modest salinity gradient was related to the lower salinities at the surface which is likely an indication of freshwater influence in the surface layer. There was also some indication of a small temperature decline with depth at the stations however there was no thermocline present. The absence of a distinct gradient and thermocline at these stations was expected due to the shallow nature of the sampling sites and the likelihood that the water was well mixed due to wave and tidal action. A single water sample was collected at each station to characterize the water chemistry conditions.

3.2.1.2 Field Water Quality

Field water quality measurements were taken at all sampling stations at Dowden's Point on October 20, 2010. Field measurements were taken from the samples collected at or near the surface (1 to 2 m). Water quality results were generally comparable between stations, with temperatures demonstrating little variability between stations, ranging from 8.32 to 8.54 °C. Conductivity values ranged from 4.62 to 4.79 $S{\cdot}m^{-1}$, which are near typical of seawater. Values for pH were alkaline ranging from 7.94 to 8.07. Dissolved oxygen values varied from 10.01 to 11.84 $mg{\cdot}L^{-1}$ and were supersaturated (104.1 to 111.1 % saturation). ORP values, an indication of the ability to breakdown contaminants, ranged from 233.9 to 244.7 mV. Table 3.26 presents the field water quality measurements for all stations sampled.

Table 3.26 Results of Field Water Quality Measurements for Samples Collected from Dowden's Point October 2010

Station ID	Temp. (°C)	Cond. ($S{\cdot}m^{-1}$)	pH	DO ($mg{\cdot}L^{-1}$)	DO (% sat)	ORP (mV)
W-020	8.34	4.77	8.07	10.01	104.1	242.0
W-021	8.32	4.79	7.98	10.57	110.0	244.7
W-022	8.54	4.75	7.96	11.84	111.1	233.9
W-023	8.35	4.62	7.94	10.36	107.3	235.0

3.2.1.3 Laboratory Water Quality

Results of water quality analysis, including statistical summary, for conventional parameters, nutrients, major ions, and metals are presented in Table 3.27. Results of analysis for petroleum hydrocarbons are presented in Table 3.28. Detailed results of laboratory water analysis are presented in Appendix A, including sample duplicates and laboratory QA/QC data.

Conventional parameters were very uniform between all sampling stations. Values for pH were alkaline and ranged from 7.79 to 7.81, well within the CCME guidelines. Very few nutrients were detected in the samples with only orthophosphate detected in all four samples, all at the detection limit. Metals in samples were also low, with only boron and strontium detected in all samples. Mercury was detected in two samples and, while both exceeded the CCME (2002) water quality guideline, it is noteworthy that the CCME guideline is for inorganic mercury while the reported values are for total mercury. All other metals tested were found to be below the RDL.

For petroleum hydrocarbons, only toluene was detectable in one sample and the value was at the detection limit and consequently the CCME water quality guideline of 0.215 $mg{\cdot}L^{-1}$ was not exceeded. All other hydrocarbons were below the RDL.

Table 3.27 Statistical Summary of Water Quality Analysis Including Conventional Parameters, Nutrients, Major Ions and Metals for Samples Collected from Dowden's Point October 2010

	Units	RDL	CCME Guideline	W-020	W-021	W-022	W-023	Mean	Std. Dev.	Min.	Max.
Conventional Parameters											
pH	pH	N/A	7.0 - 8.7	7.79	7.80	7.81	7.81	7.80	0.01	7.79	7.81
Total Alkalinity	$mg \cdot L^{-1}$	5		95	94	94	93	94.0	0.8	93	95
Hardness	$mg \cdot L^{-1}$	1		5000	4900	5100	5300	5075.0	170.8	4900	5300
Turbidity	NTU	1		ND	ND	ND	ND				
Conductivity	$\mu S \cdot cm^{-1}$	1		44000	44000	44000	44000	44000.0	0.0	44000	44000
Total Suspended Solids	$mg \cdot L^{-1}$	1		2	2	2	2				
Calculated TDS	$mg \cdot L^{-1}$	1		31100	30800	30900	31600	31100.0	355.9	30800	31600
Colour	TCU	5		ND	ND	ND	ND				
Total Organic Carbon	$mg \cdot L^{-1}$	0.5		ND	ND	ND	ND				
Reactive Silica	$mg \cdot L^{-1}$	0.5		ND	ND	ND	ND				
Nutrients											
Nitrate + Nitrite	$mg \cdot L^{-1}$	0.05		ND	ND	ND	ND				
Nitrite	$mg \cdot L^{-1}$	0.01		ND	ND	ND	ND				
Nitrite (N)	$mg \cdot L^{-1}$	0.05	16[a]	ND	ND	ND	ND				
Nitrate (Ammonia)	$mg \cdot L^{-1}$	0.05		ND	ND	ND	ND				
Total Phosphorous	$\mu g \cdot L^{-1}$	10000		ND	ND	ND	ND				
Orthophosphate	$mg \cdot L^{-1}$	0.01		0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Major Ions											
Total Calcium	$mg \cdot L^{-1}$	10		409	410	400	403	405.5	4.8	400	410
Total Magnesium	$mg \cdot L^{-1}$	10		964	953	1000	1050	991.8	43.7	953	1050
Total Sodium	$mg \cdot L^{-1}$	10		10100	9640	9860	9710	9827.5	203.5	9640	10100
Total Potassium	$mg \cdot L^{-1}$	10		356	353	354	350	353.3	2.5	350	356
Dissolved Chloride	$mg \cdot L^{-1}$	300		17000	17000	17000	18000	17250.0	500.0	17000	18000
Dissolved Sulphate	$mg \cdot L^{-1}$	100		2300	2400	2400	2300	2350.0	57.7	2300	2400
Metals											
Total Aluminum	$\mu g \cdot L^{-1}$	500		ND	ND	ND	ND				
Total Antimony	$\mu g \cdot L^{-1}$	100		ND	ND	ND	ND				
Total Arsenic	$\mu g \cdot L^{-1}$	100	12.5	ND	ND	ND	ND				

Table 3.27 Statistical Summary of Water Quality Analysis Including Conventional Parameters, Nutrients, Major Ions and Metals for Samples Collected from Dowden's Point October 2010 (Cont'd)

	Units	RDL	CCME Guideline	W-020	W-021	W-022	W-023	Mean	Std. Dev.	Min.	Max.
Total Barium	$\mu g{\cdot}L^{-1}$	100		ND	ND	ND	ND				
Total Beryllium	$\mu g{\cdot}L^{-1}$	100		ND	ND	ND	ND				
Total Bismuth	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Boron	$\mu g{\cdot}L^{-1}$	500		3540	3510	3330	3200	3395.0	159.7	3200	3540
Total Cadmium	$\mu g{\cdot}L^{-1}$	1.7	0.12	ND	ND	ND	ND				
Total Chromium	$\mu g{\cdot}L^{-1}$	100	56, 1.5[c]	ND	ND	ND	ND				
Total Cobalt	$\mu g{\cdot}L^{-1}$	40		ND	ND	ND	ND				
Total Copper	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Iron	$\mu g{\cdot}L^{-1}$	5000		ND	ND	ND	ND				
Total Lead	$\mu g{\cdot}L^{-1}$	50		ND	ND	ND	ND				
Total Manganese	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Mercury	$\mu g{\cdot}L^{-1}$	0.013	0.016[b]	ND	ND	0.025	0.018	0.022	0.00	0.018	0.025
Total Molybdenum	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Nickel	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Selenium	$\mu g{\cdot}L^{-1}$	100		ND	ND	ND	ND				
Total Silver	$\mu g{\cdot}L^{-1}$	10		ND	ND	ND	ND				
Total Strontium	$\mu g{\cdot}L^{-1}$	200		6320	6280	6130	6440	6292.5	127.9	6130	6440
Total Thallium	$\mu g{\cdot}L^{-1}$	10		ND	ND	ND	ND				
Total Tin	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Titanium	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Uranium	$\mu g{\cdot}L^{-1}$	10		ND	ND	ND	ND				
Total Vanadium	$\mu g{\cdot}L^{-1}$	200		ND	ND	ND	ND				
Total Zinc	$\mu g{\cdot}L^{-1}$	500		ND	ND	ND	ND				

Notes:

ND - Not Detected

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

Table 3.28 Water Quality Analysis for Petroleum Hydrocarbons for Samples Collected from Dowden's Point October 2010

Petroleum Hydrocarbons	Units	RDL	CCME Guideline	W-020	W-021	W-022	W-023
Benzene	$mg\cdot L^{-1}$	0.001	0.11	ND	ND	ND	ND
Toluene	$mg\cdot L^{-1}$	0.001	0.215	0.001	ND	ND	ND
Ethylbenzene	$mg\cdot L^{-1}$	0.001	0.025	ND	ND	ND	ND
Xylene (Total)	$mg\cdot L^{-1}$	0.002		ND	ND	ND	ND
C_6 - C_{10} (less BTEX)	$mg\cdot L^{-1}$	0.010		ND	ND	ND	ND
>C_{10} - C_{16} Hydrocarbons	$mg\cdot L^{-1}$	0.050		ND	ND	ND	ND
>C_{16} - C_{21} Hydrocarbons	$mg\cdot L^{-1}$	0.050		ND	ND	ND	ND
>C_{21} -< C_{32} Hydrocarbons	$mg\cdot L^{-1}$	0.100		ND	ND	ND	ND
Modified TPH (Tier1)	$mg\cdot L^{-1}$	0.100		ND	ND	ND	ND
Reached Baseline at C_{32}	$mg\cdot L^{-1}$	N/A		Yes	Yes	Yes	Yes
Surrogate Recovery (%)							
Isobutylbenzene - Extractable	%			100	103	101	102
n-Dotriacontane - Extractable	%			104	96	104	103
Isobutylbenzene - Volatile	%			103	104	90	97

Notes:
ND - Not detected
RDL - Reportable Detection Limit
Results relate only to the items tested.

