# *Offshore Environmental Effects Monitoring for Deep Panuke*

***Program Annual Report 2011***

*Encana number: DMMG-X00-RP-EH-90-0001.02U*

**McGregor number:** *1113-EEMRDP*


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encana natural gas

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McGregor Project Number: 1113

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## Executive Summary

McGregor GeoScience Ltd. (McGregor) was contracted by Encana Corporation for provision of environmental effects monitoring services for the Deep Panuke Project. McGregor conducted field sampling, sample processing and report production as part of the Environmental Effects Monitoring Plan (EEMP) (Encana, 2011).

The objective of this study was to provide the follow up program to address all production operations-related environmental effects monitoring (EEM) commitments made during the Deep Panuke regulatory process outlined in the 2007 Comprehensive Study Report (CSR) and environmental effects predictions made in the 2002, 2006 and 2008 Environmental Assessments (EAs). The Deep Panuke EEMP builds on results and lessons learned to date from the Sable Offshore Energy Project (SOEP) EEM program which has been carried out on Sable Island Bank since 1997.

The Deep Panuke offshore 2011 EEM program was designed to address the following objectives:

- identify and quantify environmental effects;
- verify predictions made during the EA processes;
- evaluate the effectiveness of mitigation and identify the need for improved or altered mitigation;
- provide an early warning of undesirable change in the environment; and,
- assist in identifying research and development needs.

This document details the specific results of McGregor GeoScience Ltd.'s initial field survey to collect marine water quality samples (section 6.2.5 and 6.2.6 of the EEMP), sediment chemistry and toxicity samples (section 6.3.5 and 6.3.6 of the EEMP) and fish habitat alteration observations (section 6.4.5 and 6.4.6 of the EEMP) in the fourth quarter of 2011. Sampling was conducted from the ATLANTIC CONDOR, which was mobilized from Halifax, Nova Scotia. Field sampling took place December 1 - 6, 2011.

This report also documents the findings of the marine wildlife observations (section 6.6.5 and 6.6.6 of the EEMP) conducted throughout 2011 by Acadia University's seabird research study, The Sable Island beached bird survey, The Oil and Gas Observers

Program (OGOP), and In-field marine mammals, turtles and bird observations (including stranded birds) were observed by SBM and Encana personnel .

The results of the 2011 EEM program include the following:

Marine Water Quality Monitoring

- This data set represents baseline levels measured prior to the PFC becoming operational;
- Metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines) where available;
- Water column Boron, Calcium, Magnesium, Molybdenum, Potassium, Strontium, Sulphur and Uranium concentrations are near ocean mean levels;
- Barium was detected at Stations 1B and 2M (the two upstream stations) with a value of 13 µg/L and 70 µg/L, respectively;
- PAH, Total Hydrocarbons including BTEX-TPH and alkylated phenols are below laboratory RDL except for BTEX-TPH Toluene, which is slightly above the laboratory RDL of 0.001µg/L with a water quality guideline value of 215µg/L for the protection of aquatic marine life.

Sediment Chemistry and Toxicity

- Metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines) where available;
- The sediment type at all stations ranged from fine to medium sand
- Sediment quality has remained at 2008 levels or has improved at all the field stations: D-41, F-70, E-70, M-79A, H-08, 250m DS, 500m DS and 1000m DS (2000m DS was not sampled in 2008). Aluminum levels in 2008 were much higher at all stations than in 2011;
- Arsenic was found to be below laboratory RDL at all 2011 benthic stations;
- TPH and Barium are below laboratory RDL at all 2011 benthic stations;
- Mercury concentrations remain below laboratory RDL for all benthic stations;
- PAH, BTEX-TPH and Alkylated Phenol’s remain below laboratory RDL for all benthic stations;

- Sulphide levels are slightly above laboratory RDL for all benthic stations excluding H08 and F70, where results were below laboratory RDL;
- TOC concentrations remain low at approximately the same levels as the 2008 survey.

Sediment Toxicity

- The samples and control sediment as tested were found to be non-toxic to the amphipod *Eohaustorius estuarius*.

Fish Habitat Alteration

- No mud/cuttings piles were observed in the video at and around the E-70 drill site and wellhead. No mud/cuttings piles were observed around any of the remaining wellheads and drill sites;
- Epifauna colonization of WHPS at all well site locations observed had vertical zonation for each wellhead structure. Species composition was homogenous across all wellhead sites;
- Atlantic cod found at F-70 and not at any other wellhead sites in the June 2011 survey may be related to the presence of a food source (shrimp). Fish and shrimp had both disappeared at the same time;
- Presence of high numbers of Atlantic cod in the November 2011 survey could have a spawning/migration connection;
- Wellheads and protective structures appear to be acting as an artificial reef/refuge as evidenced by the colonization of the structures as mentioned in the 2006 EA predictions. The structures are attracting fish from the surrounding areas and providing shelter in an otherwise relatively featureless seafloor.

Marine Wildlife Observations

- Oil and Gas Observer Program (OGOP) was successfully carried out during the Tow Program, the Rock Placement Program and the Umbilicals Program. 60+ sightings of marine mammals were noted with some feeding and the majority transiting through the area;
- A single bird stranding occurred with the bird being returned to its natural habitat unharmed;

- Improvements to bird monitoring technologies (bird radar and telemetry tags) are being developed to increase the capabilities of the bird monitoring program;
- The 2011 oiling rate is 13.0% compared to 5.3% observed 2010. However, this rate is consistent with previous <15% recorded over the last four years. Six samples of oil were collected in 2011, and likely represented four separate discharge events. None of the six samples contained light or mid-ranged distillate fuels, or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms off Sable Island.

Fish Health (section 6.5 of the EEMP) and Air Quality Monitoring (section 6.7 of the EEMP) will be included in the program during the operations phase of Deep Panuke which is expected to commence in 2013.

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## GLOSSARY OF TERMS

| | |
|---|---|
| AC | Autoanalysis Colilert |
| ADCP | Acoustic Doppler Current Profiler |
| AL | Acid Leachable |
| APs | Alkyl Phenols |
| AQC | Analytical Quality Control |
| BTEX | Benzene, Toluene, Ethylbenzene, Xylene(s) |
| CEQG | Canadian Environmental Quality Guidelines |
| $CH_4$ | Methane |
| cm | centimetre(s) |
| CNLOPB | Canada-Newfoundland and Labrador Offshore Petroleum Board |
| CNSOPB | Canada-Nova Scotia Offshore Petroleum Board |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| COPAN | Cohasset and Panuke |
| CPI | Carbon Preference Index |
| CRM | Certified Reference Material |
| CSR | Comprehensive Study Report |
| CTD | Conductivity, Temperature, Depth |
| CVAA | Cold Vapor Atomic Absorption |
| CWS | Canadian Wildlife Service |
| DCM | Dichloromethane |
| DGPS | Differential Global Positioning System |
| DIC | Dissolved Inorganic Carbon |
| DO | Dissolved Oxygen |
| DOC | Dissolved Organic Carbon |
| DP | Dynamic Positioning |
| DVD | Digital Video Disc/ Digital Versatile Disc |
| EA | Environmental Assessment |
| EEM | Environmental Effects Monitoring |
| EEMP | Environmental Effects Monitoring Plan |
| EPA | Environmental Protection Agency (USA) |

| | |
|---|---|
| EPCMP | Environment Protection and Compliance Monitoring Plan |
| EPS1/RM/35 | Reference method for determining acute lethality of sediment to marine or estuarine amphipods |
| EQG | Environmental Quality Guidelines |
| EROD | Ethoxyresorufin-O-deethylase |
| ESRF | Environmental Studies Research Fund |
| GC-FID | Gas Chromatography – Flame Ionisation Detection |
| GC-MS | Gas Chromatography – Mass Spectrometry |
| GC-PID/FID | Gas Chromatography – Photoionization detection/ Flame Ionisation Detection |
| GEP | Gas Export Pipeline |
| GHG | Greenhouse Gases |
| GPS | Global Positioning System |
| GVI | General Visual Inspection |
| $H_2S$ | Hydrogen Sulphide |
| HF | Hydrofluoric Acid |
| hr | Hour |
| HS- | Hydrogen Sulphide ion |
| IC | Ion Chromatography |
| ICAP | Inductively Coupled Atomic Photometry |
| ICP- AES | Inductively Coupled Plasma- Atomic Emission Spectrometry |
| ICP- MS | Inductively Coupled Plasma- Mass Spectrometry |
| ICP- OES | Inductively Coupled Plasma- Optical Emission Spectrometry |
| ID | Identification |
| ISE | Ion Selective Electrode |
| kg | Kilogram |
| km | Kilometre |
| L | Litre(s) |
| LC49 | Bioassay acute toxicity analysis |
| LAT | Lowest Astronomical Tide |
| LOD | Limit of Detection |
| LOI | Loss on Ignition |
| LRMS | Low resolution mass spectrometry |
| m | metres |

| | |
|---|---|
| MB | Method blank |
| MBES | Multibeam Bathymetry Echo Sounder |
| MFO | Mixed Function Oxygenase |
| mg | milligram(s) |
| mg/L | Milligrams Per Litre |
| ml | millilitre(s) |
| MLA-004 | AXYS method for determination of 4-n-octylphenol, nonyphenol and nonylphenol ethoxylates in aqueous samples |
| mm | millimetre(s) |
| MOPU | Mobile Offshore Production Unit |
| MS | Mass Spectrometry |
| N | North |
| NA | Not tested for |
| NaOH | Sodium Hydroxide |
| NAS | Northwestern Aquatic Sciences |
| ND | Not detectable |
| NE | North East |
| NEB | National Energy Board |
| ng | Nanogram |
| $NO_2$ | Nitrogen Dioxide |
| $NO_3$ | Nitrate |
| NOx | Nitrogen Oxides |
| NP | Nonylphenol |
| NP1EO | 4-Nonylphenol monoethoxylate |
| NP2EO | 4-Nonylphenol diethoxylate |
| $O_3$ | Ozone |
| OP | 4-n-Octylphenol |
| OPR | Ongoing Precision and Recovery |
| OR | Oregon |
| OWTG | Offshore Waste Treatment Guidelines |
| PAH | Polynuclear Aromatic Hydrocarbons |
| PEL | Probable Effect Level |
| PFC | Production Field Centre |
| pH | Power of Hydrogen |

| | |
|---|---|
| Phi | Particle Size unit (Krumbein phi scale) |
| PM2.5 | Fine Particulate Matter |
| PPMW | Parts per million by weight |
| ppt | Parts per thousand |
| PSA | Particle Size Analysis |
| PSU | Practical Salinity Units |
| PTGC | Programmed Temperature Gas Chromatography |
| P/T MS | P/T Mass Spectrophotometry |
| RACON | RADAR Beacon |
| RADAR | Radio Detection and Ranging |
| RBR XR-620 | Multi-channel Logger |
| RDL | Reporting Detection Limit |
| ROV | Remotely Operated Vehicle |
| QA | Quality Assurance |
| QC | Quality Control |
| $S^{2-}$ | Sulphide |
| SACFOR | Abundance Scale; S-superabundant, A-abundant, C-common, F-frequent, O-occasional, R-rare |
| SBM | Synthetic-based mud |
| SE | South East |
| SD | Sample duplicates |
| S.D. | Standard Deviation |
| SM 4500-S2-F | Sulphide Test Iodometric 20th Ed. |
| $SO_2$ | Sulphur Dioxide |
| SOEP | Sable Offshore Energy Project |
| SS | Sample spikes |
| SSIV | Subsea Isolation Valve |
| SW | South West |
| TC | Total Carbon |
| THC | Total Hydrocarbon Content |
| TIC | Total Inorganic Carbon |
| TOC | Total Organic Carbon |
| TOM | Total Organic Matter |
| TPH | Total Petroleum Hydrocarbons |

| | |
|---|---|
| TVG | Time Varied Gain |
| VACM | Vector Averaging Current Meter |
| VECs | Valued Environmental Components |
| VIV | Vortex Induced Vibration |
| VOCs | Volatile Organic Compounds |
| μm | micrometre(s) |
| μg | microgram(s) |
| UCM | Unresolved Complex Mixture |
| UTC | Coordinated Universal Time |
| UTM | Universal Transverse Mercator |
| W | West |
| WBM | Water-based Mud |
| WGS84 | World Geodetic System 1984 |
| WHPS | Wellhead Protection Structure |
| XAD-2 | Liquid Chromatography Water Sampling Columns/ Resin/ Filters |

# 1 INTRODUCTION

McGregor GeoScience Ltd. (McGregor) has been contracted by Encana Corporation (Encana) for provision of environmental effects monitoring services and data analysis for the Deep Panuke Project. McGregor undertook field sampling, sample processing and report production as per the Environmental Effects Monitoring Plan (EEMP) (Encana, 2011: DMEN-X00-RP-EH-90-0003).

The 2011 EEM project team consists of:

- McGregor GeoScience Ltd.
- Seabird research study: Acadia University
- Sable Island beached bird survey: Zoe Lucas Consulting
- Marine mammal and seabird observations: Oil and Gas Observers Program
- In-field marine mammals, turtles and bird observations (including stranded birds): SBM/Encana (personnel from PFC and supply/standby vessels MV ATLANTIC CONDOR and MV RYAN LEET)

This document details the specific results of McGregor GeoScience Ltd.'s initial field survey to collect marine water quality samples (section 6.2.5 and 6.2.6 of the EEMP), sediment chemistry and toxicity samples (section 6.3.5 and 6.3.6 of the EEMP) and fish habitat alteration observations (section 6.4.5 and 6.4.6 of the EEMP) in the fourth quarter of 2011. Sampling was conducted from the ATLANTIC CONDOR, which was mobilized from Halifax, Nova Scotia. Field sampling took place December 1 - 6, 2011.

This report also documents the findings of the marine wildlife observations (section 6.6.5 and 6.6.6 of the EEMP). Acadia University's seabird research study assesses bird-human interactions at offshore installations by incorporating instrument-based approaches. This study combines multiple automated, instrument-based monitoring techniques (e.g. radar, VHF tracking, satellite telemetry) to quantify patterns of individual and population level bird activities on and around offshore installations (section 6.3.6.4 2002 CSR and 6.6 of the EEMP). Field sampling took place between June and August 2011.

The Sable Island beached bird survey aims to monitor numbers and oiling rates in beached birds on Sable Island in order to monitor trends in oiling rate in beached bird corpses and to identify oil types found on seabird feathers and in pelagic tar (section 6.6 of the EEMP). Field sampling took place between January 1 and December 31, 2011.

Marine mammal and seabird observations conducted by the Oil and Gas Observers Program (OGOP) took place during the PFC Tow program, Deep Panuke Rock Placement Program, and Deep Panuke 2011 Umbilicals Program between July 21 – August 6, 2011 (section 6.6 of the EEMP).

In-field marine mammals, turtles and bird observations (including stranded birds) were observed by SBM and Encana personnel from the PFC and supply/standby vessels, including the ATLANTIC CONDOR and RYAN LEET between January 1 – and December 31, 2011 (section 6.6 of the EEMP).

Fish Health (section 6.5 of the EEMP) and Air Quality Monitoring (section 6.7 of the EEMP) will be included in the program during the operations phase of Deep Panuke.

**Table 1.1** provides an overview of the 2011 EEM program including relevant environmental effects monitoring (EEM) components and survey timing.