3.2.2 Nearshore Habitat Surveys

Nearshore habitat surveys assessed the habitat characteristics at the Shore Zone level of detail (Kelly et al. 2009, draft) including: (i) backshore; (ii) intertidal zone; and (iii) shallow subtidal zone. The deep subtidal zone was not surveyed as the electrode will not extend into this zone. The major features assessed and presented in the following sections included: (i) water depth (bathymetry); (ii) substrate type and distribution; (iii) macrofloral class and distribution; (iv) macrofaunal presence; and (v) integrated habitat class distribution.

3.2.2.1 Overview

The Dowden's Point electrode site is located in the Conception Bay Ecoregion (Kelly et al. 2009, draft) and is described as an open coast marine ecosystem. Ice can develop in the bay but development is largely from ice foot development from bays along the northwest coast of Conception Bay. Pack ice and icebergs have entered the bay in some years resulting in ice scour effects. Tidal data from DFO's tide gauge at Holyrood (Easting 340136, Northing 5246233) indicate a mean tidal amplitude of 0.94 m and high tide amplitude of 1.34 m with a mean water level of 0.58 m (DFO 2010). The current in Conception Bay flows in a counter clockwise direction, consequently the currents at Dowden's Point would be parallel to the shore flowing in a northeast direction (Catto et al. 1999). There are strong tidal currents in the bay particularly along the northeast shore. Dowden's Point is semi-exposed, as the shoreline is largely open and exposed with no embayments, with a maximum fetch of 60 km from the north and 25 km from the west. The site is erosional in nature and sediment transport is in the normal onshore to offshore direction with the beach being well washed of smaller granular and finer materials. The Dowden's Point electrode site is typical of the shoreline for that area which consists of steep but low sediment bluffs (cliffs) of glaciofluvial material with moderate to steep sloping gravel beaches dominated by large boulders.

3.2.2.2 Bathymetry

The depth distributions from the bathymetric survey in October 2010 were modelled and mapped in two-dimensions in Figure 3.17. The maximum depth apparent in the study area was 5.5 m and therefore the entire study area (3.10 ha) was within the 5 m contour. The bathymetry was very uniform with trend to increasing depth from the shoreline largely parallel with the shoreline. There were no obvious depressions or hummocks in the seabed topography.

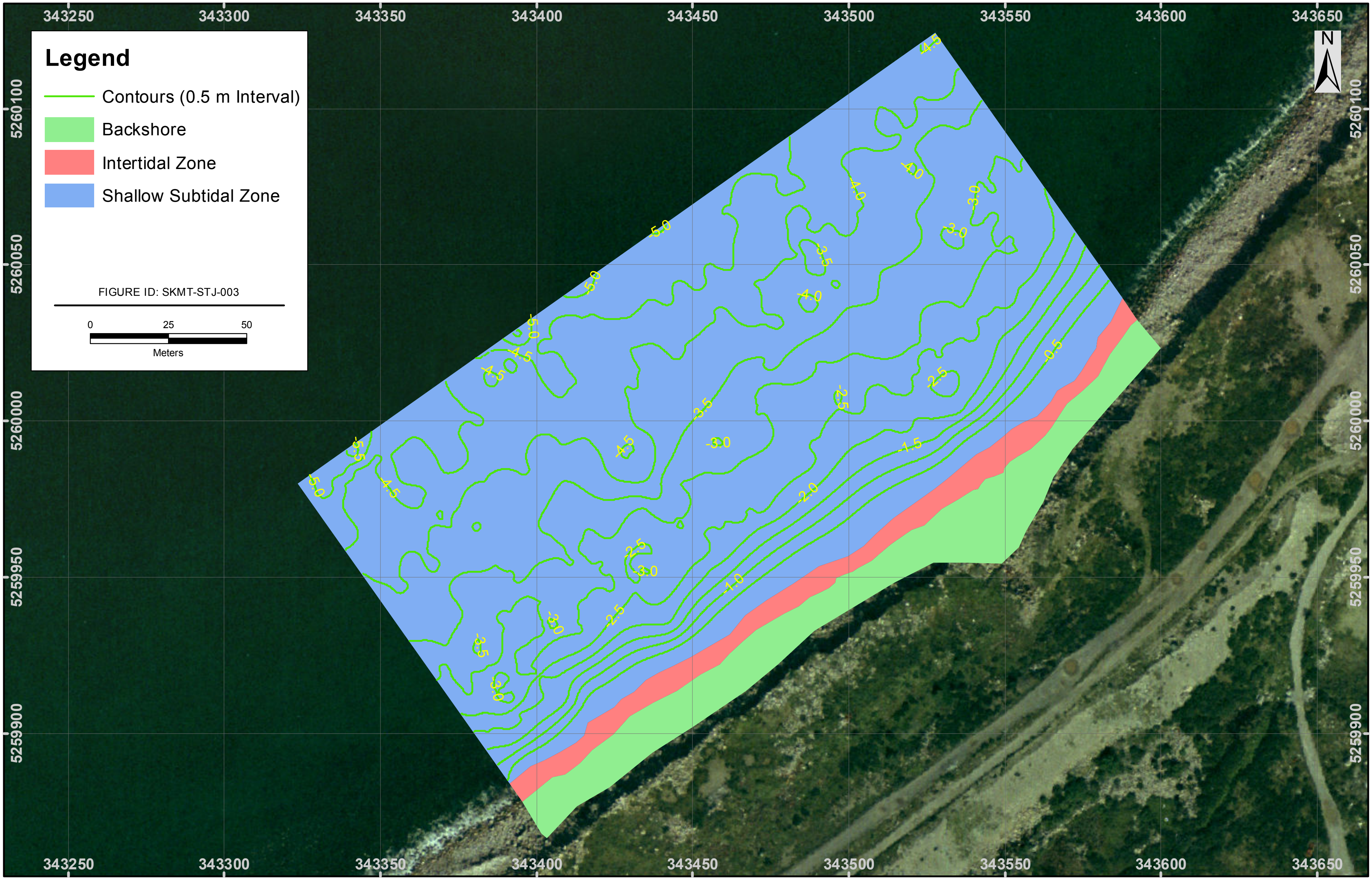

FIGURE 3.17

Dowden's Point Bathymetry and Backshore, Intertidal and Subtidal Zones

3.2.2.3 Intertidal and Backshore Zones

The demarcation between the intertidal and subtidal zones was determined from the mean and high tidal range from the tidal gauge at Holyrood, from interpretation of the digital LiDAR image for the site, and from observations and photos taken during the survey. A total of 0.16 ha (5.3 %) of the study area is within the intertidal zone and this consisted entirely of boulder/rubble habitat (Figures 3.18 and 3.19).

The backshore, extending from the intertidal zone to the inland extent of the influence of marine processes, in this case the top of the sediment bluff, was interpreted from the LiDAR image for the site and photographs taken during the survey. The Shore Unit classification for the site is Gravel/Flat Beach (after Kelly et al. 2009, draft) while Catto et al. (1999) described the shoreline as Steep Gravel and Sand Beach. Note that Catto et al. (1997, 1999) considers 'gravels' as all granular material larger than sand including pebbles, cobbles, and boulders. The backshore area within the study site was determined to be 0.33 ha. The lower reach of the backshore was modestly steep and comprised entirely of boulder/rubble while the upper reach of the backshore was even steeper (45 to 90 % slope) and was comprised of a mix of substrate materials that appeared to be eroding, possibly during extreme storm events or through wind and possible ice action (Figure 3.18).

Figure 3.18 Boulder/Rubble Intertidal Zone and Steep Gravel and Sand Beach Backshore, Dowden's Point

3.2.2.4 Substrate Distribution

The distribution of substrate types as determined from underwater video analyses for Dowden's Point is presented in Table 3.29. The substrate types identified were either a single substrate type or combinations of two and three substrate types. Generally, the substrate was relatively uniform comprising various mixes of boulder, cobble and sand with boulder/cobble the dominant substrate type (81.1 %), followed by boulder/cobble/sand (12.6 %), boulder (4.6 %), and sand with boulder/cobble (1.6 %). There were very small patches of sand intermixed and overlain with the other substrate types. Boulders ranged in size from small to very large and were often densely packed with cobble. There was no need to aggregate the substrate classes for the purposes of mapping.

The observations of the four substrate classes were modelled and mapped in two-dimensions in Figure 3.19 and the total area (ha) represented by each substrate class is provided in Table 3.30. Noteworthy observations on substrate distribution were the association of the three patches of boulder substrate with the shoreline while substrate types containing sand were away from the shoreline, largely at depths of 4.0 m or greater. This suggests the finer substrates have been removed from the inshore areas and may be deposited in the slightly deeper areas where the wave energy is diminished.

Table 3.29 Substrate Classes Identified in the Underwater Video for Dowden's Point October 2010

Substrate Class[1]	Time Viewed (s)	Percent (%)
Boulder/Cobble	3002	81.1
Boulder/Cobble/Sand	465	12.6
Boulder	172	4.6
Sand with Boulder/Cobble	61	1.6
Total Time Viewed/Percent	**3700**	**100.0**

Note [1]: Dominant substrate is identified first, followed by the next most important substrate type, followed by the third and fourth (if applicable)

Table 3.30 Area (ha) for Substrate Classes as Mapped from the Underwater Video from Dowden's Point October 2010

Substrate Class[1]	Area (ha)	Percent (%)[2]
Boulder/Cobble	2.63	84.9
Boulder	0.24	7.9
Boulder/Cobble/Sand	0.21	6.9
Sand with Boulder/Cobble	0.01	0.2
Total Area	**3.10**	**100.0**

Note [1]: Dominant substrate is identified first, followed by the next most important substrate type, followed by the third and fourth (if applicable)
Note [2]: The percent of each substrate class, by area, is different from percent by observation, due to the modelling algorithm

nalcor energy

FIGURE 3.19

Dowden's Point Substrate Distribution

3.2.2.5 Macrofloral Distributions

Table 3.31 provides a listing of the macroflora types identified in the underwater video. The macroflora were identified to species and/or genus, where possible, although that was not always possible due to the resolution of the video related to elevation from the bottom and/or vessel speed. Generally, there was very little diversity in macroflora in the study site with six different taxa identified, with 99.6 % of the observations belonging to two taxa.

Table 3.31 Macrofloral Types Identified in the Underwater Video from Dowden's Point October 2010

Taxon	Macrofloral Type	Time Viewed (s)	Percent (%)
Calcareous encrusting Rhodophyta	Red Algae	3671	66.7
Lithothamnium sp.	Red Algae	1807	32.9
Calcareous Branched Rhodophyta - *Corallina officinalis*	Red Algae	8	0.1
Brown algae	Brown Algae	4	0.1
Brown Filamentous algae	Brown Algae	7	0.1
Red filamentous algae	Red Algae	3	0.1
Total %		**5500**	**100.0**

The dominant macrofloral class was the calcareous encrusting red algae (66.7 %) with various Rhodophyta species apparent. The second most dominant taxon was the calcareous branched red algae of the genus *Lithothamnium* (32.9 %). The *Lithothamnium* species were upright in orientation, attached to the surface of rocks, darker in colour, and more roughly textured. Other macroflora observed, collectively totaling less than 1 %, included coralline red algae (*Corallina officinalis)*, brown algae, filamentous brown algae, and filamentous red algae. The distribution of macroflora was influenced by substrate distribution. Most of the boulder and cobble had algal growth on their surface, chalky white to pink to purple in colour, with coverage from 25 to 75 % of the surface area.

The macroflora were aggregated for two-dimensional mapping after an examination of the data. Four taxa were not included as they represented only a very small proportion (0.4 % collectively) of the distributions. Calcareous encrusting Rhodophyta (CER) were commonly viewed alone and they represented the largest aggregated macroflora class (72.5 %) (Table 3.32). The other major macroflora taxon was the genus *Lithothamnium*, and this taxon only occurred in association with the CER, with this hybrid class representing 25.2 % of the macrofloral distribution. Macroflora were absent from 2.3 % of the habitat area. The distribution of the two dominant macroflora classes was modelled and mapped in two-dimensions and presented in Figure 3.20. The total area (ha) represented by the two macroflora classes in the study area is provided in Table 3.32.

Table 3.32 Area (ha) for Macrofloral Classes as Mapped from the Underwater Video from Dowden's Point October 2010

Macrofloral Type	Area (ha)	Percent (%)[1]
No Algae	0.07	2.3
Calcareous encrusting Rhodophyta (CER)	2.25	72.6
CER and *Lithothamnium*	0.78	25.2
Total	**3.10**	**100.00**

Note [1]: The percent of each macrofloral class, by area, is different from percent by observation, due to the modelling algorithm.

nalcor energy

FIGURE 3.20

Dowden's Point Macroflora Distribution

3.2.2.6 Macrofaunal Distributions

The macrofauna observed in the underwater video for Dowden's Point in 2010 are listed in Table 3.33. The dominant fauna were the green urchin (*Strongylocentrotus droebachiensis*) with many viewed in each frame, and consequently there was no attempt to enumerate them. A total of 119 starfish were observed, all members of the *Asterias* species, and these Echinoderms could be considered occasional within the study area. The blue mussel (*Mytilus edulis*) was viewed in 13 frames of video, was not apparent in high densities and was considered occasional in the study area. Eight gadoid fish were observed and these were most likely Atlantic cod (*Gadus morhua*). As fish are mobile and may have avoided the video camera due to the lights, noise, and other disturbances, the number observed may not be indicative of their presence or abundance in the study site. One rock crab, possibly *Cancer irroratus*, was also observed. The macrofaunal observations, other than urchins, were too few to map.

Table 3.33 Macrofauna Observed in the Underwater Video from Dowden's Point October 2010

Taxon	Common Name	Time (s) or Number Viewed
Strongylocentrotus droebachiensis	green urchin	3694 s[1]
Asterias sp.	starfish	119
Mytilus edulis	blue mussel	13 s[1]
Gadus sp.	fish	8
Cancer sp.	rock crab	1

[1]Note: Green urchins too numerous to count

3.2.2.7 Habitat Distributions

The aggregated substrate distribution was integrated with the aggregated macroflora distribution to define integrated habitat classes for the shallow subtidal zone. The homogeneity of both attributes at the Dowden's Point site required no additional aggregation for modelling and mapping. The habitat classes developed from integration of substrate and macrofloral distributions in the subtidal zone, and the area (ha) of each as determined from modelling and mapping, are provided in Table 3.34.

Table 3.34 Habitat Area (ha) for Integrated Habitat Classes as Mapped from the Underwater Video from Dowden's Point October 2010

Integrated Habitat Class	Area (ha)	Percent (%)
Boulder/Cobble with Macroflora	2.61	84.2
Boulder/Cobble with No Macroflora	0.04	1.3
Boulder/Cobble/Sand with Macroflora	0.21	6.8
Boulder with Macroflora	0.23	7.4
Sand with Boulder/Cobble with No Macroflora	0.01	0.3
Total Area	**3.10**	**100.0**

An integrated habitat map (Figure 3.21) is presented including three zones for Shore Zone habitat characterization including:

1. Backshore (one class);
2. Intertidal Zone (one class); and
3. Shallow Subtidal Zone (five classes).

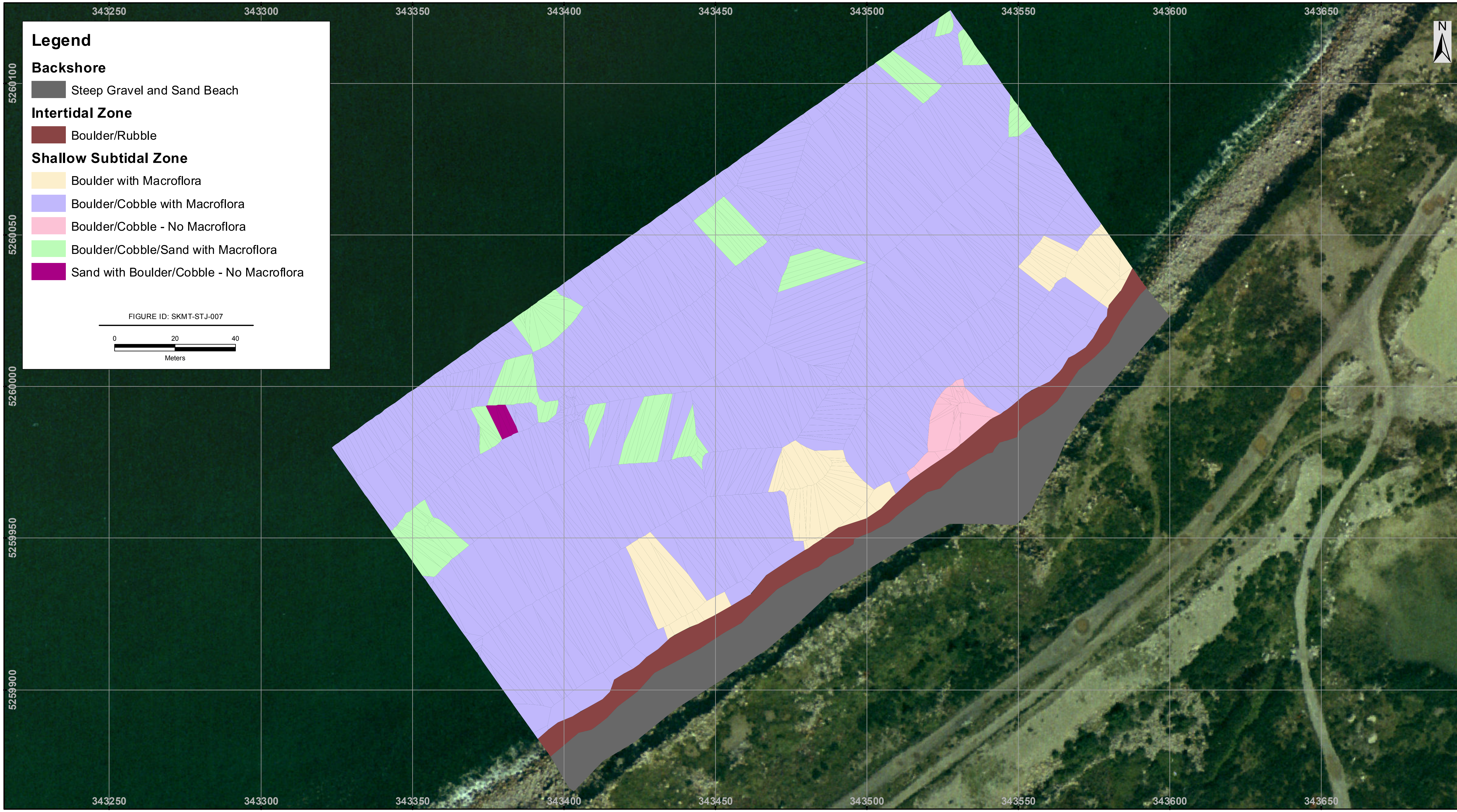

FIGURE 3.21

Dowden's Point Habitat Distribution

4.0 DISCUSSION AND CONCLUSIONS

The results of the marine water, sediment, benthos, and nearshore habitat surveys at the two potential electrode sites in 2010 are discussed in relation to the descriptive characteristics of the samples and data collected. Water and sediment characteristics are discussed in relation to relevant CCME environmental quality guidelines and the potential for demonstration of anthropogenic influences. The water, sediment and benthos are further discussed in relation to comparable information for these characteristics. Nearshore habitat characteristics are discussed in relation to the key attributes (bathymetry, substrate distribution, macroflora and macrofauna, intertidal and backshore features) that define each site.