**Table 1.1 - Overview of 2011 EEM Program**

| *EEM Component(s)* | *2011 EEM Program* | *Survey Timing* |
|---|---|---|
| - Marine Water Quality<br>- Monitoring<br>- Fish Habitat Alteration<br>- Fish Health Assessment | Tri-level seawater samples at 7 upstream and downstream locations. | December, 2011 |
| - Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration | Surface sediment samples at 9 upstream and downstream locations.<br><br>Inspection of ROV video data to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | December, 2011<br><br>November, 2011 |
| - Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration | Surface sediment samples from 9 upstream and downstream locations.<br><br>ROV video data to be inspected in order to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | December, 2011<br><br>July, 2011 and November, 2011 |
| - Sediment Chemistry<br>- and Toxicity<br>- Fish Habitat Alteration | ROV video data to be inspected in order to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | July, 2011 and November, 2011 |
| - Fish Habitat Alteration | ROV video data to be inspected in order to determine and interpret the development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | July, 2011 and November, 2011 |

| | | |
|---|---|---|
| - Fish Habitat Alteration | ROV video data to be inspected in order to determine and interpret the development of benthic communities along the pipeline. | July, 2011 and November, 2011 |
| - Marine Water Quality<br>- Monitoring<br>- Marine Wildlife Observations | Summarize observations from the OGOP, Tow program, Rock Placement Program, and Umbilicals Program. | July, 2011 – August, 2011 |
| - Marine Wildlife Observations | Summarize observations and findings from OGOP, Acadia University Telemetry, Acadia University Colour Banding, Acadia University Bird-Radar Development (RACON), | January, 2011 – December, 2011 |
| - Marine Water Quality<br>- Monitoring<br>- Marine Wildlife Observations | Summarize observations and findings from Sable Island Beach Surveys and vessel observations. | January, 2011 – December, 2011 |

## 1.1 DEEP PANUKE BACKGROUND

The Deep Panuke project is located offshore 250km southeast of Halifax, Nova Scotia, approximately 45km to the West of Sable Island in water depths ranging from 42m to 50m (**Figure 1**).

The project involves offshore production, processing and transport via a nominal 559mm (22 inch) sales gas quality pipeline to an interconnection with the Maritimes & Northeast Pipeline (M&NP) facilities near Goldboro, Nova Scotia. The M&NP main transmission pipeline delivers to markets in Canada and the Northeast United States. The condensate produced offshore is to be treated and used as fuel on the production field centre (PFC).

The Deep Panuke project facilities consist of a PFC which includes a hull and topsides facilities, four subsea production wells, a disposal well and associated subsea flowlines and control umbilicals, a gas export pipeline to shore, and support vessel and helicopter operations.

Deep Panuke is a sour gas reserve with raw gas containing approximately 0.18 mol % hydrogen sulphide ($H_2S$). The offshore processing system consists of separation, compression (inlet and export), gas sweetening, gas dehydration, gas dewpointing (via Joule-Thompson), condensate sweetening and stabilization, and produced water treatment and disposal. Once $H_2S$ and carbon dioxide (acid gas) have been removed from the raw gas stream to acceptable levels, the acid gas is injected into a dedicated underground disposal well.

In November 2007, Encana entered into an agreement with Single Buoy Moorings Inc. (SBM) for the engineering, procurement, fabrication, installation and commissioning of the Deep Panuke PFC. In addition to the provision of the PFC, SBM will provide personnel to help ensure a smooth transition from the development phase into the project's production phase, and will be responsible for the long-term operations of the production facilities, including logistics. During the production operations phase at Deep Panuke, Encana will remain the operator of record but SBM will own and operate the production facility and oversee day-to-day field operations, as directed by Encana, including production, marine, helicopter and onshore logistics.

The following Deep Panuke construction programs took place in 2011:

- subsea asset inspection survey (May-June 2011);
- umbilicals laying and trenching (July 2011);
- rock placement on the flowlines, sections of the gas export pipeline and PFC footings (July-August 2011);
- PFC tow from Mulgrave, Nova Scotia, and installation at the field centre location (end of July to early August 2011);
- diving program for PFC and subsea hook-up and commissioning (July to November 2011); and
- PFC hook-up and commissioning program (August 2011 – ongoing).

PFC hook-up and commissioning activities are still ongoing with First Gas currently planned for the second quarter of 2012.

## 1.2 2011 PROJECT OVERVIEW

The project location of the Deep Panuke EEMP is shown in **Figure 1**. Water quality and sediment sampling stations are located in **Figure 2** and **Figure 4**.

McGregor collected marine water quality samples from 7 sampling stations, and sediment samples from 11 sampling stations (9 field stations and 2 reference stations). Samples were sub-sampled and prepared onboard the vessel for subsequent analytical analysis once returned to shore using appropriate procedures (DMMG-X00-PR-EH-97-006.04). Samples were stored under appropriate conditions before dispatch to the specialist subcontracted laboratories for analysis.

## 1.3 HORIZONTAL DATUM

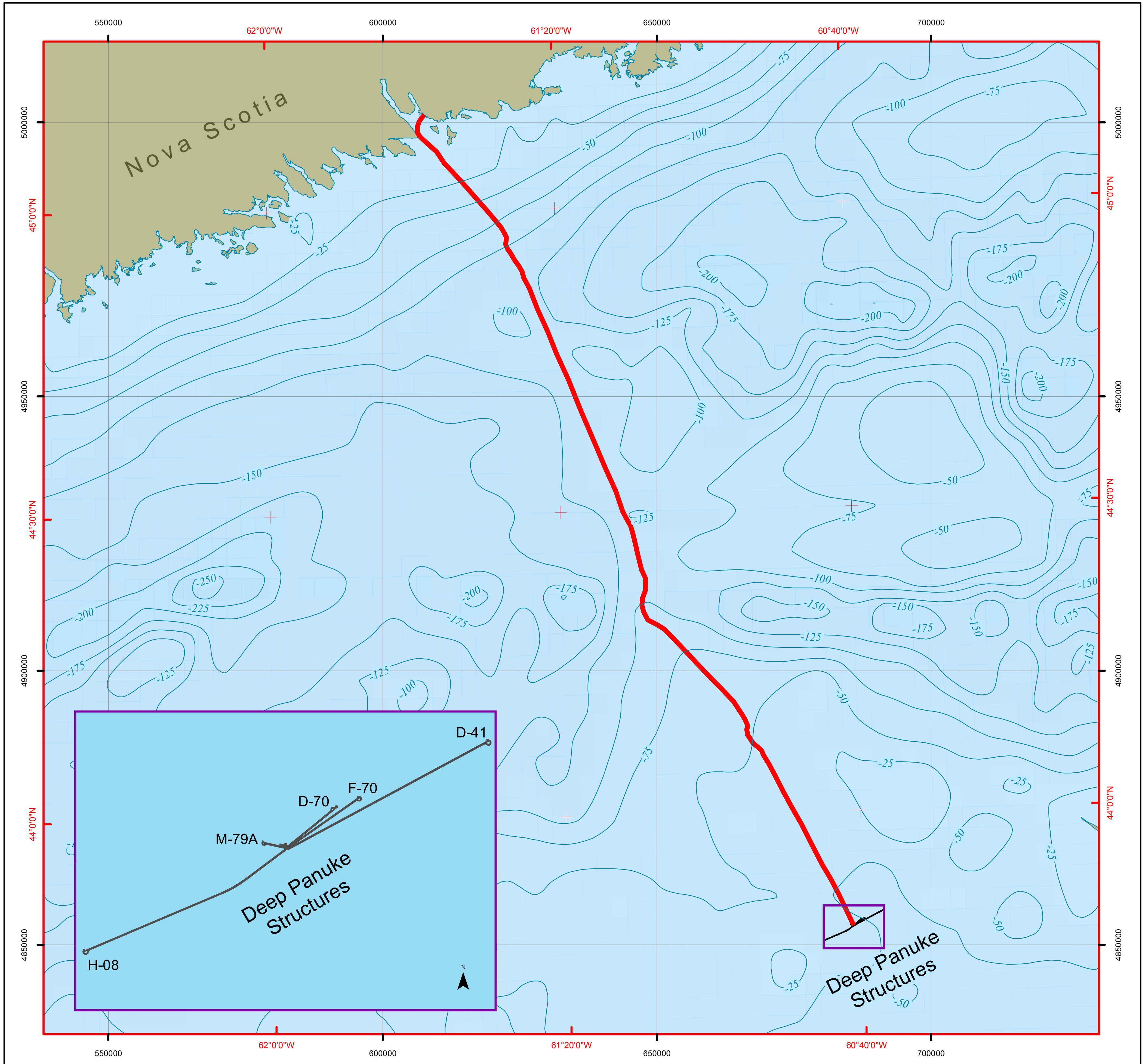
Primary horizontal positioning data was acquired using the vessel differentially corrected GPS. Geodetic and mapping projection parameters used during the project are presented below:

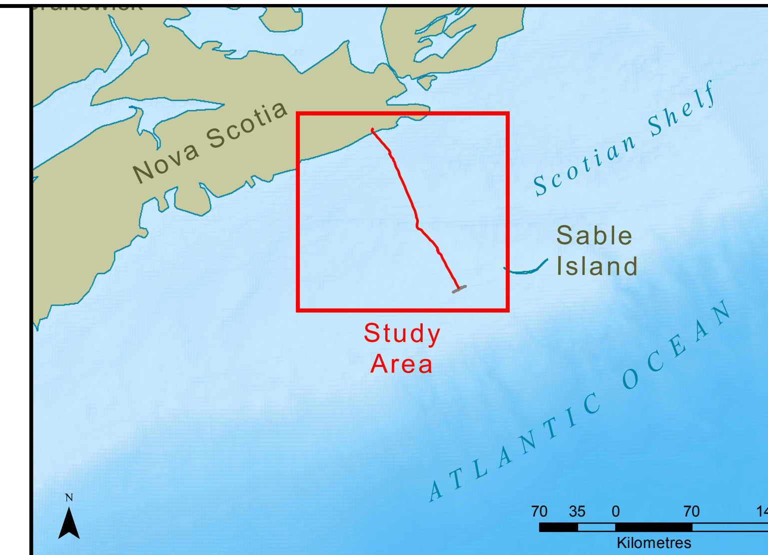
**Table 1.2 - Geodetic Parameters**

| Parameter | Value |
|---|---|
| Ellipsoid | WGS84 |
| Datum | WGS84 |
| Semi-Major Axis (a) | 6 378 137.000 m |
| Reciprocal Flattening (l/f) | 1/298.257223563000030000 |

**Table 1.3** - Mapping Projection Parameters

| Parameter | Value |
|---|---|
| Projection | Universal Transverse Mercator |
| Zone | 20 N |
| False Northing | 0 m |
| False Easting | 500 000 m |
| Longitude of Origin of Projection | 63° W |
| Scale Factor along Standard Parallel | 0.9996 |




Coordinate System: WGS 1984 UTM Zone 20N
Projection: Transverse Mercator
Datum: WGS 1984
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

0 10 20 40 60
Kilometres

Pipeline

*Note:*
*Map scale 1:750,000 when printed on 11x17 size paper*
*25 m contour interval*

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**Project General Location**

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited

McGregor GeoScience Ltd.
Bedford, Nova Scotia, Canada

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McGregor Project No.: 1113

**Figure: 1**

Filename: ENCANA_Pipe

# 2 COMPONENTS

## 2.1 PRODUCED WATER CHEMISTRY AND TOXICITY

### 2.1.1 Background

Produced waters, which are generated during the production of oil and gas, represent a complex mixture of dissolved and particulate organic and inorganic chemicals varying in salinity from freshwater to concentrated saline brine (Lee and Neff, 2011). The physical and chemical properties of produced water vary widely depending on the geological age, depth, geochemistry of the hydrogen-bearing formation as well as the chemical composition of the oil and gas phases in the reservoir and processes added during production. On most offshore platforms, these waters represent the largest volume waste stream in oil and gas exploration and production operations (Stephenson, 1991).

There is considerable concern about the ocean disposal of produced water because of the potential danger of chronic ecological harm. The chemicals of greatest environmental concern include aromatic hydrocarbons, some alkylated phenols and a few metals. These chemicals, if present in high enough concentrations lead to bioaccumulation and toxicity in marine organisms.

Based on the concentration of chemicals in produced waters and the predicted dispersion rates, the effects of produced water on individual offshore production sites are likely to be minor.

The proposed Deep Panuke produced water compliance monitoring program is designed to meet testing and reporting requirements from the *Offshore Waste Treatment Guidelines* (*OWTG*) (CNSOPB, C-NLOPB, NEB, December 2010) and is outlined in the Deep Panuke Production Environment Protection and Compliance Monitoring Plan (EPCMP) (DMEN-X00-RP-EH-90-0002).

The *OWTG* specify a maximum limit of 30mg/L (30-day weighted average) and 44 mg/L (24-hour arithmetic average) of oil in produced water discharged to the marine environment. Encana’s design target for Deep Panuke is 25mg/L (30-day weighted average). The concentration of oil in produced water will be measured at least every 12 hours and a volume weighted 30-day rolling average calculated daily.

Produced water quality and toxicity will be measured in the 2012 sampling season following commencement of production by the Deep Panuke PFC.

## 2.2 MARINE WATER QUALITY MONITORING

### 2.2.1 Background

The 2006 Deep Panuke Environmental Assessment (EA) (p. 8-38) made the following specific predictions with respect to water quality dispersion:

- The maximum discharge rate of produced water will be 6,400 $m^3$/day (266.7 $m^3$/hr) and 2,400 $m^3$/hr for cooling water giving a dilution rate of 9:1;
- The project's produced water treatment facilities are expected to treat produced water so that $H_2S$ concentration prior to mixing with cooling water does not exceed 1 to 2 ppmw; and
- Produced water will be mixed with cooling water prior to discharge. Upon being released to the marine environment, discharged water will be rapidly diluted by ambient currents and background oceanic mixing as per **Table 2.1** below (Table 8.18 from the 2006 Deep Panuke EA).

**Table 2.1 - Summary of Discharged Water Far-Field Dispersion Modelling Results**

| Distance from Discharge Site | Dilution (Discharge/Background Waters) | Temperature Anomaly (°C) | Salinity Anomaly (PSU) | Hydrocarbon Concentration (mg/L) | $H_2S$ Concentration (PPMW) | Oxygen Concentration Relative to Background (%) |
|---|---|---|---|---|---|---|
| End of Pipe* | No dilution | 25 | 6.25 | .8 | 0.2 | 0 |
| Site (seafloor) | 10:1 | 2.5 | 0.6 | 0.28 | 0.02 | 90 |
| 500m | 70:1 | 0.4 | 0.1 | 0.04 | 0.003 | 98 |
| 1km | 100:1 | 0.25 | 0.06 | 0.03 | 0.002 | 99 |
| 2km | 400:1 | 0.06 | 0.02 | 0.007 | 0.0005 | 100 |
| End of discharge caisson at a depth of 10m | | | | | | |

Note: discharge water consists of produced water mixed with cooling water (9:1 mixing ration)

The Deep Panuke Production EPCMP (DMEN-X00-RP-EH-90-0002) provides more recent information on the design of the PFC produced water system. The current system is designed for a produced water rate of 6,400 $m^3$/d (266.7 $m^3$/hr). After treatment and sampling, the treated produced water will go down the seawater discharge caisson located in the PFC SE leg and be mixed with the spent 3,340 $m^3$/hr cooling water inside the leg prior to discharge into the ocean environment at a depth of approximately 26m below Lowest Astronomical Tide (LAT). Therefore, the dilution ratio for a maximum produced water rate has increased from 1:9 to 1:13, with the discharge depth changed from 10m to 26m below LAT.

### 2.2.2 EEMP Goal

- To validate predictions regarding water quality dispersion made in the 2006 Deep Panuke EA [EA predictions #1, 3, 4, 5, 6, 11 & 13 in **Table 3.1**].

### 2.2.3 Objectives

- Analyze key water quality parameters in seawater samples collected on the PFC (i.e. prior to mixing with cooling water and discharge to marine environment) and at several locations away from the Deep Panuke PFC; and
- Analyze key water quality parameters via conductivity, temperature and depth (CTD) in seawater samples collected at sites in the vicinity of the PFC.

### 2.2.4 Sampling

| | |
|---|---|
| Survey Date: | December 3, 2011 |
| Platform: | M/V Atlantic Condor |
| Type of Sample: | Water samples, Water column sampling |
| Test Sample Locations: | (see table below) |
| Number of Samples/Locations: | Tri-level seawater samples were collected from the surface, mid-water column and near-bottom depths at the PFC location; 250m, 500m, 1,000m and 2,000m from the PFC downstream along the tide direction at the time of sampling activities. Two stations upstream of the PFC were also collected at 250m and 2,000m. Water sampling locations are shown in **Figure 2.** |

Test Sample Locations:

| # | Station | Time UTC | Water Depth(m) | Easting | Northing |
|---|---|---|---|---|---|
| 1 | 2000m US | 13:45 | 50m | 684196 | 4854653 |
| 2 | 250m US | 17:00 | 52m | 685723 | 4853825 |
| 3 | PFC (20m) | 18:10 | 51m | 686000 | 4853691 |
| 4 | 250m DS | 17:35 | 50m | 686159 | 4853602 |
| 5 | 500m DS | 16:40 | 50m | 686362 | 4853281 |
| 6 | 1000m DS | 21:50 | 45m | 686419 | 4852776 |
| 7 | 2000m DS | 22:55 | 42m | 686003 | 4851668 |
| WGS84 UTM Zone 20N | | | | | |

<table>
<tr><td>Equipment:</td><td>Water column properties were collected via a single profile at each station via a multi-parameter CTD (RBR XR-620 Multi-channel Logger) which measured conductivity (salinity derived), temperature, pressure, pH and dissolved oxygen.<br><br>Physical water samples were collected with 5L Niskin bottles (at the surface, mid-water and near-bottom at each station. All three bottles were deployed in tandem via an onboard winch and crane at each station location from the starboard side of the ATLANTIC CONDOR. Logs are available in Appendix A.</td></tr>
<tr><td>Sample Preparation:</td><td>Each 5L Niskin was subsampled into the following for subsequent analysis:<br><table><tr><th>Parameter</th><th>Preservative</th></tr><tr><td>Organic acids</td><td>no preservative</td></tr><tr><td>Mercury</td><td>Potassium Dichromate</td></tr><tr><td>Metal scan and Sulphur</td><td>Nitric acid</td></tr><tr><td>BTEX/TPH</td><td>Sodium Bisulphate</td></tr><tr><td>BTEX/TPH - volatile</td><td>Sodium Bisulphate</td></tr><tr><td>Alkylated Phenols</td><td>no preservative</td></tr><tr><td>PAHs</td><td>no preservative</td></tr><tr><td>Nitrate/ortho-P/Total Nitrogen</td><td>no preservative</td></tr><tr><td>Sulphide</td><td>Zn Acetate + NaOH</td></tr><tr><td>Total P/Ammonia</td><td>Sulphuric Acid</td></tr></table></td></tr>
</table>

### 2.2.5 Analysis

Water samples collected were analyzed for parameters summarized in **Table 2.2**. 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). Nutrients were be determined by a variety of instruments including chromatographs, colorimeters, and spectrophotometers. DIC was measured on an Elemental Analyzer. DOC was measured with a carbon analyzer after high temperature catalytic oxidation.

Water samples were also analyzed for Total Petroleum Hydrocarbons (TPH) including Benzene, Toluene, Ethylbenzene, and Xylene(s) (BTEX), gasoline range organics (C6 to C10), and analysis of extractable hydrocarbons – fuel oil (>C10 to C16), fuel oil (>C16 to C21) and lube oil (>C21 to C32) range organics. BTEX and gasoline range organics were analyzed by purge and trap-gas chromatography/ mass spectrometry or headspace – gas chromatography (MS/flame ionization detectors). Extractible hydrocarbons, including diesel and lube range organics were analyzed using capillary column gas chromatography (flame ionization detector).

Alkylated Phenols were analyzed by AXYS Analytical Services Ltd. for Maxxam Analytics. AXYS method MLA-004 describes the determination of 4-n-octylphenol, nonylphenol and nonylphenol ethoxylates in aqueous samples, and in extracts from water sampling columns (XAD-2 columns). Concentrations in XAD-2 resin and filters are reported on a per sample basis or a per volume basis.

Sulphides in water were analyzed via the methylene blue method. Sulphide reacts with N-dimethyl-p-phenylenediamine oxalate under acidic conditions in the presence of ferric chloride to produce methylene chloride, a deep blue complex. The intensity of colour is proportional to the sulphide concentration. The sulphide may be in the form of S2-, HS- or $H_2S$. Temperature, salinity and DO affect the amount of $H_2S$ found in undissociated form. Sulphide $H_2S$ was determined using SM 4500-S2-F. To calculate $H_2S$, field pH, conductivity and temperature measurements recorded from the multiparameter CTD deployments at each station were used.

### *2.2.5.1 Parameters Analyzed*

**Table 2.2 - Water Quality Parameters Measured**

| Parameter | Units | RDL | CEQG Threshold | Analysis Method |
|---|---|---|---|---|
| **Nutrients** | | | | |
| Nitrate + Nitrite | $mg{\cdot}L^{-1}$ | 0.05 | N/A | chromatography |
| Nitrate (N) | $mg{\cdot}L^{-1}$ | 0.05 | 16000 | chromatography |
| Nitrite (N) | $mg{\cdot}L^{-1}$ | 0.01 | N/A | chromatography |
| Nitrogen (Ammonia) | $mg{\cdot}L^{-1}$ | 0.01 | 2.33 | colorimetry |
| Orthophosphate (P) | $mg{\cdot}L^{-1}$ | 0.01 | N/A | spectrophotometry |
| **Major Ions** | | | | |
| Phosphorus | $mg{\cdot}L^{-1}$ | 0.02 | N/A | AC |
| Sulphide | $mg{\cdot}L^{-1}$ | 0.02 | N/A | ISE |
| **Organic Acids** | | | | |
| Formic Acid | $mg{\cdot}L^{-1}$ | 0.50 | N/A | IC |
| Acetic Acid | $mg{\cdot}L^{-1}$ | 1 | N/A | IC |
| Propionic Acid | $mg{\cdot}L^{-1}$ | 1 | N/A | IC |
| Butyric Acid | $mg{\cdot}L^{-1}$ | 2 | N/A | IC |
| **Trace Metals** | | | | |
| Aluminum (Al) | $\mu g{\cdot}L^{-1}$ | 5 | N/A | ICP-MS |
| Antimony (Sb) | $\mu g{\cdot}L^{-1}$ | 1 | N/A | ICP-MS |
| Arsenic (As) | $\mu g{\cdot}L^{-1}$ | 1 | 12.5 | ICP-MS |
| Barium (Ba) | $\mu g{\cdot}L^{-1}$ | 1 | N/A | ICP-MS |
| Beryllium (Be) | $\mu g{\cdot}L^{-1}$ | 1 | N/A | ICP-MS |
| Bismuth (Bi) | $\mu g{\cdot}L^{-1}$ | 2 | N/A | ICP-MS |
| Boron (B) | $\mu g{\cdot}L^{-1}$ | 50 | N/A | ICP-MS |
| Cadmium (Cd) | $\mu g{\cdot}L^{-1}$ | 0.02 | 0.12 | ICP-MS |
| Calcium (Ca) | $\mu g{\cdot}L^{-1}$ | 100 | N/A | ICP-MS |
| Chromium (Cr) | $\mu g{\cdot}L^{-1}$ | 1 | Hex = 1.5, Tri = 54 | ICP-MS |
| Cobalt (Co) | $\mu g{\cdot}L^{-1}$ | 0.40 | N/A | ICP-MS |
| Copper (Cu) | $\mu g{\cdot}L^{-1}$ | 2 | N/A | ICP-MS |
| Iron (Fe) | $\mu g{\cdot}L^{-1}$ | 50 | N/A | ICP-MS |
| Lead (Pb) | $\mu g{\cdot}L^{-1}$ | 0.50 | N/A | ICP-MS |
| Magnesium (Mg) | $\mu g{\cdot}L^{-1}$ | 100 | N/A | ICP-MS |

| Parameter | Units | RDL | CEQG Threshold | Analysis Method |
|---|---|---|---|---|
| Manganese (Mn) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Mercury (Hg) | $\mu g \cdot L^{-1}$ | 0.01 | 0.016 | Cold Vapour AA |
| Molybdenum (Mo) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Nickel (Ni) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Potassium (K) | $\mu g \cdot L^{-1}$ | 100 | N/A | ICP-MS |
| Selenium (Se) | $\mu g \cdot L^{-1}$ | 1 | N/A | ICP-MS |
| Silver (Ag) | $\mu g \cdot L^{-1}$ | 0.10 | N/A | ICP-MS |
| Sodium (Na) | $\mu g \cdot L^{-1}$ | 100 | N/A | ICP-MS |
| Strontium (Sr) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Sulphur (S) | $\mu g \cdot L^{-1}$ | 5000 | N/A | ICP-MS |
| Thallium (Tl) | $\mu g \cdot L^{-1}$ | 0.10 | N/A | ICP-MS |
| Tin (Sn) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Titanium (Ti) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Uranium (U) | $\mu g \cdot L^{-1}$ | 0.10 | NRG | ICP-MS |
| Vanadium (V) | $\mu g \cdot L^{-1}$ | 2 | N/A | ICP-MS |
| Zinc (Zn) | $\mu g \cdot L^{-1}$ | 5 | N/A | ICP-MS |
| **PAH** | | | | |
| Naphthalene | $\mu g \cdot L^{-1}$ | 0.20 | 1.4 | GC/MS |
| Benzo(j)fluoranthene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Chrysene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Benzo(b)fluoranthene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Benzo(k)fluoranthene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Benzo(a)pyrene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Perylene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Acenaphthylene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Indeno(1,2,3-cd)pyrene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Dibenz(a,h)anthracene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Benzo(g,h,i)perylene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| 2-Methylnaphthalene | $\mu g \cdot L^{-1}$ | 0.05 | N/A | GC/MS |
| Acenaphthene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Fluorene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| 1-Methylnaphthalene | $\mu g \cdot L^{-1}$ | 0.05 | N/A | GC/MS |
| Benzo(a)anthracene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Phenanthrene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Anthracene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Fluoranthene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| Pyrene | $\mu g \cdot L^{-1}$ | 0.01 | N/A | GC/MS |
| **BTEX-TPH** | | | | |
| Benzene | $mg \cdot L^{-1}$ | 0.001 | 110 | PTGC |
| Toluene | $mg \cdot L^{-1}$ | 0.001 | 215 | PTGC |
| Ethylbenzene | $mg \cdot L^{-1}$ | 0.001 | 25 | PTGC |
| Xylene (Total) | $mg \cdot L^{-1}$ | 0.002 | N/A | PTGC |
| $C_6$ - $C_{10}$ (less BTEX) | $mg \cdot L^{-1}$ | 0.01 | N/A | PTGC |
| $>C_{10}$-$C_{16}$ Hydrocarbons | $mg \cdot L^{-1}$ | 0.05 | N/A | PTGC |
| $>C_{16}$-$C_{21}$ Hydrocarbons | $mg \cdot L^{-1}$ | 0.05 | N/A | PTGC |
| $>C_{21}$-$<C_{32}$ Hydrocarbons | $mg \cdot L^{-1}$ | 0.1 | N/A | PTGC |
| Modified TPH (Tier1) | $mg \cdot L^{-1}$ | 0.1 | N/A | PTGC |
| Reached Baseline at $C_{32}$ | $mg \cdot L^{-1}$ | N/A | N/A | PTGC |
| **Alkylated Phenols** | | | | |
| Nonylphenol (NP) | $ng \cdot L^{-1}$ | 10 | 0.7 | LRMS |
| 4-Nonylphenol monoethoxylate (NP1EO) | $ng \cdot L^{-1}$ | 50 | 0.7 | LRMS |
| 4-Nonylphenol diethoxylate (NP2EO) | $ng \cdot L^{-1}$ | 50 | 0.7 | LRMS |
| 4-n-Octylphenol (OP) | $ng \cdot L^{-1}$ | 50 | 0.7 | LRMS |
| **Field Measurements** | | | | |
| pH (field) | pH units | | 7.0-8.7 | Field meter |
| Temperature | °C | | N/A | Field meter |
| Dissolved oxygen | $mg \cdot L^{-1}$, % sat. | | 8 | Field meter |
| Salinity | ppt | | N/A | Field meter |

#### 2.2.5.2 *Analysis QA/QC*

- Metals in water: Method Blank, Spike Blank, CRM, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Mercury in water: Method Blank, Spike Blank, CRM, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- PAH: Method Blank, Blank Spike, Duplicate Sample, Matrix Spike: 1 per 20 samples, Surrogate for all samples.
- Ammonia in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- NOX/NO2/NO3 in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Ortho-Phos in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Total Phosphorous in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Organic acids in water: Continuous Calibration Blank, Continuous Calibration Verification, Matrix Spike, - minimum one each per batch, minimum frequency of 1 every 20 samples
- Sulphides in water: Blank Spike, Continuous Calibration Blank, Continuous Calibration Verification, Matrix Spike, - Minimum one each per batch, minimum frequency of 1 every 20 samples
- Alkylated Phenols in water: Blank Spike, Continuous Calibration Blank, OPR (On-going Precision and Recovery) Samples, Matrix Spike, - minimum one each per batch, minimum frequency of 1 every 20 samples

### 2.2.6 Results

- 2011 Maxxam Water Quality data is included in **Digital Appendix A;**
- 2011 CTD Data is presented in **Digital Appendix B** and **Figure 3** including: salinity, temperature and pH results;
- CEQG for marine water quality are included in **Appendix B;**
- Nutrients, major ions and organic acid results are shown below in **Table 2.3** with results below or slightly above laboratory RDL;

- Trace metals, hydrocarbons and alkylated phenol results are listed in **Table 2.4**, **Table 2.5** and **Table 2.6** respectively;
- Water column Boron, Calcium, Magnesium, Molybdenum, Potassium, Strontium, Sulphur and Uranium concentrations are near ocean mean levels;
- Barium was detected at Stations 1B and 2M (the two upstream stations) with a value of 13 µg/L and 70 µg/L, respectively;
- PAH, Total Hydrocarbons including BTEX-TPH and alkylated phenols are below laboratory RDL except for BTEX-TPH Toluene, which is slightly above the laboratory RDL of 0.001µg/L with a water quality guideline value of 215µg/L for the protection of aquatic marine life.

### 2.2.7 Summary and Conclusions

- This data set represents baseline levels measured prior to the PFC becoming operational;
- Metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines) where available. Therefore, there is negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of the ecosystem and the designated resource uses they support.