4.1 Water Quality

CTD profiles were successfully collected at four sites at both L'Anse au Diable and Dowden's Point and field water quality measurements were taken at all stations from surface samples. CTD profiles revealed little evidence of gradients in temperature and salinity, with no thermocline, and this was expected owing to the shallow and well mixed water column at these sites. Within each potential electrode site, field water quality results were generally comparable between sampling sites. Salinities in surface samples at Dowden's Point suggested freshwater influence. Temperatures ranged from with 6.80 to 8.47 °C and 8.32 to 8.54 °C, at L'Anse au Diable and Dowden's Point, respectively. Conductivity values ranged from 4.71 to 4.77 $S{\cdot}m^{-1}$ and 4.62 to 4.79 $S{\cdot}m^{-1}$ at L'Anse au Diable and Dowden's Point, respectively, which were near typical of seawater. Values for pH were alkaline at both sites within a narrow range. Dissolved oxygen values were high (above 10 $mg{\cdot}L^{-1}$) and supersaturated at all sampling locations at both sites.

Water samples were analyzed at a laboratory for conventional parameters, nutrients, major ions, metals and petroleum hydrocarbons. Conventional parameters were similar between all sampling stations within each site. Values for pH were alkaline within a narrow range for each site. Orthophosphate was the only nutrient detected being measured at the detection limit in three and four samples at L'Anse au Diable and Dowden's Point, respectively. The low marine nutrient content is consistent with the generally pristine nature of the marine environment in the study areas (Sikumiut 2010, 2011).

Metals in samples at both sites were also low, with only strontium detected in all samples at both sites while boron was detected in three of four samples at L'Anse au Diable and all four samples at Dowden's Point. All metals detected at L'Anse au Diable were within CCME limits while at Dowden's Point, mercury was detected in two samples and both values exceeded CCME guideline limits. The CCME guideline value however is for inorganic mercury while the analytical result is for total mercury. From a baseline data perspective, there are detectable levels of mercury at this site, at least during the sampling period (October 20, 2010).

Toluene was the only petroleum hydrocarbon detected, among those tested for, and this hydrocarbon was measured at the detection limit at four sites and one site at L'Anse au Diable and Dowden's Point, respectively. Hydrocarbons in the marine environment can reflect natural sources (e.g., oil seeps) and also anthropogenic inputs from industry, and commercial and recreational boating activity. Water quality data collected in 2010 from both sites has confirmed the pristine nature of the marine environment in the study areas and there is no evidence of any anthropogenic influence on marine water quality for trace elements/metals and hydrocarbons. This is particularly noteworthy for Dowden's Point which is in close proximity to the Holyrood oil fired generating station and the communities of Conception Bay South and Holyrood.

4.2 Sediment Quality

Eight sediment samples, four from the subtidal and four from the intertidal sites, were collected from the L'Anse au Diable study site. No samples were collected from Dowden's Point, despite considerable sampling effort, due to the coarse nature of substrates at this site. Physical analysis of sediment demonstrated that sand dominated the composition of sediment at all sites with this fraction representing from 94 to 99 % of each sample. Clay was apparent in all samples in small quantities (0.4 to 1.2 %), while gravel was apparent in three samples (0.1 to 5.4 %) and silt in two samples (both at 0.2 %).

Chemical analyses of sediment included analysis for major ions, metals, total organic carbon, moisture content, and petroleum hydrocarbons. Major ions were comparable between subtidal and intertidal locations, with subtidal values being slightly higher and potassium only being detected in the subtidal samples. Organic carbon content was low being 0.5 $g \cdot kg^{-1}$ or less in all samples. Low organic carbon levels could be related to the lack of clay in sediments which has a high affinity to bind organic carbon. The L'Anse au Diable sediments may be well washed with the finer particles (clay, silt) and organic carbon, being removed and settling in environments with less energy (depositional environments). Moisture content was higher in subtidal sediments, ranging from 17 to 19 %, as compared to 8 to 19 % in intertidal sediments.

Most of the metals tested were below detectable levels with only aluminum, iron, and manganese detected in all samples while strontium (n=1), thallium (n=1), and vanadium (n=4) were also detected. No CCME (2002) ISQGs or PELs Guidelines for the Protection of Aquatic Life were exceeded in L'Anse au Diable sediment samples. The absence of a clay sediment fraction and the low organic content likely plays a role in the low metal content, as trace metals and other contaminants in marine sediments are commonly related to particle size and organic carbon content (Halcrow et al. 1973).

Hydrocarbons were not detected in any sample consequently no CCME and PEL guidelines were exceeded. Consistent with the water quality results, the absence of hydrocarbons and low metal content in L'Anse au Diable sediments confirmed the pristine nature of the marine environment in this area and there is no evidence of anthropogenic input.

4.3 Benthic Invertebrates

Eight sites were successfully sampled for benthos, four each from the subtidal and intertidal zones, at L'Anse au Diable. As indicated previously, sediment could not be sampled at Dowden's Point, consequently no benthic samples were obtained at this site. Samples contained low to moderate abundances while biomass and diversity of organisms were low, with biomass and taxon richness appreciably less in intertidal samples.

A total of 561 and 844 benthic organisms were identified from the four subtidal and intertidal stations, respectively. In the subtidal samples, the benthic community was dominated by Polychaetes (43.0 %), Archiannelida (27.1 %), Nemertea (16.8 %), Amphipods (11.8 %), and Bivalves (1.2 %). In intertidal samples, 99 % of the benthos were small unidentified marine Oligochaetes of the Group Archiannelida. A total of 33 taxa were identified in subtidal samples with the Polychaetes *Scoloplos acutus* and *Spio filicornis*, unidentified small marine Oligochaeta, a small unidentified Nemertean, and the Amphipod *Psammonyx terranovae* identified in all samples. In the intertidal samples, only six taxa were identified and small unidentified marine Oligochaetes were evident in all samples.

Subtidal samples had moderate abundance from 110 to 189 organisms (mean ± Std. Dev. of 140.0 ± 35.8) while intertidal samples ranged from 35 to 398 organisms (mean ± Std. Dev. of 211.0 ± 177.1). Biomass ranged from 0.84 to 2.45 (mean ± Std. Dev. of 1.66 ± 0.78) at the subtidal sites which was an order of magnitude greater than that at the intertidal sites (range of 0.04 to 0.47, mean ± Std. Dev. of 0.16 ± 0.21). Similarly, there was a large difference in taxon richness with subtidal richness ranging from 11 to 16 taxon (mean ± Std. Dev. of 14.3 ± 2.4) and intertidal richness ranging from 2 to 3 taxon (mean ± Std. Dev. of 2.5 ± 0.6).

A variety of diversity indices were calculated to characterize the benthic community and for all indices, there was a large difference between the subtidal and intertidal benthic community. The Shannon-Wiener Diversity Index, a widely used index to describe the proportional abundance of species, ranged from 0.78 to 0.94 (mean ± Std. Dev. of 0.87 ± 0.07) and from 0.01 to 0.09 (mean ± Std. Dev. of 0.05 ± 0.04) in the subtidal and intertidal zones, respectively. Pielou's Evenness Index, used to measure species evenness, ranged from 0.73 to 0.82 (mean ± Std. Dev. of 0.76 ± 0.04) and from 0.03 to 0.19 (mean ± Std. Dev. of 0.11 ± 0.09) in the subtidal and intertidal zones, respectively. McIntosh's Index, an indicator of proportional abundances of species, ranged from 0.59 to 0.68 (mean ± Std. Dev. of 0.62 ± 0.04) and from 0.003 to 0.05 (mean ± Std. Dev. of 0.02 ± 0.02) in the subtidal and intertidal zones, respectively. Simpson's Index, also an indicator of proportional abundances of species, ranged from 0.15 to 0.22 (mean ± Std. Dev. of 0.19 ± 0.03) and from 0.91 to 1.00 (mean ± Std. Dev. of 0.96 ± 0.04) in the subtidal and intertidal zones, respectively. Margalef's Index, a species richness or community diversity index, ranged from 2.10 to 3.02 (mean ± Std. Dev. of 2.69 ± 0.40) and from 0.17 to 0.45 (mean ± Std. Dev. of 0.31 ± 0.12) in the subtidal and intertidal zones, respectively.

The benthic community at L'Anse au Diable in the September 2010 survey reflected both the substrate from which they were collected and the semi-exposed nature of the shallow subtidal and intertidal regions. Substrate materials in both zones were dominated by sand and consequently the benthic community was dominated by infauna, particularly Polychaetes and small Oligochaetes, with relatively few bivalves, amphipods, and no Echinoderms. In these habitats, there is no large substratum for epifauna to attach to and no associated macroflora to provide a food source and protection (cover) from predators.

In contrast, the recently completed survey of sites in the Strait of Belle Isle (Sikumiut 2011), a total of 308 taxa were identified and average abundance (1,162 organisms/sample), biomass (37.0 g/sample), and taxon richness (60.1 taxa/sample) were considerably higher than that observed at L'Anse au Diable. While the benthic community in that study was also dominated by Polychaetes, other benthic groups including Amphipods, Echinoderms, Bivalves and Porifera were also well represented indicating a diverse benthic community of both infauna and epifauna. Substrates sampled in that study were much coarser consisting of gravel, cobble, and shell debris providing numerous attachment sites for epifauna and diverse micro-niches for various organisms.

4.4 Nearshore Habitat

Nearshore habitat surveys assessed the habitat characteristics at the Shore Zone level of detail including: (i) backshore; (ii) intertidal zone; and (iii) shallow subtidal zone. The deep subtidal zone was not surveyed at either site as the footprint of the potential electrodes did not extend into that zone.