## Table 2.3 - Water Quality: Nutrients, Major Ions and Organic Acids

| Calculated Parameters (mg/L) | Station 1S | Station 2S | Station 3S | Station 4S | Station 5S | Station 6S | Station 7S |
|---|---|---|---|---|---|---|---|
| **Nutrients** | | | | | | | |
| Nitrate + Nitrite | ND | ND | ND | ND | ND | ND | ND |
| Nitrate (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrite (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrogen (Ammonia) | ND | 0.08 | 0.19 | 0.05 | 0.08 | ND | ND |
| Orthophosphate (P) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Major Ions** | | | | | | | |
| Phosphorus | ND | 0.02 | 0.02 | 0.02 | ND | ND | ND |
| Sulphide | ND | ND | ND | ND | ND | ND | ND |
| **Organic Acids** | | | | | | | |
| Formic Acid | ND | ND | ND | ND | ND | ND | ND |
| Acetic Acid | ND | ND | ND | ND | ND | ND | ND |
| Propionic Acid | ND | ND | ND | ND | ND | ND | ND |
| Butyric Acid | ND | ND | ND | ND | ND | ND | ND |
| **Calculated Parameters (mg/L)** | **Station 1M** | **Station 2M** | **Station 3M** | **Station 4M** | **Station 5M** | **Station 6M** | **Station 7M** |
| **Nutrients** | | | | | | | |
| Nitrate + Nitrite | ND | ND | ND | ND | ND | ND | ND |
| Nitrate (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrite (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrogen (Ammonia) | ND | 0.12 | ND | ND | ND | ND | 0.05 |
| Orthophosphate (P) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Major Ions** | | | | | | | |
| Phosphorus | ND | ND | 0.02 | 0.02 | ND | 0.02 | ND |
| Sulphide | ND | ND | ND | ND | ND | ND | ND |
| **Organic Acids** | | | | | | | |
| Formic Acid | ND | ND | ND | ND | ND | ND | ND |
| Acetic Acid | ND | ND | ND | ND | ND | ND | ND |
| Propionic Acid | ND | ND | ND | ND | ND | ND | ND |
| Butyric Acid | ND | ND | ND | ND | ND | ND | ND |
| **Calculated Parameters (mg/L)** | **Station 1B** | **Station 2B** | **Station 3B** | **Station 4B** | **Station 5B** | **Station 6B** | **Station 7B** |
| **Nutrients** | | | | | | | |
| Nitrate + Nitrite | ND | ND | ND | ND | ND | ND | ND |
| Nitrate (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrite (N) | ND | ND | ND | ND | ND | ND | ND |
| Nitrogen (Ammonia) | ND | 0.05 | 0.05 | 0.06 | ND | ND | ND |
| Orthophosphate (P) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Major ions** | | | | | | | |
| Phosphorus | ND | 0.02 | 0.02 | 0.02 | ND | 0.03 | ND |
| Sulphide | ND | ND | ND | ND | ND | ND | ND |
| **Organic Acids** | | | | | | | |
| Formic Acid | ND | ND | ND | ND | ND | ND | ND |
| Acetic Acid | ND | ND | ND | ND | ND | ND | ND |
| Propionic Acid | ND | ND | ND | ND | ND | ND | ND |
| Butyric Acid | ND | ND | ND | ND | ND | ND | ND |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.4 - Water Quality: Trace Metals

| Metals (µg/L) | Station 1S | Station 2S | Station 3S | Station 4S | Station 5S | Station 6S | Station 7S |
|---|---|---|---|---|---|---|---|
| **ICP/MS Method** | | | | | | | |
| Total Aluminum (Al) | ND | ND | ND | 318 | 105 | ND | ND |
| Total Antimony (Sb) | ND | ND | ND | ND | ND | ND | ND |
| Total Arsenic (As) | ND | ND | ND | ND | ND | ND | ND |
| Total Barium (Ba) | ND | ND | ND | ND | ND | ND | ND |
| Total Beryllium (Be) | ND | ND | ND | ND | ND | ND | ND |
| Total Bismuth (Bi) | ND | ND | ND | ND | ND | ND | ND |
| Total Boron (B) | 4410 | 4530 | 4670 | 4610 | 4510 | 4490 | 4530 |
| Total Cadmium (Cd) | ND | ND | ND | ND | ND | ND | ND |
| Total Calcium (Ca) | 363000 | 363000 | 375000 | 380000 | 372000 | 365000 | 371000 |
| Total Chromium (Cr) | ND | ND | ND | 39 | 151 | ND | ND |
| Total Cobalt (Co) | ND | ND | ND | ND | ND | ND | ND |
| Total Copper (Cu) | ND | ND | ND | ND | ND | ND | ND |
| Total Iron (Fe) | ND | ND | ND | ND | ND | ND | ND |
| Total Lead (Pb) | ND | ND | ND | ND | ND | ND | ND |
| Total Magnesium (Mg) | 1240000 | 1250000 | 1290000 | 1310000 | 1280000 | 1260000 | 1270000 |
| Total Manganese (Mn) | ND | ND | ND | ND | ND | ND | ND |
| Total Molybdenum (Mo) | ND | ND | ND | ND | ND | ND | ND |
| Total Nickel (Ni) | ND | ND | ND | ND | ND | ND | ND |
| Total Potassium (K) | 340000 | 342000 | 354000 | 352000 | 348000 | 340000 | 343000 |
| Total Selenium (Se) | ND | ND | ND | ND | ND | ND | ND |
| Total Silver (Ag) | ND | ND | ND | ND | ND | ND | ND |
| Total Sodium (Na) | 9560000 | 9660000 | 10100000 | 10100000 | 10100000 | 9520000 | 9720000 |
| Total Strontium (Sr) | 6860 | 6850 | 7110 | 7040 | 7020 | 6870 | 6840 |
| Total Sulphur (S) | 875000 | 893000 | 933000 | 921000 | 933000 | 877000 | 896000 |
| Total Thallium (Tl) | ND | ND | ND | ND | ND | ND | ND |
| Total Tin (Sn) | ND | ND | ND | ND | ND | ND | ND |
| Total Titanium (Ti) | ND | ND | ND | ND | ND | ND | ND |
| Total Uranium (U) | 3.0 | 2.8 | 3.1 | 3.3 | 2.7 | 3.0 | 2.7 |
| Total Vanadium (V) | ND | ND | ND | ND | ND | ND | ND |
| Total Zinc (Zn) | ND | ND | ND | ND | ND | ND | ND |
| **Cold Vapour AA Method** | | | | | | | |
| Total Mercury (Hg) | ND | ND | ND | ND | ND | ND | ND |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.4 – Water Quality: Trace Metals

| Metals (µg/L) | Station 1M | Station 2M | Station 3M | Station 4M | Station 5M | Station 6M | Station 7M |
|---|---|---|---|---|---|---|---|
| **ICP/MS Method** | | | | | | | |
| Total Aluminum (Al) | 66 | ND | ND | ND | ND | ND | ND |
| Total Antimony (Sb) | ND | ND | ND | ND | ND | ND | ND |
| Total Arsenic (As) | ND | ND | ND | ND | ND | ND | ND |
| Total Barium (Ba) | ND | 70 | ND | ND | ND | ND | ND |
| Total Beryllium (Be) | ND | ND | ND | ND | ND | ND | ND |
| Total Bismuth (Bi) | ND | ND | ND | ND | ND | ND | ND |
| Total Boron (B) | 4660 | 4750 | 4650 | 4710 | 4780 | 4790 | 4820 |
| Total Cadmium (Cd) | ND | ND | ND | ND | ND | ND | ND |
| Total Calcium (Ca) | 375000 | 382000 | 375000 | 386000 | 388000 | 385000 | 391000 |
| Total Chromium (Cr) | ND | 84 | 313 | ND | ND | ND | 38 |
| Total Cobalt (Co) | ND | ND | ND | ND | ND | ND | ND |
| Total Copper (Cu) | ND | ND | ND | ND | ND | ND | ND |
| Total Iron (Fe) | ND | ND | ND | ND | ND | ND | ND |
| Total Lead (Pb) | ND | ND | ND | ND | ND | ND | ND |
| Total Magnesium (Mg) | 1190000 | 1230000 | 1200000 | 1240000 | 1220000 | 1230000 | 1250000 |
| Total Manganese (Mn) | ND | ND | ND | ND | ND | ND | ND |
| Total Molybdenum (Mo) | ND | ND | ND | ND | ND | ND | ND |
| Total Nickel (Ni) | ND | ND | ND | ND | ND | ND | ND |
| Total Potassium (K) | 354000 | 358000 | 356000 | 363000 | 365000 | 361000 | 369000 |
| Total Selenium (Se) | ND | ND | ND | ND | ND | ND | ND |
| Total Silver (Ag) | ND | ND | ND | ND | ND | ND | ND |
| Total Sodium (Na) | 10100000 | 10300000 | 10200000 | 10500000 | 10500000 | 10400000 | 10700000 |
| Total Strontium (Sr) | 7020 | 7020 | 6900 | 7110 | 7220 | 7080 | 7230 |
| Total Sulphur (S) | 914000 | 959000 | 916000 | 941000 | 964000 | 956000 | 964000 |
| Total Thallium (Tl) | ND | ND | ND | ND | ND | ND | ND |
| Total Tin (Sn) | ND | ND | ND | ND | ND | ND | ND |
| Total Titanium (Ti) | ND | ND | ND | ND | ND | ND | ND |
| Total Uranium (U) | 3.1 | 2.8 | 2.7 | 3.0 | 3.1 | 3.0 | 2.9 |
| Total Vanadium (V) | ND | ND | ND | ND | ND | ND | ND |
| Total Zinc (Zn) | ND | ND | ND | ND | ND | ND | ND |
| **Cold Vapour AA Method** | | | | | | | |
| Total Mercury (Hg) | ND | ND | ND | ND | ND | ND | ND |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.4 – Water Quality: Trace Metals

| Metals (µg/L) | Station 1B | Station 2B | Station 3B | Station 4B | Station 5B | Station 6B | Station 7B |
|---|---|---|---|---|---|---|---|
| **ICP/MS Method** | | | | | | | |
| Total Aluminum (Al) | ND | ND | ND | ND | ND | ND | ND |
| Total Antimony (Sb) | ND | ND | ND | ND | ND | ND | ND |
| Total Arsenic (As) | ND | ND | ND | ND | ND | ND | ND |
| Total Barium (Ba) | 13 | ND | ND | ND | ND | ND | ND |
| Total Beryllium (Be) | ND | ND | ND | ND | ND | ND | ND |
| Total Bismuth (Bi) | ND | ND | ND | ND | ND | ND | ND |
| Total Boron (B) | 4760 | 4660 | 4810 | 4700 | 4700 | 4710 | 4690 |
| Total Cadmium (Cd) | ND | ND | ND | ND | ND | ND | ND |
| Total Calcium (Ca) | 387000 | 386000 | 389000 | 385000 | 382000 | 383000 | 378000 |
| Total Chromium (Cr) | 116 | 194 | 519 | ND | 538 | ND | ND |
| Total Cobalt (Co) | ND | ND | ND | ND | ND | ND | ND |
| Total Copper (Cu) | ND | ND | ND | ND | ND | ND | ND |
| Total Iron (Fe) | ND | ND | ND | ND | ND | ND | ND |
| Total Lead (Pb) | ND | ND | ND | ND | ND | ND | ND |
| Total Magnesium (Mg) | 1220000 | 1240000 | 1240000 | 1230000 | 1210000 | 1240000 | 1220000 |
| Total Manganese (Mn) | ND | ND | ND | ND | ND | ND | ND |
| Total Molybdenum (Mo) | ND | ND | ND | ND | ND | ND | ND |
| Total Nickel (Ni) | ND | ND | ND | ND | ND | ND | ND |
| Total Potassium (K) | 362000 | 363000 | 369000 | 361000 | 357000 | 362000 | 355000 |
| Total Selenium (Se) | ND | ND | ND | ND | ND | ND | ND |
| Total Silver (Ag) | ND | ND | ND | ND | ND | ND | ND |
| Total Sodium (Na) | 10500000 | 10300000 | 10600000 | 10500000 | 10300000 | 10400000 | 10300000 |
| Total Strontium (Sr) | 7100 | 6990 | 7190 | 7130 | 7010 | 7140 | 7040 |
| Total Sulphur (S) | 979000 | 966000 | 989000 | 969000 | 948000 | 960000 | 943000 |
| Total Thallium (Tl) | ND | ND | ND | ND | ND | ND | ND |
| Total Tin (Sn) | ND | ND | ND | ND | ND | ND | ND |
| Total Titanium (Ti) | ND | ND | ND | ND | ND | ND | ND |
| Total Uranium (U) | 3.2 | 2.8 | 2.9 | 2.9 | 2.9 | 2.8 | 2.6 |
| Total Vanadium (V) | ND | ND | ND | ND | ND | ND | ND |
| Total Zinc (Zn) | ND | ND | ND | ND | ND | ND | ND |
| **Cold Vapour AA Method** | | | | | | | |
| Total Mercury (Hg) | ND | ND | ND | ND | ND | ND | ND |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.5 - Water Quality: PAH and Petroleum Hydrocarbon Results

| Parameter | Station 1S | Station 2S | Station 3S | Station 4S | Station 5S | Station 6S | Station 7S |
|---|---|---|---|---|---|---|---|
| **Polyaromatic Hydrocarbons (µg/L)** | | | | | | | |
| 1-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| 2-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthylene | ND | ND | ND | ND | ND | ND | ND |
| Anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(b)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(g,h,i)perylene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(j)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(k)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Chrysene | ND | ND | ND | ND | ND | ND | ND |
| Dibenz(a,h)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Fluorene | ND | ND | ND | ND | ND | ND | ND |
| Indeno(1,2,3-cd)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Naphthalene | ND | ND | ND | ND | ND | ND | ND |
| Perylene | ND | ND | ND | ND | ND | ND | ND |
| Phenanthrene | ND | ND | ND | ND | ND | ND | ND |
| Pyrene | ND | ND | ND | ND | ND | ND | ND |
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | | | |
| Benzene | ND | 0.001 | ND | 0.001 | ND | ND | ND |
| Toluene | 0.004 | 0.001 | 0.023 | 0.001 | 0.016 | 0.005 | 0.016 |
| Ethylbenzene | ND | 0.001 | ND | 0.001 | ND | ND | ND |
| Xylene (Total) | ND | 0.002 | ND | 0.003 | ND | ND | ND |
| C6 - C10 (less BTEX) | ND | 0.01 | ND | 0.01 | ND | ND | ND |
| >C10-C16 Hydrocarbons | ND | 0.05 | ND | 0.05 | ND | ND | ND |
| >C16-C21 Hydrocarbons | ND | 0.05 | ND | 0.05 | ND | ND | ND |
| >C21-<C32 Hydrocarbons | ND | 0.1 | ND | 0.1 | ND | ND | ND |
| Modified TPH (Tier1) | ND | 0.1 | ND | 0.1 | ND | ND | ND |
| Reached Baseline at C32 | NA | N/A | NA | N/A | NA | NA | NA |
| Hydrocarbon Resemblance | NA | N/A | NA | N/A | NA | NA | NA |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.5 - Water Quality: PAH Polyaromatic Hydrocarbon Results

| Parameter | Station 1M | Station 2M | Station 3M | Station 4M | Station 5M | Station 6M | Station 7M |
|---|---|---|---|---|---|---|---|
| **Polyaromatic Hydrocarbons (µg/L)** | | | | | | | |
| 1-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| 2-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthylene | ND | ND | ND | ND | ND | ND | ND |
| Anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(b)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(g,h,i)perylene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(j)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(k)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Chrysene | ND | ND | ND | ND | ND | ND | ND |
| Dibenz(a,h)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Fluorene | ND | ND | ND | ND | ND | ND | ND |
| Indeno(1,2,3-cd)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Naphthalene | ND | ND | ND | ND | ND | ND | ND |
| Perylene | ND | ND | ND | ND | ND | ND | ND |
| Phenanthrene | ND | ND | ND | ND | ND | ND | ND |
| Pyrene | ND | ND | ND | ND | ND | ND | ND |
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | | | |
| Benzene | ND | ND | ND | ND | ND | ND | ND |
| Toluene | 0.009 | 0.021 | 0.018 | 0.009 | 0.040 | 0.004 | 0.038 |
| Ethylbenzene | ND | ND | ND | ND | ND | ND | ND |
| Xylene (Total) | ND | ND | ND | ND | ND | ND | ND |
| C6 - C10 (less BTEX) | ND | ND | ND | ND | ND | ND | 0.01 |
| >C10-C16 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| >C16-C21 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| >C21-<C32 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| Modified TPH (Tier1) | ND | ND | ND | ND | ND | ND | ND |
| Reached Baseline at C32 | NA | NA | NA | NA | NA | NA | NA |
| Hydrocarbon Resemblance | NA | NA | NA | NA | NA | NA | NA |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.5 - Water Quality: PAH Polyaromatic Hydrocarbon Results