The L'Anse au Diable electrode site is located in the Labrador South Ecoregion and is considered an open coast marine ecosystem. An ice pack will develop along the coast and Arctic ice and ice bergs are extensive resulting in considerable ice scour. A mean and high tidal amplitude of 0.91 m and 1.37 m, respectively, and a mean water level of 0.94 m, have been recorded at Battle Harbour. The current flows parallel to the shore in a southwesterly direction and tidal currents are very strong. The outer coastline at L'Anse au Diable is semi-exposed, with the inner embayment semi-protected, with maximum fetch from the south of 30 km. The site is stable with rock platforms sheltering two stable sand beaches. The site is representative of the Labrador side of the Strait of Belle Isle with rugged bedrock dominated shorelines with occasional sheltered embayments with gravel and/or sand beaches.

At L'Anse au Diable, the bathymetry is irregular with maximum depth of 8.0 m. Areas within the inner coves contain steep bedrock slopes which changes to a plateau of more uniform depth. Outside of the inner cove the sea bed slopes more regularly into the shallow subtidal zone. The intertidal zone contains 0.42 ha consisting of bedrock (0.24 ha) and sand (0.18 ha), both devoid of macroflora. Two types of backshore were identified including 0.71 ha of Rock Platform and 0.22 ha of Sand/Flat Beach.

Subtidal substrate types at L'Anse au Diable were heterogeneous and consisted of a single substrate type or combinations of two and three substrate types. Within the subtidal zone, there were areas of bedrock structures with steep slopes which then changed to a plateau containing boulder, cobble, and sandy regions. Sandy substrates were usually rippled suggesting some current on the seabed. Six substrate classes were modelled and mapped. Bedrock (50.1 %) was extensively distributed throughout the study area while sand (35.3 %) was also well represented, largely as two extensive patches.

There was an abundance and diversity of macroflora at L'Anse au Diable with coralline red algae (27.1 %) the most predominant. Brown algae (25.9 %) were also important and included various filamentous species. Various red algae including filamentous species, dulse, red fern, and other species comprised 20.4 % of the macroflora observed. The brown algae edible kelp, and sea lettuce in the green algae group, comprised 13.7 % and 12.4 % of the observed macroflora, respectively. The distribution of macroflora was influenced by substrate distribution. Bedrock, boulder, and to a lesser extent cobble had calcareous encrusting coralline red algae. Sea colander was frequently observed on the vertical side of bedrock and in crevices within bedrock. Most of the other seaweed species were associated with the bedrock, boulder, and cobble substrate. No macroflora were observed in association with sandy substrates. The distribution of macroflora classes was modelled and mapped and the largest class was No Macroflora (36.1 %) which was highly correlated to the distribution of sand substrates. Red and brown algae (23.0 %) were also important and the distribution was patchy but highly associated with bedrock/boulder substrates. Combinations of all three algae types were also well represented (18.7 %) and the distribution of this class was most closely associated with bedrock/boulder.

The dominant macrofauna observed at L'Anse au Diable were sea urchins, either pale urchin or green urchin. Sea urchins were abundant and, where present, were numerous. Starfish (n=41) were occasional in the study area including polar sea star (n=28) and *Asterias* species (n=13). Eleven sculpin were also observed. The macrofaunal observations were too few to map and the only important habitat association was the absence of sea urchins in sandy substrates.

The substrate distribution was integrated with the macrofloral distribution to define integrated habitat classes for the shallow subtidal zone at L'Anse au Diable. The resulting habitat distribution was as follows: (i) coarse substrate with macroflora (1.53 ha, 50 %); (ii) coarse substrate with no macroflora (0.03 ha, 1 %); (iii) mixed substrate with macroflora (0.42 ha, 14 %); (iv) mixed substrate with no macroflora (0.03 ha, 1 %); and (v) fine substrate with no macroflora (1.02 ha, 34 %).

The Dowden's Point electrode site is an open coast marine ecosystem in Conception Bay. Ice development in the bay is largely from ice foot development while pack ice and icebergs can enter the bay in some years. A mean and high tidal amplitude of 0.94 m and 1.34 m, respectively, and a mean water level of 0.58 m, have been recorded at Holyrood (DFO 2010). Currents in the bay are counter clockwise with currents at Dowden's Point parallel to the shore flowing in a northeast direction. Dowden's Point is semi-exposed with a maximum fetch of 60 km from the north. The site is erosional in nature with sediment transport in the onshore to offshore direction. Dowden's Point is typical of the shoreline in the area consisting of steep but low sediment bluffs (cliffs) of glaciofluvial material with moderate to steep sloping gravel beaches dominated by boulders.

The bathymetry of Dowden's Point was modelled and mapped with a maximum depth of 5.5 m in the study area. Bathymetry was very uniform with a trend of increasing depth parallel with the shoreline with no obvious depressions or hummocks in the seabed topography. The intertidal zone consisted entirely of boulder/cobble habitat (0.16 ha). The backshore was considered a Steep Gravel and Sand Beach with the lower reach modestly steep while the upper reach was steeper (45 to 90 % slope) and was comprised of a mix of glaciofluvial substrate materials that appeared to be eroding.

The distribution of substrate at Dowden's Point was either a single substrate type or combinations of boulder, cobble and sand. Boulder/cobble was the dominant substrate type (81.1 %), followed by boulder/cobble/sand (12.6 %), boulder (4.6 %), and sand with boulder/cobble (1.6 %). There were very small patches of sand intermixed and overlain with the other substrate types. Boulders ranged in size from small to very large and were often densely packed with cobble. Patches of boulder only substrate were associated with the shoreline while substrate types containing sand were largely at depths of 4.0 m or greater.

There was little diversity in macroflora in the study site with six taxa being identified, 99.6 % of which belonged to two taxa. The dominant macrofloral class was calcareous encrusting red algae (66.7 %) with the second most dominant taxon the calcareous branched red algae of the genus *Lithothamnium* (32.9 %). Other macroflora were observed but collectively totaled less than 1 % of observations. The distribution of macroflora was influenced by substrate distribution with most boulder and cobble having calcareous encrusting red algae on their surface, covering 25 to 75 % of the surface area. The macroflora were aggregated for mapping and the CER were commonly viewed alone, representing 72.5 % of the aggregated distribution, while *Lithothamnium* only occurred in association with the CER, with this hybrid class representing 25.2 % of the distribution. Macroflora were absent from only 2.3 % of the habitat area.

Macrofauna observed at Dowden's Point in 2010 were dominated by green urchin which were commonly viewed and numerous when present. *Asterias* species starfish (n=119) were observed and could be considered occasional within the study area. The blue mussel was viewed occasionally and was not apparent in high densities. Eight gadoids, likely Atlantic cod, were also observed. The macrofaunal observations were too few to map.

The substrate distribution was integrated with the macrofloral distribution to define integrated habitat classes for the shallow subtidal zone. The integrated habitat classes as determined from the modelling included: (i) Boulder/Cobble with Macroflora (2.61 ha, 84.3 %); (ii) Boulder/Cobble with No Macroflora (0.04 ha, 1.2 %); (iii) Boulder/Cobble/Sand with Macroflora (0.21 ha, 6.8 %); (iv) Boulder with Macroflora (0.23 ha, 7.6 %); and (v) Sand with Boulder/Cobble with No Macroflora (0.01 ha, 0.2 %).

DFO has developed a system for classifying and quantifying marine fish habitat which can be potentially affected by industrial developments (Kelly et al. 2009, draft). In this study, the DFO system was used to characterize and classify the subtidal and intertidal habitats at the Shore Unit, which is largely based on geomorphology and substrate, and Shore Zone, which incorporates tidal influences and biological criteria, levels of detail. The next step, which involves quantification of habitat using published habitat utilization information for fish species/invertebrates, was outside of the scope of work. The process of quantification, if required, involves the integration of species specific habitat utilization information for fish and/or invertebrate species, which are in turn based on concepts related to habitat suitability indices (HSIs). The approach uses habitat data including depth, substrate and substrate/macroflora combinations, as collected in this study, coupled to life stage specific habitat suitability information, to determine the habitat equivalent units (HEUs) at a particular site.

Macrofaunal observations during this study identified sea urchins as the dominant species at both sites while very few fish were observed, although it is recognized that underwater video has limitations in assessing fish presence/absence and abundance. Certain life stages (e.g., lobster larvae) may not be visible during video surveys and fish and invertebrate species will utilize substrate and macroflora as visual shelter from predators.

4.5 Summary

In summary, the L'Anse au Diable electrode site is an open coast marine system with a semi-exposed coastline and semi-protected inner embayment. Water and sediment quality data are representative of a pristine marine environment. The benthic community in sandy substrates is dominated by infauna with different communities in the intertidal and subtidal zones. Bathymetry is irregular containing some steep slopes. The backshore is characterized by Rock Platforms protecting Sand Beaches. Substrate in the subtidal zone is heterogeneous and dominated by bedrock/boulder and sand. Macroflora are abundant and diverse while the macrofauna were less so with sea urchins numerous. Substrate and macroflora data were integrated and modelled to define five habitat classes.

The Dowden's Point electrode site is a semi-exposed open coast marine ecosystem. Water quality data are largely representative of a pristine marine environment. Bathymetry was very uniform with a maximum depth of 5.5 m within the site. The intertidal zone was comprised entirely of boulder/rubble substrate while the backshore was a Steep Gravel and Sand Beach rising steeply to a low bluff of glaciofluvial material. Subtidal substrate was very uniform consisting of combinations of boulder, cobble, and sand. There was very little diversity in the macroflora at the site. There were few macrofauna taxa observed although the green urchin was abundant. Substrate and macroflora data were integrated and modelled to define five habitat classes.

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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 directly, and are available from Nalcor Energy as required and requested.