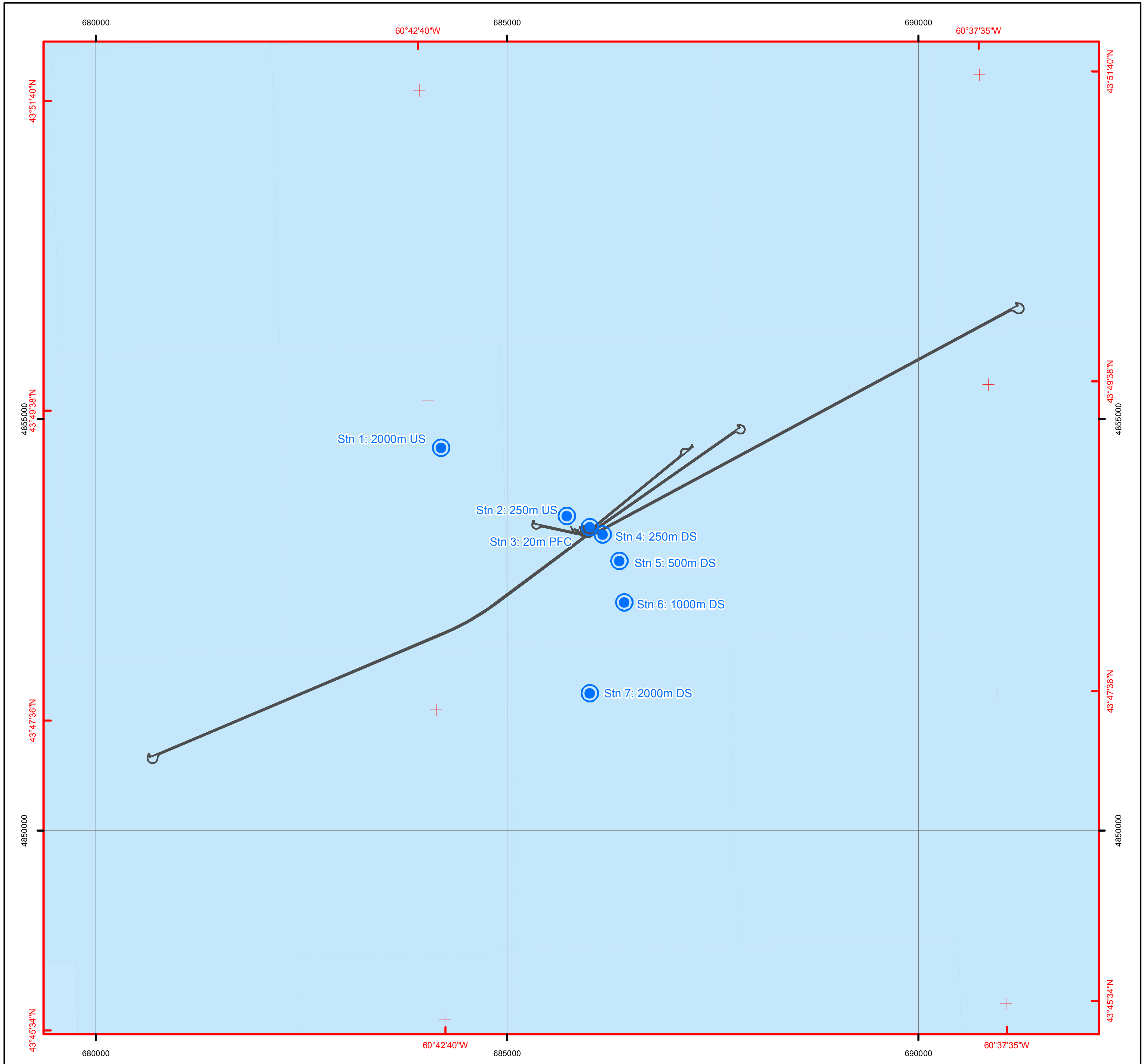
| Parameter | Station 1B | Station 2B | Station 3B | Station 4B | Station 5B | Station 6B | Station 7B |
|---|---|---|---|---|---|---|---|
| **Polyaromatic Hydrocarbons (µg/L)** | | | | | | | |
| 1-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| 2-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthene | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthylene | ND | ND | ND | ND | ND | ND | ND |
| Anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(b)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(g,h,i)perylene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(j)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Benzo(k)fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Chrysene | ND | ND | ND | ND | ND | ND | ND |
| Dibenz(a,h)anthracene | ND | ND | ND | ND | ND | ND | ND |
| Fluoranthene | ND | ND | ND | ND | ND | ND | ND |
| Fluorene | ND | ND | ND | ND | ND | ND | ND |
| Indeno(1,2,3-cd)pyrene | ND | ND | ND | ND | ND | ND | ND |
| Naphthalene | ND | ND | ND | ND | ND | ND | ND |
| Perylene | ND | ND | ND | ND | ND | ND | ND |
| Phenanthrene | ND | ND | ND | ND | ND | ND | ND |
| Pyrene | ND | ND | ND | ND | ND | ND | ND |
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | | | |
| Benzene | ND | ND | ND | ND | ND | ND | ND |
| Toluene | 0.014 | 0.013 | 0.003 | 0.002 | 0.024 | 0.009 | 0.012 |
| Ethylbenzene | ND | ND | ND | ND | ND | ND | ND |
| Xylene (Total) | ND | ND | ND | ND | ND | ND | ND |
| C6 - C10 (less BTEX) | 0.01 | ND | ND | ND | ND | ND | ND |
| >C10-C16 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| >C16-C21 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| >C21-<C32 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND |
| Modified TPH (Tier1) | ND | ND | ND | ND | ND | ND | ND |
| Reached Baseline at C32 | NA | NA | NA | NA | NA | NA | NA |
| Hydrocarbon Resemblance | NA | NA | NA | NA | NA | NA | NA |

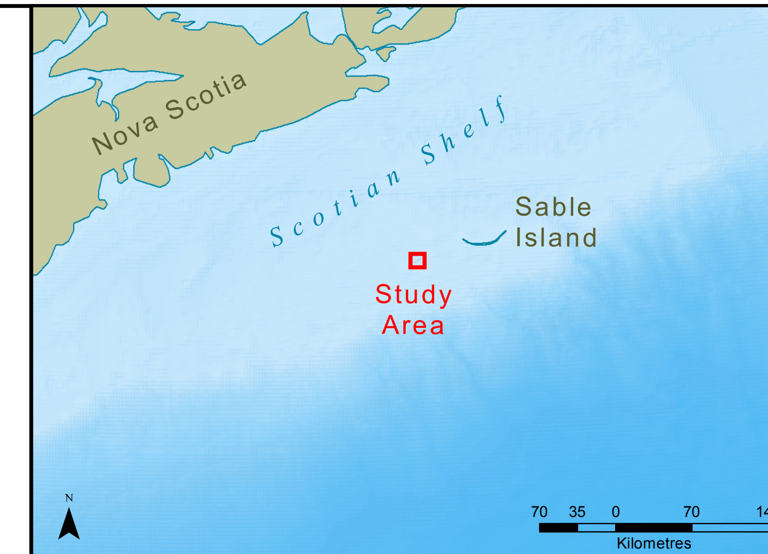
S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

## Table 2.6 - Water Quality: Alkylated Phenol Results

| Alkylated Phenols | Units | Station 1S | Station 2S | Station 3S | Station 4S | Station 5S | Station 6S | Station 7S |
|---|---|---|---|---|---|---|---|---|
| 4-Nonylphenols | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol monoethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol diethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| Octylphenol | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 13C6-4-n-Nonylphenol | % Recovery | 95 | 97.3 | 93 | 94.8 | 90.1 | 86.4 | 92.1 |
| 13C6-NP2EO | % Recovery | 106 | 107 | 103 | 32.3 | 96.2 | 97.3 | 91.2 |
| **Alkylated Phenols** | **Units** | **Station 1M** | **Station 2M** | **Station 3M** | **Station 4M** | **Station 5M** | **Station 6M** | **Station 7M** |
| 4-Nonylphenols | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol monoethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol diethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| Octylphenol | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 13C6-4-n-Nonylphenol | % Recovery | 93.4 | 88.1 | 86.4 | 67.4 | 58.7 | 49.5 | 51.9 |
| 13C6-NP2EO | % Recovery | 100 | 95.2 | 91.4 | 56.8 | 65.2 | 49 | 65 |
| **Alkylated Phenols** | **Units** | **Station 1B** | **Station 2B** | **Station 3B** | **Station 4B** | **Station 5B** | **Station 6B** | **Station 7B** |
| 4-Nonylphenols | ng/L | ND | ND | ND | ND | ND | ND | 5.35 |
| 4-Nonylphenol monoethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol diethoxylates | ng/L | ND | ND | ND | ND | ND | ND | ND |
| Octylphenol | ng/L | ND | ND | ND | ND | ND | ND | ND |
| 13C6-4-n-Nonylphenol | % Recovery | 28.7 | 41.9 | 50.2 | 52.2 | 34.9 | 47 | 46.5 |
| 13C6-NP2EO | % Recovery | 53.3 | 67.5 | 56.3 | 54.2 | 50.7 | 40.9 | 49.1 |

S – Surface , M – Mid-Depth, B – Benthic Depth, ND – Not detectable

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Projection: Transverse Mercator
Datum: WGS 1984
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 0.5 1 2 3 4
Kilometers

Water Sample
Deep Panuke sub-sea structures

*Note:*
*Map scale 1:50,000 when printed on 11x17 size paper*

encana natural gas — Encana

**Water Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

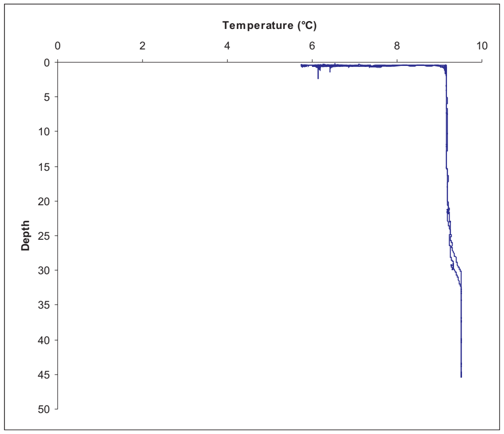
McGregor GeoScience Limited — McGregor GeoScience Ltd.
Bedford, Nova Scotia, Canada

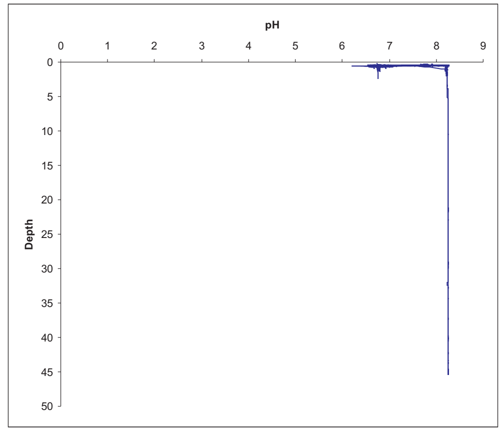
Date Saved: 26/03/2012 4:00:50 PM

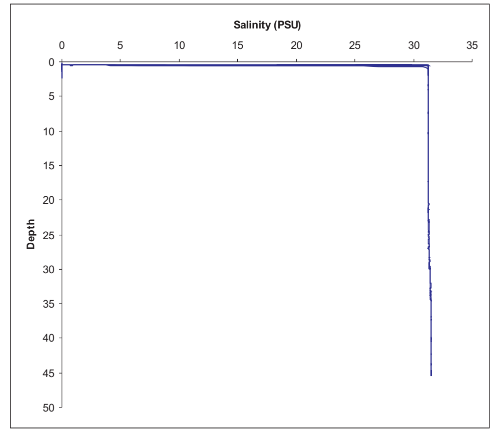
McGregor Project No.: 1113

**Figure: 2**

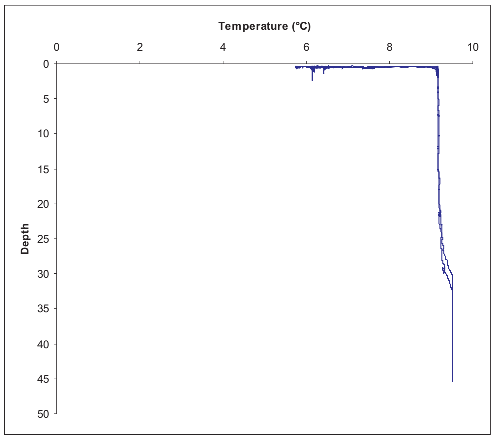
Filename: ENCANA_Location_water

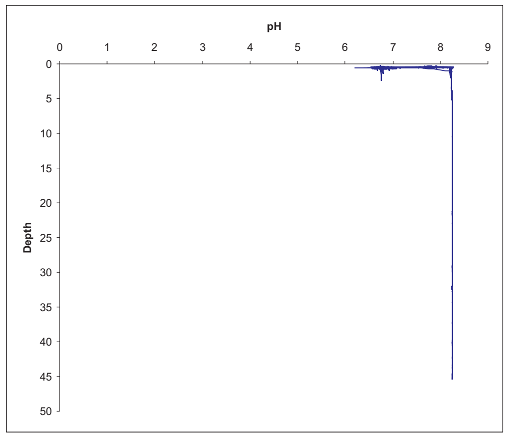


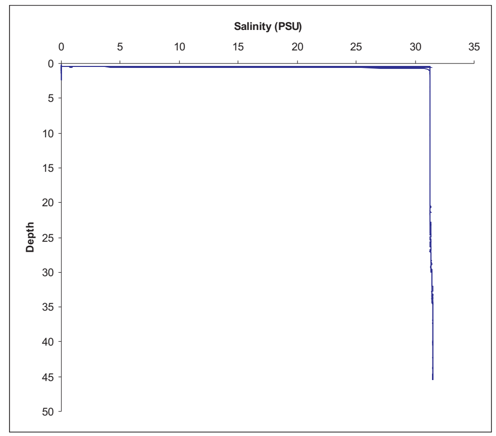




Water Sampling Station 1



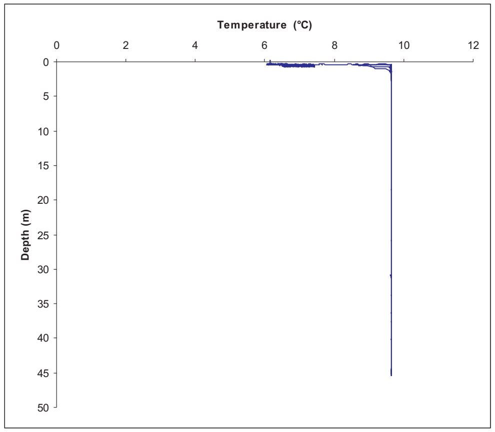



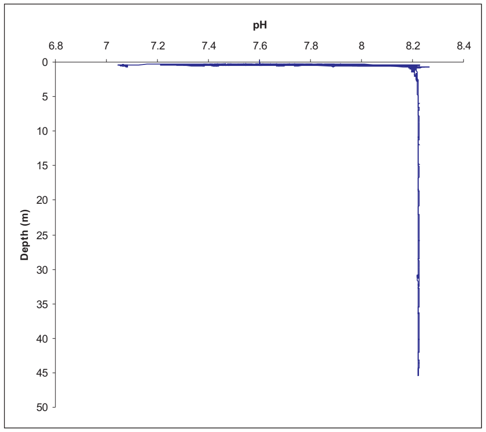



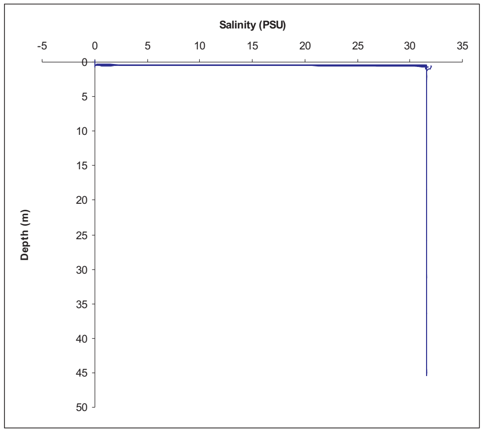

Water Sampling Station 2

McGregor GeoScience Limited

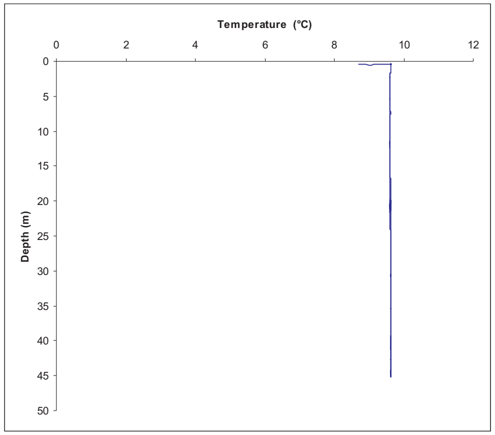
Figure 3 Salinity, temperature and pH results measured using CTD

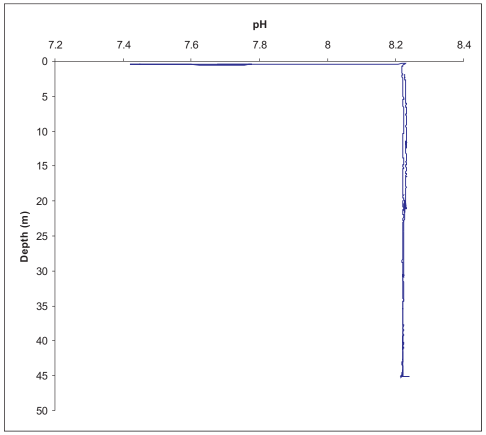


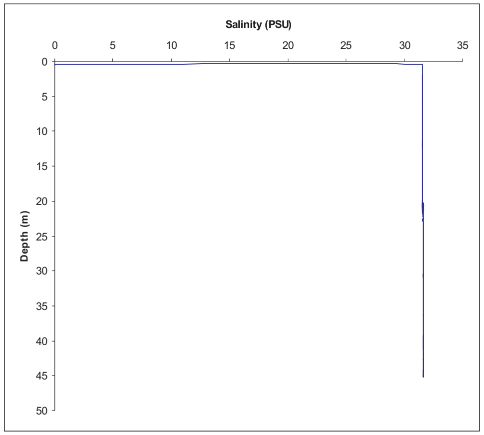




Water Sampling Station 3



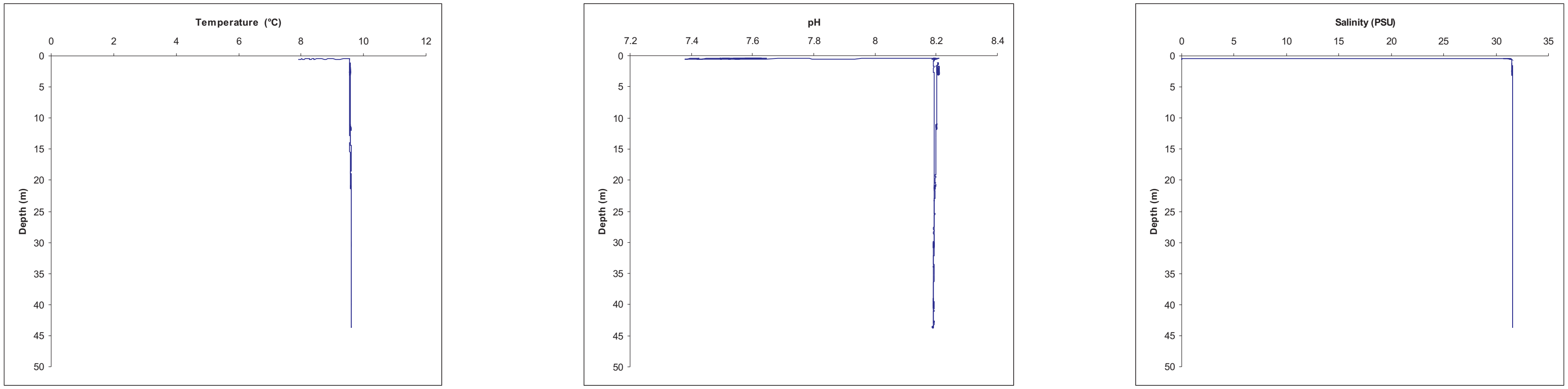



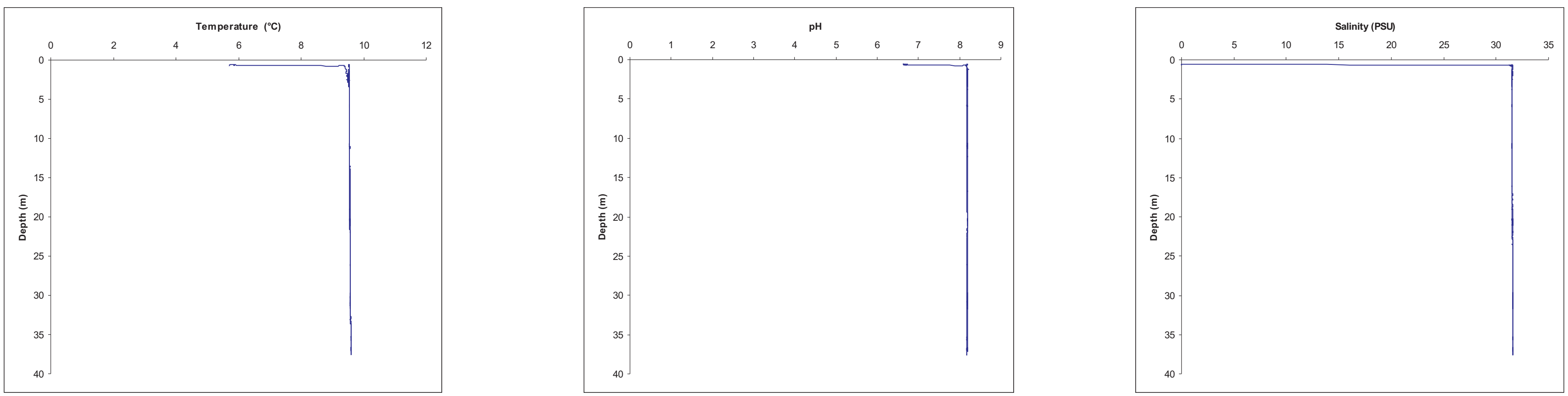

Water Sampling Station 4

McGregor GeoScience Limited

Figure 3 Salinity, temperature and pH results measured using CTD




Water Sampling Station 5




Water Sampling Station 6

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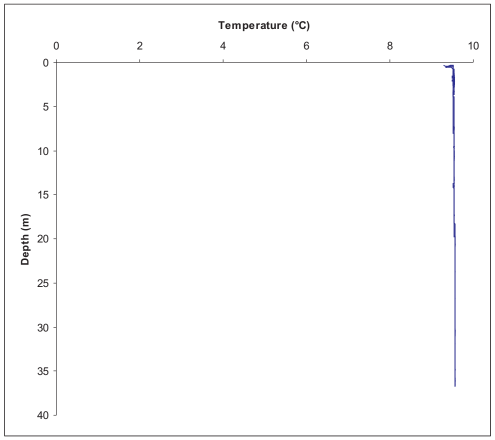
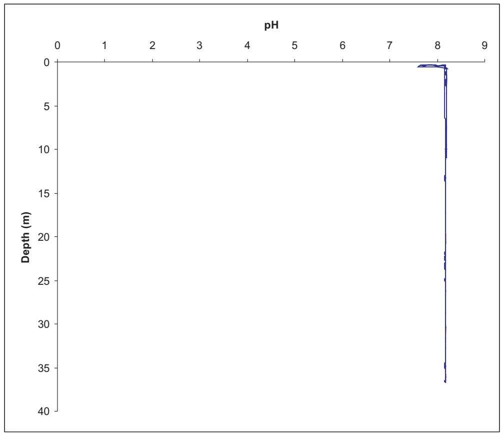
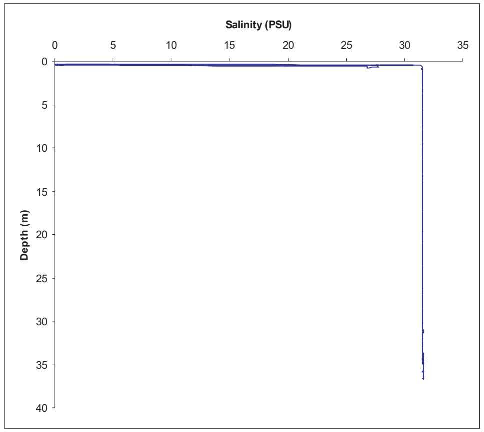
GeoScience
Limited

Figure 3 Salinity, temperature and pH results measured using CTD




Water Sampling Station 7

McGregor GeoScience Limited

Figure 3 Salinity, temperature and pH results measured using CTD

## 2.3 SEDIMENT CHEMISTRY

### 2.3.1 Background

Chemical contamination of sediments in the vicinity of offshore gas platforms can be the result of discharges of mud/cuttings during drilling and completion, produced water during production operations and/or accidental releases (i.e., spills). While effects are anticipated to be very localized, such contamination can be potentially toxic especially to bottom-dwelling fauna. Bioassay analysis using a suitable indicator species is a useful technique for evaluation of the toxicology of sediments collected at various distances from the source of contamination.

Analytical parameters for sediment chemistry initially used in the SOEP EEM program were the following: full metal (24 parameters) scan, grain size analysis, C6-C32 hydrocarbon scan, benzene, ethylbenzene, toluene, xylene, polycyclic aromatic hydrocarbons, organic and inorganic carbon, ammonia and sulphide. With the exception of barium and TPH concentrations in the near-field area (within 1,000m of a discharge site) along the direction of the prevailing current, all other parameters showed no significant differences from levels measured during baseline surveys and from other near-field and far-field reference stations. Consequently, the number of stations and parameters for recent sediment samples taken for the SOEP EEM program was first reduced to three near-field stations (at 250m, 500m and 1,000m) downstream of the main production platform at Thebaud and a few key parameters and finally discontinued from the program because of non-detectable/background levels for measured parameters.

A variety of laboratory-based sediment toxicity bioassays were originally used in the SOEP EEM program to evaluate potential lethal and sublethal effects on organisms representing several different trophic levels - amphipod (*Rhepoxynius abronius*) survival, echinoderm (*Lytechinus pictus*) fertilization and bacterial luminescence of Vibrio fischeri (Microtox). Within a relatively short period (two to three years of sampling), the echinoderm fertilization and Microtox tests were discontinued as the results did not correlate with trends in sediment chemistry results. However, the marine amphipod survival test has proved to be the most reliable indicator of sediment contamination and continues to be a valuable monitoring parameter in the SOEP EEM program.

At the Deep Panuke site, produced water and hydrocarbon spills are the only potential sources of TPH in sediments since only WBM was used during drilling and completion activities. While barium was a component of WBM used to drill the production wells in 2000 (M-79A and H-08) and 2003 (F-70 and D-41), it was not a component of WBM used for the 2010 drilling and completion program (drilling of the new E-70 disposal well and recompletion of the four production wells), which instead used brine as a weighting agent.

The 2008 Baseline Benthic Study provided comparative data on sediment quality for the 2011 EEM program. Results from the 2008 Baseline Benthic Study indicated that the concentrations of metals in offshore sediments collected at the Deep Panuke site (pipeline route and PFC area) in 2008 (before the 2010 drilling and completion program but post drilling of the four production wells) were within background ranges found in other offshore studies on Scotian Shelf sediments (in particular, mercury levels were non-detectable).

### 2.3.2 EEMP Goal

To validate predictions re sediment toxicity made in the 2006 Deep Panuke EA [EA predictions #1, 2, 3, 4, 5, 6, 7 & 8 in **Table 3.1**].

### 2.3.3 Objectives

- Determine the dispersion of key drilling and production chemical parameters at drill sites and production site;

### 2.3.4 Sampling

| | |
|---|---|
| Survey Date: | December 4, 2011 |
| Platform: | M/V Atlantic Condor |
| Type of Sample: | Sediment Physico-Chemistry |

Test Sample Locations – Field Stations:

| Station | Time UTC | Water Depth(m) | Easting | Northing |
|---|---|---|---|---|
| D-41 | 10:02 | 48 | 691139 | 4856457 |
| F-70 | 10:48 | 49 | 687804 | 4854991 |
| E-70 | 11:15 | 47 | 687304 | 4854714 |
| M-79A | 12:36 | 49 | 685249 | 4853759 |
| 250m DS | 13:02 | 40 | 685735 | 4853499 |
| 500m DS | 13:30 | 50 | 685649 | 4853245 |
| 1000m DS | 14:12 | 48 | 685223 | 4852944 |
| 2000m DS | 14:52 | 45 | 684492 | 4852266 |
| H-08 | 15:24 | 42 | 680692 | 4850974 |
| WGS84 UTM Zone 20N | | | | |

Test Sample Locations – Reference Stations:

| Station: | Time UTC | Water Depth(m) | Easting | Northing |
|---|---|---|---|---|
| 5000m US NE | 09:12 | 42 | 689477 | 4857176 |
| 5000m DS SW | 16:15 | 42 | 682340 | 4850141 |
| WGS84 UTM Zone 20N | | | | |

Number of Samples/Locations:

Sediment samples were collected from the seafloor surface from 11 stations both upstream and downstream from the PFC. For safety reasons the 2011 sampling stations were located outside the 50m buffer zone - away from seafloor infrastructure. In subsequent years of sampling during operations phase, the 250m station will be the closest one to facility locations for safety reasons as per SOEP sampling program. Sediment sampling locations are available in **Figure 4a** through **4i**. Logs are available in **Appendix A**.

Field stations:

- 250m downstream of PFC (2008 station #12);
- 500m downstream of PFC (2008 station #13);
- 1,000m downstream of PFC (2008 station #14);
- 2,000m downstream of PFC (not surveyed in 2008);
- M-79A (2008 station #15);
- E-70 (2008 station #16);
- F-70 (2008 station #17);
- D-41 (2008 station #18); and
- H-08 (2008 station #19).

Reference stations:

- 5,000m upstream (NE) of the PFC area
- 5,000m downstream (SW, towards the Haddock Box) of the PFC area

| | |
|---|---|
| Equipment: | A stainless steel van Veen grab was deployed as the ATLANTIC CONDOR held position via dynamic positioning (DP). The onboard winch and crane were used to deploy the van Veen over the starboard side of the vessel at each sample location to capture physical samples of the surficial sediments.<br><br>Following touchdown the van Veen grab was raised to the surface and recovered via crane onboard the vessel. Retrieved samples were visually inspected, digitally photographed (**Appendix A**, fully described and sub-sampled and logged. |
| Sample Preparation: | Samples were collected and subsampled into the following for subsequent analysis:<br><br><table><tr><th>Parameter</th><th>Preservative</th></tr><tr><td>PSA and TOC</td><td>no preservative</td></tr><tr><td>Metal scan (incl. Hg)</td><td>no preservative</td></tr><tr><td>BTEX/TPH/PAHs</td><td>no preservative</td></tr><tr><td>Sulphide</td><td>Zinc Acetate</td></tr></table> |

### 2.3.5 Analysis

Maxxam Analytics undertook analysis of the physico-chemical composition of sediment samples. Parameters analyzed in sediment samples are listed in **Table 2.7**, including analysis methods and reportable detection limits. Major ions were determined by inductively coupled atomic photometry (ICAP). Metals were determined via Atomic Emission Spectrometry (ICP-AES). Following analysis, metal/Al ratios were calculated for comparison of concentrations across the stations and with previous studies in order to compensate for the effects of sediment grain size characteristics on metal concentrations (i.e. to specifically address footnote #40 in EEMP in connection to Ba/Al ratio – see **Table 2.9**). Gas range hydrocarbons were determined by P/T mass spectrophotometry (P/T MS) and diesel range hydrocarbons by gas chromatography (GC/MS or headspace-GC-PID/FID) – see **Table 2.10**. Total Organic Carbon (TOC) was determined using LECO furnace methods – see **Table 2.11**. Moisture, as %, was determined by the difference between the wet and dry weight of a sample.