APPENDIX B

Benthic Invertebrate Data

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
SPECIES								
MOLLUSCA								
BIVALVIA								
Astarte borealis	0	0	0	0	0	0	0	0
Astarte quadrans	0	0	0	0	0	0	0	0
Astarte undata	0	0	0	0	0	0	0	0
Astarte undata?	0	0	0	0	0	0	0	0
Bivalve sp. A	0	0	0	0	0	0	0	0
Bivalve sp. B	0	0	0	0	0	0	0	0
Bivalve unid.	0	0	0	0	0	0	0	0
Cerastoderma pinnulatum	0	0	0	0	0	0	0	0
Chlamys islandicus	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0
Crenella faba	0	0	0	0	0	0	0	0
Crenella? *faba*	0	0	0	0	0	0	0	0
Crenella glandula	0	0	0	0	0	0	0	0
Cyclocardia borealis	0	0	0	0	0	0	0	0
Cyclocardia novaeangliae	0	0	0	0	0	0	0	0
Cyclocardia novaeangliae?	0	0	0	0	0	0	0	0
Hiatella arctica	0	0	0	0	0	0	0	0
Limatula subauriculata	0	0	0	0	0	0	0	0
Liocyma fluctuosa	1	0	0	0	0	0	0	0
Modiolus modiolus	2	0	0	0	0	0	0	0
Musculus niger	0	0	0	0	0	0	0	0
Mya truncata	0	1	0	0	0	0	0	0
Mytilus edulis	3	0	0	0	0	0	0	0
Thracia myopsis	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
GASTROPODA								
Anomia squamula	0	0	0	0	0	0	0	0
Boreotrophan truncatus	0	0	0	0	0	0	0	0
Buccinidae?	0	0	0	0	0	0	0	0
Colus sp.	0	0	0	0	0	0	0	0
Gastropod sp. A	0	0	0	0	0	0	0	0
Gastropod sp. B	0	0	0	0	0	0	0	0
Gastropod sp. C	0	0	0	0	0	0	0	0
Gastropod sp. D	0	0	0	0	0	0	0	0
Gastropod sp. E	0	0	0	0	0	0	0	0
Gastropod sp. F	0	0	0	0	0	0	0	0
Gastropod sp. G	0	0	0	0	1	0	0	0
Gastropod sp. H	0	0	0	0	0	0	1	0
Gastropod sp. I	0	0	0	0	0	0	0	0
Gastropod sp. J	0	0	0	0	0	0	0	0
Gastropod sp. K	0	0	0	0	0	0	0	0
Gastropod unid.	0	0	0	0	0	0	0	0
Lacuna vincta	0	0	0	0	0	0	0	0
Lepeta caeca	0	0	0	0	0	0	0	0
Margarites costalis	0	0	0	0	0	0	0	0
Margarites costalis, var. A	0	0	0	0	0	0	0	0
Margarites sp.	0	0	0	0	0	0	0	0
Moelleria costulata	0	0	0	0	0	0	0	0
Muricidae	0	0	0	0	0	0	0	0
Nudibranch sp. A	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Nudibranch sp. B	0	0	0	0	0	0	0	0
Nudibranch sp. C	0	0	0	0	0	0	0	0
Nudibranch sp. D	0	0	0	0	0	0	0	0
Nudibranch unid	0	0	0	0	0	0	0	0
Odostomia? sp.	0	0	0	0	0	0	0	0
Oenopota nobilis	0	0	0	0	0	0	0	0
Oenopota sp.	0	0	0	0	0	0	0	0
Onchidoris? sp.	0	0	0	0	0	0	0	0
Polinices immaculatus	0	0	0	0	0	0	0	0
Puncturella noachina	0	0	0	0	0	0	0	0
Retusidae	0	0	0	0	0	0	0	0
Solariella obscura	0	0	0	0	0	0	0	0
Solariella obscura?	0	0	0	0	0	0	0	0
Solariella varicosa	0	0	0	0	0	0	0	0
Solariella sp.	0	0	0	0	0	0	0	0
Tachyrhynchus erosus	0	0	0	0	0	0	0	0
Trichotropis? borealis	0	0	0	0	0	0	0	0
Velutina undata	0	0	0	0	0	0	0	0
POLYPLACOPHORA								
Ischnochiton albus	0	0	0	0	0	0	0	0
Tonicella marmorea	0	0	0	0	0	0	0	0
Tonicella rubra	0	0	0	0	0	0	0	0
Chiton sp. A	0	0	0	0	0	0	0	0
Chiton unid	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	S-016	S-017	S-018	S-019	S-020	S-021	S-022	S-023
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
BRACHIOPODA								
Glaciarcula spitzbergensis	0	0	0	0	0	0	0	0
Hermithiris psittacea	0	0	0	0	0	0	0	0
Brachiopod sp. B	0	0	0	0	0	0	0	0
ANNELIDA								
POLYCHAETA								
Ampharetidae unid	0	0	0	0	0	0	0	0
Anobothrus gracilis	0	0	0	0	0	0	0	0
Arcteobia anticostiensis	0	0	0	0	0	0	0	0
Aricidea catherinae	0	0	0	0	0	0	0	0
Aricidea sp. B	0	0	0	0	0	0	0	0
Asabellides? sp	0	0	0	0	0	0	0	0
Capitella capitata	0	0	3	7	0	0	0	0
Capitellidae unid	0	0	0	0	0	0	0	0
Chaetozone? sp.	0	0	0	4	0	0	0	0
Chitinopoma serrula	0	0	0	0	0	0	0	0
Chone sp.	0	0	0	0	0	0	0	0
Cirratulidae unid.	0	0	0	0	0	0	0	0
Cirratulus sp.	0	0	0	0	0	0	0	0
Diplocirrus? sp.	0	0	0	0	0	0	0	0
Eteone flava?	0	0	0	0	0	0	0	0
Eteone longa	0	0	0	1	0	0	0	0
Euchone papillosa	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Euchone sp. A	0	0	0	0	0	0	0	0
Eulalia? sp.	0	0	0	0	0	0	0	0
Eumida sanquinea	0	0	0	0	0	0	0	0
Eumida sp.	0	0	0	0	0	0	0	0
Exogone dispar	0	0	0	0	0	0	0	0
Exogone hebes	0	0	0	0	0	0	0	0
Exogone verugera?	0	0	0	0	0	0	0	0
Flabelligera affinis	0	0	0	0	0	0	0	0
Flabelligeridae?	0	0	0	0	0	0	0	0
Glycera capitata	0	0	0	0	0	0	0	0
Glycera dibranchiata	0	0	0	0	0	0	0	0
Gyptis sp.	1	0	0	0	0	0	0	0
Harmothoe extenuata	0	0	0	0	0	0	0	0
Heteromastus filiformis	5	2	5	0	0	0	0	0
Levinsenia? sp.	0	0	0	7	0	0	0	0
Maldanidae	0	0	0	0	0	0	0	0
Maldanidae sp. A	0	0	0	0	0	0	0	0
Maldanidae sp. B	0	0	0	0	0	0	0	0
Maldanidae sp. C	0	0	0	1	0	0	0	0
Mediomastus ambiseta	0	0	0	0	0	0	0	0
Microphthalmus sczelkoweii	2	0	1	0	0	0	0	0
Microphthalmus sp.	0	0	0	0	0	0	0	0
Nereis sp.	0	0	0	0	0	0	0	0
Nothria conchylega	0	0	0	0	0	0	0	0
Ophelina acuminata	19	3	11	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Owenia? sp.	0	0	0	0	0	0	0	0
Paradoneis? sp.	1	0	0	0	0	0	0	0
Paraonidae sp. B	0	0	0	0	0	0	0	0
Paraonidae sp. C	0	0	0	0	0	0	0	0
Paraonidae unid	0	0	0	0	0	0	0	0
Parougia caeca	0	0	0	0	0	0	0	0
Pectinaria granulata	0	0	0	0	0	0	0	0
Pherusa sp.	0	0	0	0	0	0	0	0
Pholoe minuta	0	0	0	0	0	0	0	0
Pholoe sp.	0	0	0	0	0	0	0	0
Phyllodoce maculata?	0	0	0	0	0	0	0	0
Phyllodoce mucosa?	0	0	0	0	0	0	0	0
Phyllodocidae sp. A	0	0	0	0	0	0	0	0
Phyllodocidae sp. B	0	0	0	0	0	0	0	0
Polychaete sp. A	0	0	0	0	0	0	0	0
Polychaete sp. B	0	0	0	0	0	0	0	0
Polychaete sp. C	0	0	0	0	0	0	0	0
Polychaete sp. D	0	0	0	0	0	0	0	0
Polychaete sp. E	0	3	0	0	0	0	0	0
Polychaete unid	0	0	0	0	0	0	0	0
Polycirrus sp.	0	0	0	0	0	0	0	0
Polynoidae unid	0	0	0	0	0	0	0	0
Praxillella? sp.	0	0	0	0	0	0	0	0
Pygospio? *elegans*	0	0	0	1	0	0	0	0
Sabellidae unid	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Scoloplos acutus	3	1	24	57	0	0	0	0
Spio filicornis	32	7	18	9	0	0	0	0
Spionidae	0	0	0	0	0	0	0	0
Spirorbis spp.	0	0	0	0	0	0	0	0
Syllidae unid	0	0	0	0	0	0	0	0
Terebellidae unid.	0	0	0	0	0	0	0	0
Tharyx sp.	0	0	0	0	0	0	0	0
Thelepus cincinnatus	0	0	0	0	0	0	0	0
Travisia? sp.	0	0	0	12	0	0	0	0
ARCHIANNELIDA								
Archiannelid unid	0	23	6	0	0	0	0	0
Protodrilidae unid.	0	3	1	1	0	0	0	0
MARINE OLIGOCHAETE	60	6	26	26	83	321	34	397
ECHINODERMATA								
Crossaster papposus	0	0	0	0	0	0	0	0
Echinarachnius parma	0	0	0	0	0	0	0	0
Ophiopholis aculeata (Ophiuroid sp. A)	0	0	0	0	0	0	0	0
Ophiura robusta (Ophiuroid sp. B)	0	0	0	0	0	0	0	0
Ophiuroid sp. C	0	0	0	0	0	0	0	0
Ophiuroid sp. D	0	0	0	0	0	0	0	0
Ophiuroid sp. E	0	0	0	0	0	0	0	0
Psolus phantapus	0	0	0	0	0	0	0	0
Strongylocentrotus droebachiensis	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Strongylocentrotus pallidus	0	0	0	0	0	0	0	0
Strongylocentrotus sp.	0	0	0	0	0	0	0	0
ARTHROPODA								
CHELICERATA								
PYCNOGONIDA								
Ammothea? *achelioides*	0	0	0	0	0	0	0	0
Nymphon rubrum	0	0	0	0	0	0	0	0
Pseudopallene? *discoidea*	0	0	0	0	0	0	0	0
Pycnogonid A	0	0	0	0	0	0	0	0
Pycnogonid B	0	0	0	0	0	0	0	0
CRUSTACEA								
AMPHIPODA								
Acanthonotosoma serratum?	0	0	0	0	0	0	0	0
Amphilochus manudens	0	0	0	0	0	0	0	0
Anonyx sp.	0	0	2	0	0	0	0	0
Apherusa megalops	0	0	0	0	0	0	0	0
Calliopius laeviusculus	1	0	0	0	0	0	0	1
Caprellidae unid.	0	0	0	0	0	0	0	0
Corophium? sp.	1	0	0	0	0	0	0	0
Ericthonius rubricornis	0	0	0	0	0	0	0	0
Eurystheus melanops	0	0	0	0	0	0	0	0
Eusirus cuspidatus	0	0	0	0	0	0	0	0
Gammaropsis? sp.	0	0	0	0	0	0	0	0
Gammarus oceanicus	0	0	0	0	0	1	0	0
Gitanopsis inermis	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Guernea nordenskjoldi	0	0	0	0	0	0	0	0
Hippomedon sp.	0	0	0	0	0	0	0	0
Ischyroceridae unid	0	0	0	0	0	0	0	0
Leucothoe sp.	0	0	0	0	0	0	0	0
Lysianassidae unid	0	0	0	0	0	0	0	0
Melita denata	0	0	0	0	0	0	0	0
Metopa norvegica	0	0	0	0	0	0	0	0
Neopleustes pulchellus	0	0	0	0	0	0	0	0
Oediceros saginatus	0	0	0	1	0	0	0	0
Oedicerotidae sp. A	0	0	0	0	0	0	0	0
Orchomenella minuta?	0	0	0	0	0	0	0	0
Phoxocephalus holbolli	0	0	0	0	0	0	0	0
Pleustidae unid.	0	0	0	0	0	0	0	0
Pontogeneia inermis	0	0	0	0	0	0	0	0
Protomedeia sp.	0	0	0	0	0	0	0	0
Psammonyx terranovae	18	35	5	3	0	0	0	0
Stenothoidae unid	0	0	0	0	0	0	0	0
Syrrhoe crenulata	0	0	0	0	0	0	0	0
Tiron spiniferum	0	0	0	0	0	0	0	0
Tryphosa sp.	0	0	0	0	0	0	0	0
Unciola irrorata	0	0	0	0	0	0	0	0
Unicola sp	0	0	0	0	0	0	0	0
Westwoodilla sp.	0	0	0	0	0	0	0	0
Amphipod unid	0	0	0	0	0	0	0	0
ISOPODA								