Sediment samples were also analyzed for Total Petroleum Hydrocarbons (TPH) including Benzene, Toluene, Ethylbenzene, and Xylene(s) (BTEX), gasoline range organics (C6 to C10), and analysis of extractable hydrocarbons - diesel (>C10 to C16), diesel (>C16 to C21) and lube (>C21 to C32) 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) – see **Table 2.10**. Samples were also analyzed for Alkylated phenols (APs) – see **Table 2.11**. AXYS method MLA-004 describes the determination of 4-n-octylphenol, nonylphenol and nonylphenol ethoxylates (mono- and di-) in solids (sediment, soil, biosolids).

Physical characteristics of sediment samples were analyzed by classifying the proportion (%) of sample based on the Wentworth (1922) substrate scale, as well as a detailed Particle Size Analysis (PSA) of the silt/clay fraction. To determine the proportion of sample as gravel, sand, silt and clay, organic matter and carbonates were destroyed by treating the sample with hydrogen peroxide.

Sediment samples were dispatched for acute toxicity testing by Harris Industrial testing Services (subcontractor). A single concentration amphipod test as per reference method EPS1/RM/35 December 1998 was undertaken using sediment samples from each of the 11 stations.

Single concentration tests using the amphipod *Eohaustorius estuarius* were undertaken instead of using the amphipod *Rhepoxynius abronius* due to the availability of this test species (following personal communication with G. Harris of Harris Industrial Testing.) All tests were conducted to the methods, guidelines and procedures outlined in Environment Canada document EPS1/RM/35 December 1998. Survival of replicate samples from each sampling station after a 10 day period were compared against survival of organisms exposed to control (clean) sediments.

### 2.3.5.1 Parameters Analyzed

**Table 2.7 - Sediment Quality Parameters Measured**

| Parameter | Units | RDL | Analysis Method |
|---|---|---|---|
| **Trace Elements** | | | |
| Aluminum (Al) | $mg \cdot kg^{-1}$ | 10 | ICP-AES |
| Antimony (Sb) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Arsenic (As) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Barium (Ba) | $mg \cdot kg^{-1}$ | 5 | ICP-AES |
| Beryllium (Be) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Bismuth (Bi) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Boron (B) | $mg \cdot kg^{-1}$ | 5 | ICP-AES |
| Cadmium (Cd) | $mg \cdot kg^{-1}$ | 0.30 | ICP-AES |
| Chromium (Cr) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Cobalt (Co) | $mg \cdot kg^{-1}$ | 1 | ICP-AES |
| Copper (Cu) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Iron (Fe) | $mg \cdot kg^{-1}$ | 50 | ICP-AES |
| Lead (Pb) | $mg \cdot kg^{-1}$ | 0.50 | CVAA |
| Lithium (Li) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Manganese (Mn) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Mercury (Hg) | $mg \cdot kg^{-1}$ | 0.10 | ICP-AES |
| Molybdenum (Mo) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Nickel (Ni) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Rubidium (Rb) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Selenium (Se) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Silver (Ag) | $mg \cdot kg^{-1}$ | 0.50 | ICP-AES |
| Strontium (Sr) | $mg \cdot kg^{-1}$ | 5 | ICP-AES |
| Thallium (Tl) | $mg \cdot kg^{-1}$ | 0.10 | ICP-AES |
| Tin (Sn) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Uranium (U) | $mg \cdot kg^{-1}$ | 0.10 | ICP-AES |
| Vanadium (V) | $mg \cdot kg^{-1}$ | 2 | ICP-AES |
| Zinc (Zn) | $mg \cdot kg^{-1}$ | 5 | ICP-AES |
| **PAH** | | | |
| Naphthalene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(j)fluoranthene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Chrysene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(b)fluoranthene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(k)fluoranthene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(a)pyrene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Perylene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Acenaphthylene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Indeno(1,2,3-cd)pyrene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Dibenz(a,h)anthracene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(g,h,i)perylene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| 2-Methylnaphthalene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Acenaphthene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Fluorene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| 1-Methylnaphthalene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Benzo(a)anthracene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Phenanthrene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Anthracene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Fluoranthene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| Pyrene | $mg \cdot kg^{-1}$ | 0.01 | GC/MS |
| **BTEX-TPH** | | | |
| Benzene | $mg \cdot kg^{-1}$ | 0.03 | PTGC |
| Toluene | $mg \cdot kg^{-1}$ | 0.03 | PTGC |
| Ethylbenzene | $mg \cdot kg^{-1}$ | 0.03 | PTGC |

| Parameter | Units | RDL | Analysis Method |
|---|---|---|---|
| Xylene (Total) | $mg \cdot kg^{-1}$ | 0.05 | PTGC |
| C6 - C10 (less BTEX) | $mg \cdot kg^{-1}$ | 2.50 | PTGC |
| >C10-C16 Hydrocarbons | $mg \cdot kg^{-1}$ | 10 | PTGC |
| >C16-C21 Hydrocarbons | $mg \cdot kg^{-1}$ | 10 | PTGC |
| >C21-<C32 Hydrocarbons | $mg \cdot kg^{-1}$ | 15 | PTGC |
| Reached Baseline at C32 | $mg \cdot kg^{-1}$ | 0 | PTGC |
| Modified TPH (Tier1) | $mg \cdot kg^{-1}$ | 20 | PTGC |
| **Sulphide** | ug/g | 0.02 | ISE |
| **Alkylated Phenols** | | | |
| Nonylphenol (NP) | $ng \cdot L^{-1}$ | 5 | LRMS |
| 4-Nonylphenol monoethoxylate (NP1EO) | $ng \cdot L^{-1}$ | 25 | LRMS |
| 4-Nonylphenol diethoxylate (NP2EO) | $ng \cdot L^{-1}$ | 25 | LRMS |
| 4-n-Octylphenol (OP) | $ng \cdot L^{-1}$ | 25 | LRMS |
| **Physical Measures** | | | |
| Particle Size | %, Phi | 0.1 | Sieves, hydrometer |
| Total Organic Carbon (TOC) | $g \cdot kg^{-1}$ | 2 | LECO furnace |
| Moisture | % | 0.1 | Wet and dry weights |

### *2.3.5.2 Analysis QA/QC*

- Particle Size: Sample Duplicate, Minimum frequency of 1 every 20 samples
- Metals in soil: Method Blank, Spike Blank, CRM, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- BTEX-TPH in soil: Method Blank, Blank Spike, Duplicate Sample, Matrix Spike 1 per 20 samples, Surrogate for all samples. C10-C32 – Method Blank, Blank Spike, Duplicate Sample, Matrix Spike – Surrogate for all samples.
- PAH: Method Blank, Blank Spike, Duplicate Sample, Matrix Spike: 1 per 20 samples, Surrogate for all samples.
- Sulphide in soil: Method Blank (MB): 2 per 20 samples, Matrix (Sample) Duplicates (SD): 1 per 20 samples, Matrix (Sample) Spikes (SS): 1 per 20 samples, Method (Blank) Spikes (MS): 1 per 20 samples
- Alkylated Phenols: Method Blank (MB): 1 per 20 samples, On-going Precision and Recovery (OPR) Samples – spiked reference matrix (SPM) analyzed with each batch.
- TOC in soil: Method Blank, CRM, Sample Duplicate - minimum one each per batch, minimum frequency of 1 every 20 samples

### 2.3.6 Results

- Sediment quality results including particle size analysis, metals, PAH and petroleum hydrocarbons, sulphides, alkylated phenols and total organic carbon results are presented in **Table 2.8** through **Table 2.13**, respectively, and in **Digital Appendix A**;
- CEQG for sediment quality are included in **Appendix B;**
- The sediment type at all stations ranged from fine to medium sand
- Sediment quality has remained at 2008 levels or has improved at all the field stations: D-41, F-70, E-70, M-79A, H-08, 250m DS, 500m DS and 1000m DS (2000m DS was not sampled in 2008). Aluminum levels in 2008 were much higher at all stations than in 2011;
- Arsenic was found to be below laboratory RDL at all 2011 benthic stations;
- TPH and Barium are below laboratory RDL at all 2011 benthic stations;
- Mercury concentrations remain below laboratory RDL for all benthic stations;
- PAH, BTEX-TPH and Alkylated Phenol's remain below laboratory RDL for all benthic stations;
- Sulphide levels are slightly above laboratory RDL for all benthic stations excluding H08 and F70, where results were below laboratory RDL;
- TOC concentrations remain low at approximately the same levels as the 2008 survey.

### 2.3.7 Summary and Conclusions

- Metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines) where available. Therefore, there is negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of the ecosystem and the designated resource uses they support.

## Table 2.8 - Sediment Quality: Particle Size Analysis Results

| Parameter | 5000 US (NE ) | D41 | F70 | E70 | M79A | 500 DS | 1000DS | 2000DS | H08 | 5000 DS (SW) | 250 DS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture (g/kg) | 15 | 18 | 17 | 18 | 16 | 15 | 14 | 14 | 15 | 17 | 18 |
| < -4 Phi (16 mm) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| < -3 Phi (8 mm) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| < -2 Phi (4 mm) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| < -1 Phi (2 mm) | 100 | 100 | 100 ( 1 ) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 ( 2 ) |
| < 0 Phi (1 mm) | 100 | 100 | 100 | 99 | 100 | 100 | 100 | 100 | 99 | 100 | 99 |
| < +1 Phi (0.5 mm) | 95 | 99 | 99 | 98 | 93 | 90 | 93 | 96 | 84 | 94 | 98 |
| < +2 Phi (0.25 mm) | 19 | 80 | 65 | 78 | 18 | 30 | 25 | 26 | 5.5 | 13 | 75 |
| < +3 Phi (0.12 mm) | 1.3 | 3.8 | 1.9 | 3.1 | 1.5 | 1.4 | 1.2 | 1.1 | 1.0 | 1.1 | 4.2 |
| < +4 Phi (0.062 mm) | 0.9 | 1.1 | 1.1 | 1.2 | 1.1 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.2 |
| < +5 Phi (0.031 mm) | 0.9 | 1.1 | 1.1 | 1.2 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 1.3 |
| < +6 Phi (0.016 mm) | 0.9 | 1.2 | 1.1 | 1.2 | 1.0 | 0.8 | 0.8 | 0.9 | 1.1 | 0.9 | 1.2 |
| < +7 Phi (0.0078 mm) | 0.9 | 1.1 | 1.1 | 1.2 | 1.0 | 0.8 | 0.8 | 0.9 | 1.0 | 0.9 | 1.5 |
| < +8 Phi (0.0039 mm) | 0.9 | 1.0 | 1.2 | 1.3 | 1.0 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 1.2 |
| < +9 Phi (0.0020 mm) | 0.9 | 1.0 | 1.0 | 1.1 | 1.0 | 0.9 | 0.8 | 1.1 | 0.9 | 0.9 | 1.1 |
| Gravel | ND | ND | 0.2 | 0.3 | ND | ND | ND | ND | ND | ND | 0.4 |
| Sand | 99 | 99 | 99 | 98 | 99 | 99 | 99 | 99 | 99 | 99 | 98 |
| Silt | ND | 0.1 | ND | ND | 0.2 | ND | ND | ND | ND | ND | ND |
| Clay | 0.9 | 1.0 | 1.2 | 1.3 | 1.0 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 1.2 |

ND – not detected
( 1 ) PSA: Fraction PHI -1 contained only shells
( 2 ) PSA: Fraction PHI -1 contained two pieces of shell and two small rocks

## Table 2.9 - Sediment Quality: Metal Results

| Parameter | 5000 US (NE) 2011 | D41 2008 | D41 2011 | F70 2008 | F70 2011 | E70 2008 | E70 2011 | M79A 2008 | M79A 2011 | H08 2008 | H08 2011 | 250 DS 2008 | 250 DS 2011 | 500 DS 2008 | 500 DS 2011 | 1000 DS 2008 | 1000 DS 2011 | 2000 DS 2011 | 5000 DS (SW) 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Inorganics (g/kg)** | | | | | | | | | | | | | | | | | | | |
| Moisture | 15 | **19** | 18 | **17** | 17 | **16** | 18 | **14** | 16 | **21** | 15 | **13** | 18 | **12** | 15 | **17** | 14 | 14 | 17 |
| TOC | ND | **ND** | 0.4 | **ND** | 0.3 | **0.4** | 0.4 | **ND** | ND | **ND** | ND | **ND** | 0.5 | **0.4** | ND | **ND** | ND | ND | ND |
| **Metals (mg/kg)** | **Note: all metals normalized to Al** | | | | | | | | | | | | | | | | | | |
| Aluminum (Al) | 460 | 12000 | 810 | 13000 | 570 | 17000 | 640 | 1000 | 330 | 14000 | 420 | 11000 | 810 | 13000 | 450 | 12000 | 380 | 390 | 400 |
| Antimony (Sb) | ND | 0.013 | ND | 0.015 | ND | 0.015 | ND | ND | ND | 0.016 | ND | 0.017 | ND | ND | ND | 0.016 | ND | ND | ND |
| Arsenic (As) | ND | 0.000 | ND | 0.000 | ND | 0.000 | ND | ND | ND | ND | ND | 0.000 | ND | 0.154 | ND | ND | ND | ND | ND |
| Barium (Ba) | ND | 0.013 | ND | 0.015 | ND | 0.015 | ND | 0.150 | ND | 0.016 | ND | 0.017 | ND | ND | ND | 0.016 | ND | ND | ND |
| Beryllium (Be) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | N/A | ND | ND | ND | ND | ND |
| Bismuth (Bi) | ND | ND | ND | ND | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | ND | ND |
| Boron (B) | ND | N/A | 6 | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | ND | ND | N/A | ND | ND | ND |
| Cadmium (Cd) | ND | ND | ND | ND | ND | N/A | ND | ND | ND | ND | ND | ND | ND | 0.003 | ND | ND | ND | ND | ND |
| Chromium (Cr) | 0.004 | 0.000 | 1.761 | 0.000 | 0.005 | 0.000 | 0.006 | 0.006 | ND | 0.000 | ND | 0.000 | 0.006 | ND | ND | 0.000 | ND | ND | ND |
| Cobalt (Co) | ND | ND | ND | ND | ND | 0.000 | ND | ND | ND | 0.000 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Copper (Cu) | ND | ND | ND | ND | ND | 1.286 | ND | ND | ND | ND | ND | ND | ND | 2.154 | ND | ND | ND | ND | ND |
| Iron (Fe) | 4.348 | 0.275 | 4.074 | 0.254 | 3.333 | 0.288 | 3.438 | 3.100 | 4.545 | 0.236 | 5.238 | 0.218 | 4.074 | 0.004 | 4.000 | 0.175 | 3.947 | 3.846 | 5.500 |
| Lead (Pb) | 0.002 | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 | 0.9 | 0.004 | ND | 0.000 | 0.5 | 0.000 | 1.1 | N/A | ND | 0.000 | ND | 0.001 | 0.002 |
| Lithium (Li) | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | 0.048 | ND | N/A | ND | ND | ND |
| Manganese (Mn) | 0.024 | 0.004 | 0.031 | 0.004 | 0.023 | 0.008 | 0.025 | 0.042 | 0.039 | 0.006 | 0.031 | 0.003 | 0.037 | ND | 0.036 | 0.003 | 0.032 | 0.031 | 0.045 |
| Mercury (Hg) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Molybdenum (Mo) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Nickel (Ni) | ND | ND | ND | ND | ND | 0.010 | ND | ND | ND | ND | ND | ND | ND | N/A | ND | ND | ND | ND | ND |
| Rubidium (Rb) | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | ND | ND | N/A | ND | ND | ND |
| Selenium (Se) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | N/A | ND | ND | ND | ND | ND |
| Silver (Ag) | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | 0.038 | ND | N/A | ND | ND | ND |
| Strontium (Sr) | ND | 0.004 | 0.006 | 0.004 | 0.009 | 0.004 | ND | 0.039 | ND | 0.004 | ND | 0.004 | ND | 0.000 | ND | 0.004 | ND | ND | ND |
| Thallium (Tl) | ND | 0.000 | ND | 0.000 | ND | 0.000 | ND | 0.000 | ND | 0.000 | ND | N/A | ND | N/A | ND | 0.000 | ND | ND | ND |
| Tin (Sn) | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | N/A | ND | 0.000 | ND | N/A | ND | ND | ND |
| Uranium (U) | ND | 0.000 | 0.000 | 0.000 | ND | 0.000 | 0.000 | 0.000 | ND | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | ND | 0.000 | ND | ND | ND |
| Vanadium (V) | 0.011 | 0.001 | 0.009 | 0.001 | 0.009 | 0.001 | 0.008 | 0.009 | 0.009 | 0.001 | 0.014 | 0.001 | 0.009 | 0.005 | 0.011 | 0.000 | 0.011 | 0.008 | 0.013 |
| Zinc (Zn) | ND | 0.001 | 0.007 | 0.001 | ND | 0.001 | ND | 0.006 | ND | 0.001 | ND | 0.001 | ND | 0.154 | ND | 0.001 | ND | ND | ND |