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Isopod sp. A	0	0	0	0	0	0	0	0
Isopod sp. B	0	0	0	0	0	0	0	0
Isopod sp. C	0	0	0	0	0	0	0	0
Isopod sp. D	0	0	0	0	0	0	0	0
Isopod sp. E	0	0	0	0	0	0	0	0
Munna acanthifera?	0	0	0	0	0	0	0	0
Munna fabricii	0	0	0	0	0	0	0	0
Munna sp.	0	0	0	0	0	0	0	0
Philoscia vittata	0	0	0	0	0	0	0	0
Pleurogonium spinosissmum	0	0	0	0	0	0	0	0
Synidotea nodulosa	0	0	0	0	0	0	0	0
Isopod unid.	0	0	0	0	0	0	0	0
CUMACEA								
Camplyaspis sp.	0	0	0	0	0	0	0	0
Cumacean sp. A	0	0	0	0	0	0	0	0
Leucon nasicoides	0	0	0	0	0	0	0	0
DECAPODA								
Hyas coarctatus	0	0	0	0	0	0	0	0
Shrimp sp. A	0	0	0	0	0	0	0	0
TANAIDACEA								
Tanaid sp. A	0	0	0	0	0	0	0	0
CIRRIPEDIA								
Balanus balanus	0	0	0	0	0	0	0	0
Balanus crenatus	0	0	0	0	0	0	0	0
Balanus sp.	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Barnacle unid	0	0	0	0	0	0	0	0
NEMERTEA								
Cerebratulus sp.	0	0	0	4	0	0	0	0
Nemertean sp. A	0	0	2	2	0	0	0	0
Nemertean sp. B	0	0	0	0	0	0	0	0
Nemertean sp. C	0	0	0	0	0	0	0	0
Nemertean sp. D	21	33	5	8	0	0	0	0
Nemertean sp. E	0	0	0	0	0	0	0	0
Nemertean unid	19	0	0	0	3	2	0	0
SIPUNCUIDA								
Phascolion strombi	0	0	0	0	0	0	0	0
Sipunculid sp. A	0	0	0	0	0	0	0	0
Sipunculid sp. B	0	0	0	0	0	0	0	0
PRIAPULIDA	0	0	1	0	0	0	0	0
CNIDARIA								
Alcyonaria sp. A	0	0	0	0	0	0	0	0
Alcyonaria sp. B	0	0	0	0	0	0	0	0
Anemone sp. A	0	0	0	0	0	0	0	0
Anemone sp. B	0	0	0	0	0	0	0	0
Anemone unid.	0	0	0	0	0	0	0	0
Bunodactis stella	0	0	0	0	0	0	0	0
Edwardsia elegans	0	0	0	0	0	0	0	0
Gersemia rubiformis	0	0	0	0	0	0	0	0
Hydroid unid.	0	0	0	0	0	0	0	0
HEMICHORDATA								

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Saccoglossus? sp.	0	0	0	0	0	0	0	0
CHORDATA								
Ascidia callosa	0	0	0	0	0	0	0	0
Boltenia echinata	0	0	0	0	0	0	0	0
Boltenia ovifera?	0	0	0	0	0	0	0	0
Ascidian sp. A	0	0	0	0	0	0	0	0
Ascidian sp. B	0	0	0	0	0	0	0	0
Ascidian sp. C	0	0	0	0	0	0	0	0
Ascidian sp. D	0	0	0	0	0	0	0	0
Ascidian sp. E	0	0	0	0	0	0	0	0
Ascidian sp. F	0	0	0	0	0	0	0	0
Ascidian sp. G	0	0	0	0	0	0	0	0
Ascidian unid.	0	0	0	0	0	0	0	0
PORIFERA								
Leucosolenia sp	0	0	0	0	0	0	0	0
Scypha sp.	0	0	0	0	0	0	0	0
Porifera sp. A	0	0	0	0	0	0	0	0
Porifera sp. B	0	0	0	0	0	0	0	0
Porifera sp. C	0	0	0	0	0	0	0	0
Porifera sp. D	0	0	0	0	0	0	0	0
Porifera sp. E	0	0	0	0	0	0	0	0
PLATYHELMINTHES								
Flatworm sp. A	0	0	0	0	0	0	0	0

Table B-1: Benthic Raw Data for L'Anse au Diable Electrode Site (Cont'd)

Sample Number	**S-016**	**S-017**	**S-018**	**S-019**	**S-020**	**S-021**	**S-022**	**S-023**
Percent Sampled	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
MISCELLANEOUS								
Unidentified Taxon A	0	0	0	0	0	0	0	0
Unidentified Taxon B	0	0	0	0	0	0	0	0
FISH								
Ammodytes sp.	1	0	0	0	0	0	0	0
MEIOFAUNA & PLANKTON								
Bryozoa (Present/Absent)	A	A	A	A	A	A	A	A
Calanoid Copepod	5	0	0	0	0	0	0	0
Harpacticoid Copepod	0	0	0	0	0	0	0	0
Egg cases	0	0	0	4	0	0	0	0
Fish Lice	0	0	0	0	0	0	0	0
Hydrachnidia	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	0	0
Nematoda	41	7	0	0	0	0	0	0
Foraminifera	0	0	0	0	0	0	0	0
Hard Coral (Present/Absent)	A	A	A	A	A	A	A	A

APPENDIX C

Study Photographs

Representative Photographs from Shoreline Surveys

Shoreline and backshore at the Dowden's Point electrode site

Shoreline and backshore at the L'Anse au Diable electrode site

Shoreline and backshore at the Dowden's Point electrode site

Shoreline and backshore at the L'Anse au Diable electrode site

Shoreline and backshore at the Dowden's Point electrode site

Shoreline and backshore at the L'Anse au Diable electrode site

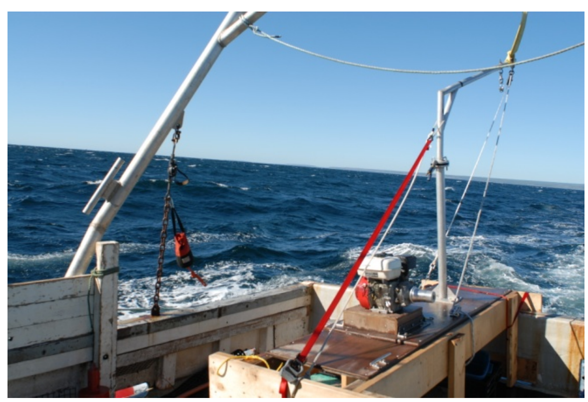
Representative Photographs from Shoreline Surveys

At the L'Anse au Diable electrode site – the speedboat used for the survey

Aerial image of the L'Anse au Diable electrode site

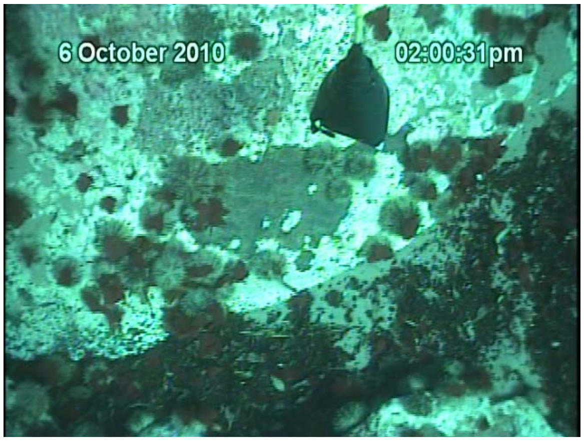
The L'Anse au Diable electrode site at low tide

Sieving benthos samples from the intertidal zone at L'Anse au Diable during low tide



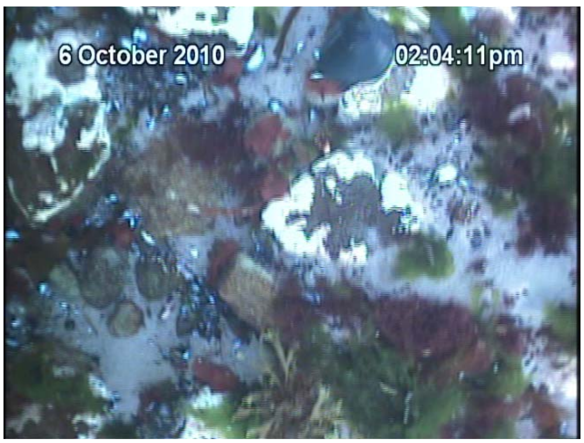
Winch with Honda hauler used for collection of water and sediment samples

Representative Photographs from L'Anse au Diable Underwater Video

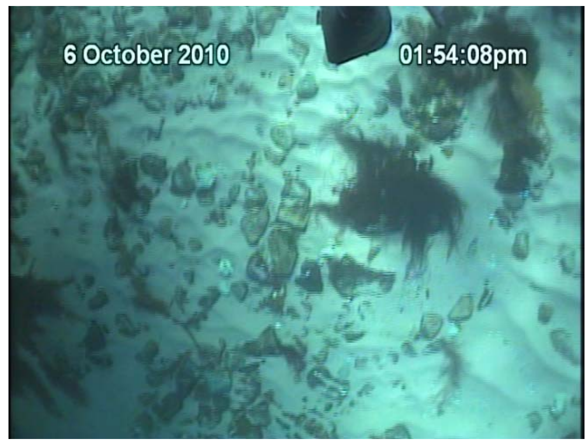


Bedrock-boulder substrate with encrusting coralline algae and red filamentous algae

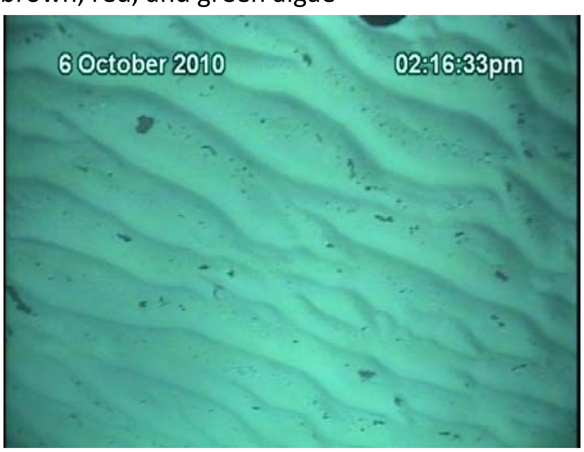
Sand and cobble with brown and green algae



Sand with boulder-cobble substrate with brown, red, and green algae



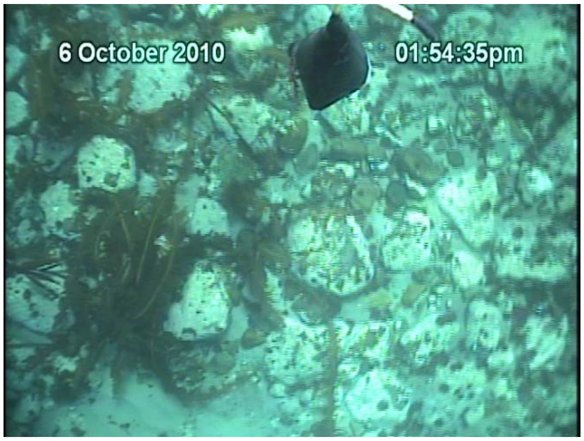
Sand with cobble and brown algae



Sand with ripples

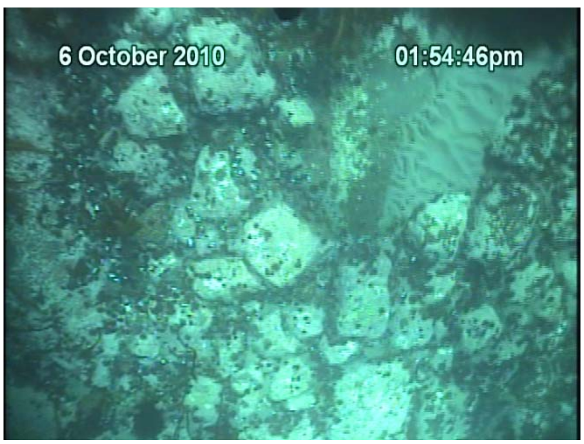
Sand with various types of algae (brown, red and green)

Representative Photographs from L'Anse au Diable Underwater Video

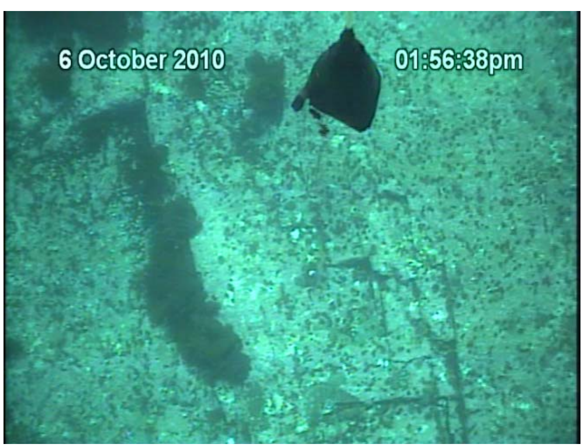


Cobble and sand substrate with brown and red algae

Bedrock/boulder with brown algae

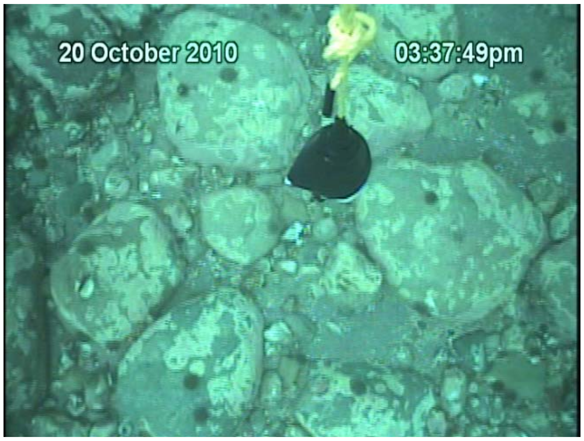


Cobble, boulder and sand substrate with brown algae and encrusting coralline algae and sea urchins



Bedrock with sea urchins, green algae and coralline algae

Representative Photographs from Dowden's Point - Underwater Video



Boulder and cobble substrate with encrusting red algae and sea urchins

Boulder sand and cobble substrate

Boulder and cobble substrate with many small sea urchins

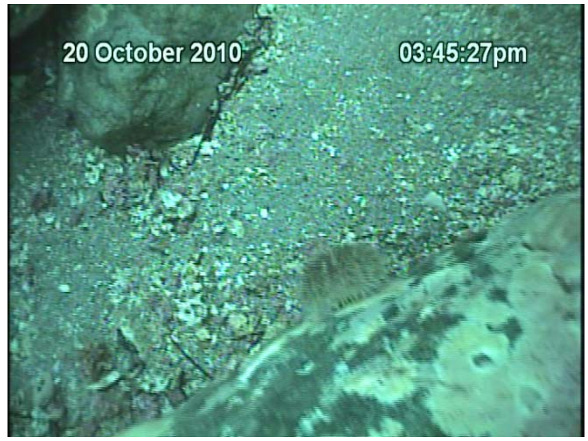
Boulder and cobble with encrusting red algae and sea urchins

Boulder and cobble substrate

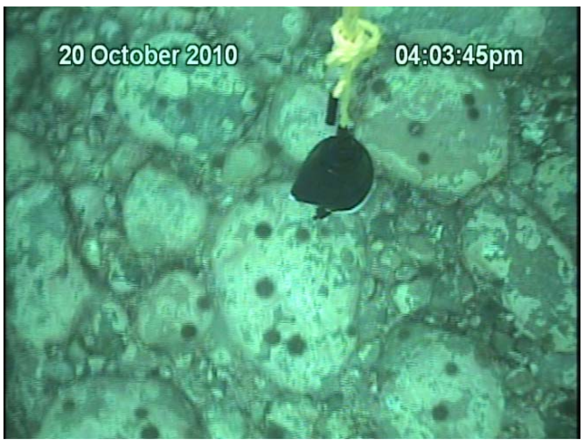
Boulder and cobble with encrusting red algae and sea urchins

Representative Photographs from Dowden's Point - Underwater Video

Boulder and cobble substrate with encrusting red algae and sea urchins



Boulder with sand and sea urchins



Boulder and cobble substrate with encrusting red algae and sea urchins

Boulder, cobble and sand substrate and sea urchins