ND – not detected
N/A – not tested

## Table 2.10 - Sediment Quality: Petroleum Hydrocarbon and PAH Results

| Parameter | 5000 US (NE ) | D41 | F70 | E70 | M79A | H08 | 250 DS | 500 DS | 1000DS | 2000DS | 5000 DS (SW) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Petroleum Hydrocarbons (mg/kg)** | | | | | | | | | | | |
| Benzene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Toluene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Ethylbenzene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Xylene (Total) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| C6 - C10 (less BTEX) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| >C10-C16 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| >C16-C21 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| >C21-<C32 Hydrocarbons | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Modified TPH (Tier1) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Reached Baseline at C32 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Hydrocarbon Resemblance | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Polyaromatic Hydrocarbons (mg/kg)** | | | | | | | | | | | |
| 1-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2-Methylnaphthalene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Acenaphthylene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Anthracene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)anthracene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(a)pyrene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(b)fluoranthene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(g,h,i)perylene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(j)fluoranthene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzo(k)fluoranthene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Chrysene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Dibenz(a,h)anthracene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fluoranthene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Fluorene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Indeno(1,2,3-cd)pyrene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Naphthalene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Perylene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Phenanthrene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Pyrene | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND – not detected

**Table 2.11 - Sediment Quality: Sulphide Results**

| Parameter | 5000 US (NE ) | D41 | F70 | E70 | M79A | H08 | 250 DS | 500 DS | 1000DS | 2000DS | 5000 DS (SW) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sulphide (mg/g)** | | | | | | | | | | | |
| $H_2S$ | 0.46 | 0.21 | <0.20 | 0.31 | 0.28 | <0.20 | 0.22 | 0.25 | 0.21 | <0.20 | 0.25 |

**Table 2.12 - Sediment Quality: Alkylated Phenol Results**

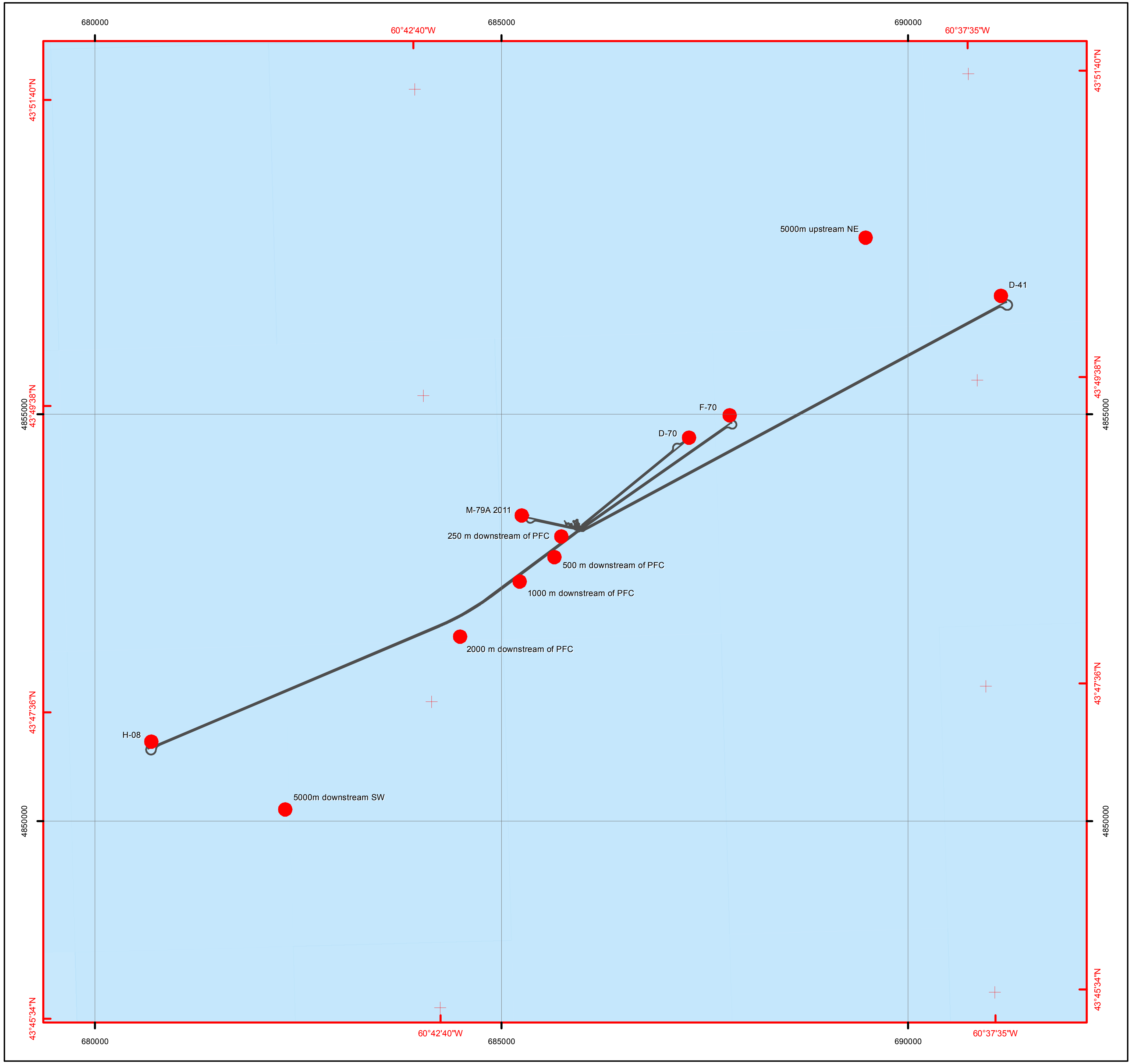
| Parameter | 5000US (NE ) | D41 | F70 | E70 | M79A | H08 | 250 DS | 500 DS | 1000DS | 2000DS | 5000DS (SW) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alkylated Phenol (ng/L)** | | | | | | | | | | | |
| Nonylphenol (NP) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol monoethoxylates (NP1EO) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 4-Nonylphenol diethoxylates (NP2EO) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 4-n-Octylphenol (OP) | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| % Moisture | 16.9 | 20.1 | 19.5 | 21.6 | 20.4 | 17.8 | 20.1 | 23.2 | 18.9 | 21.4 | 18.8 |

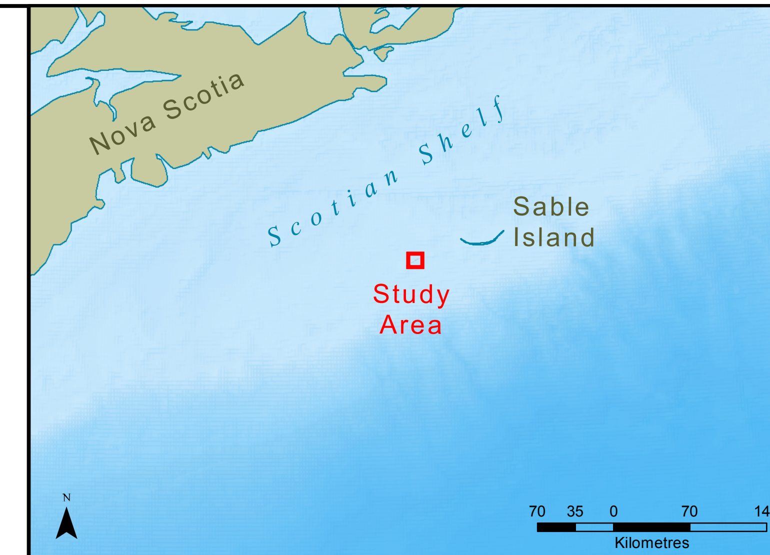
ND – not detected

**Table 2.13 - Sediment Quality: TOC Results**

| Parameter | 5000 US (NE ) | D41 | F70 | E70 | M79A | H08 | 250 DS | 500 DS | 1000 DS | 2000DS | 5000 DS (SW) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Organics (g/kg)** | | | | | | | | | | | |
| Organic Carbon (TOC) | ND | 0.4 | 0.3 | 0.4 | ND | ND | 0.5 | ND | ND | ND | ND |

ND – not detected

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Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 650 1,300 2,600 3,900
Meters

● 2011 Sample
— Deep Panuke structures

*Note:*
*Map scale 1:50,000 when printed on 11x17 size paper*

encana natural gas — Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

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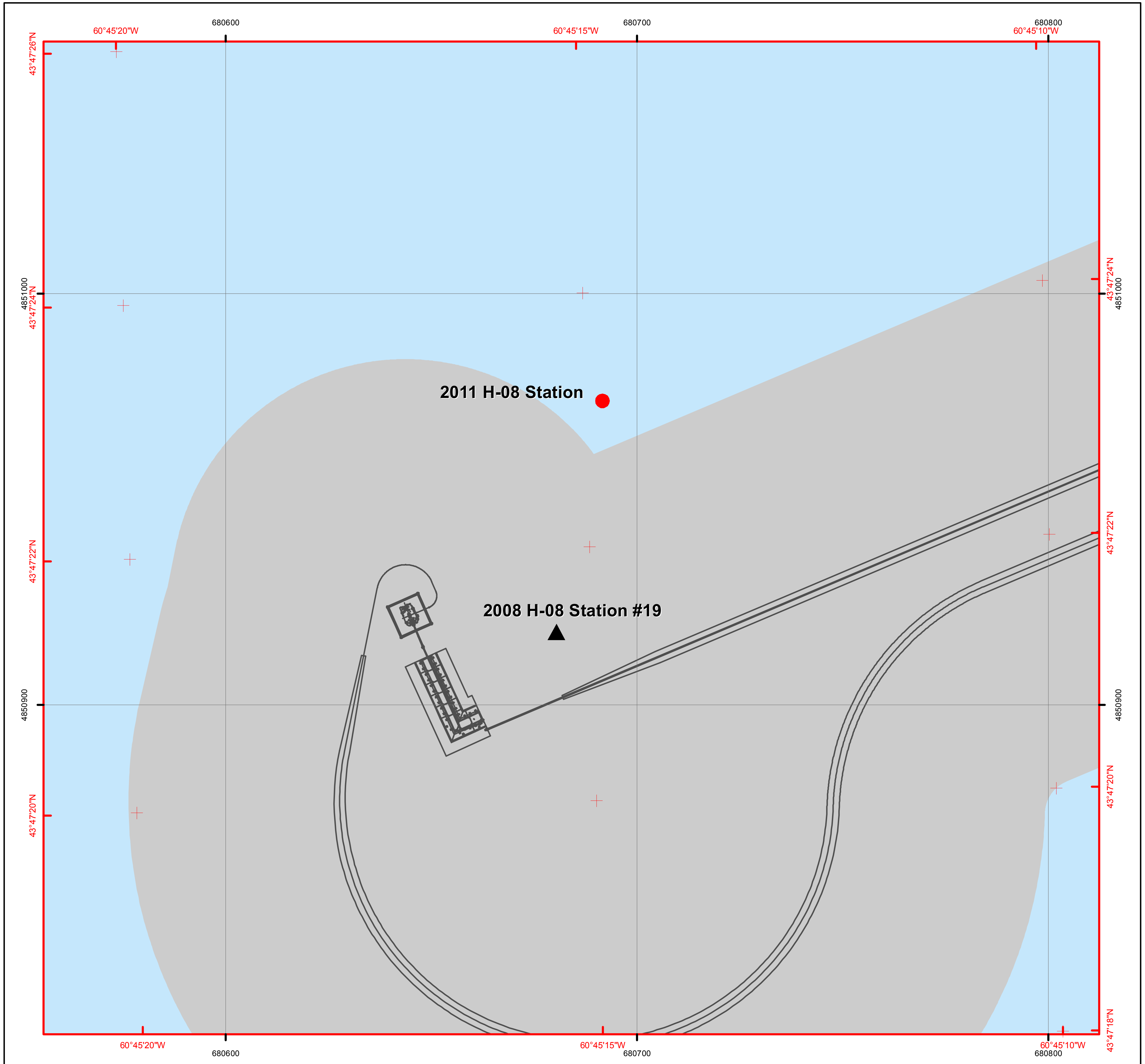
Bedford, Nova Scotia, Canada

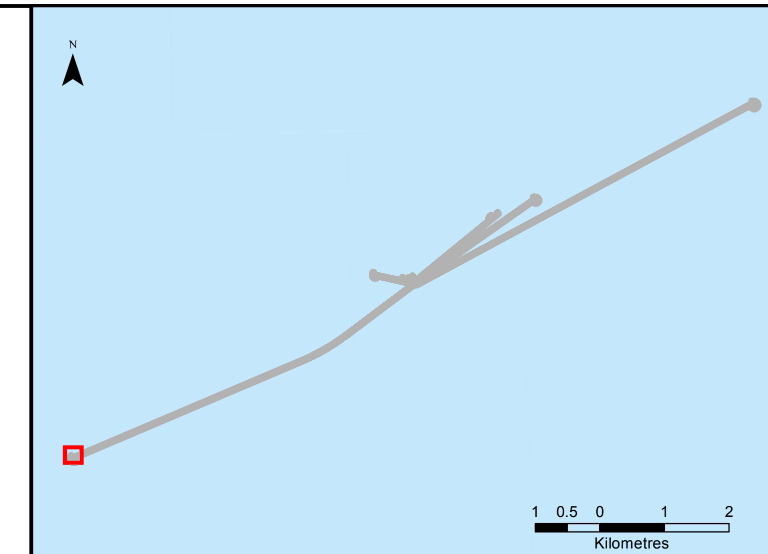
Date Saved: 26/03/2012 3:59:35 PM

McGregor Project No.: 1113

**Figure: 4a**

Filename: ENCANA_Location_grab

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Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**

- ▲ 2008 Sample
- ● 2011 Sample
- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas

Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited

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Bedford, Nova Scotia, Canada

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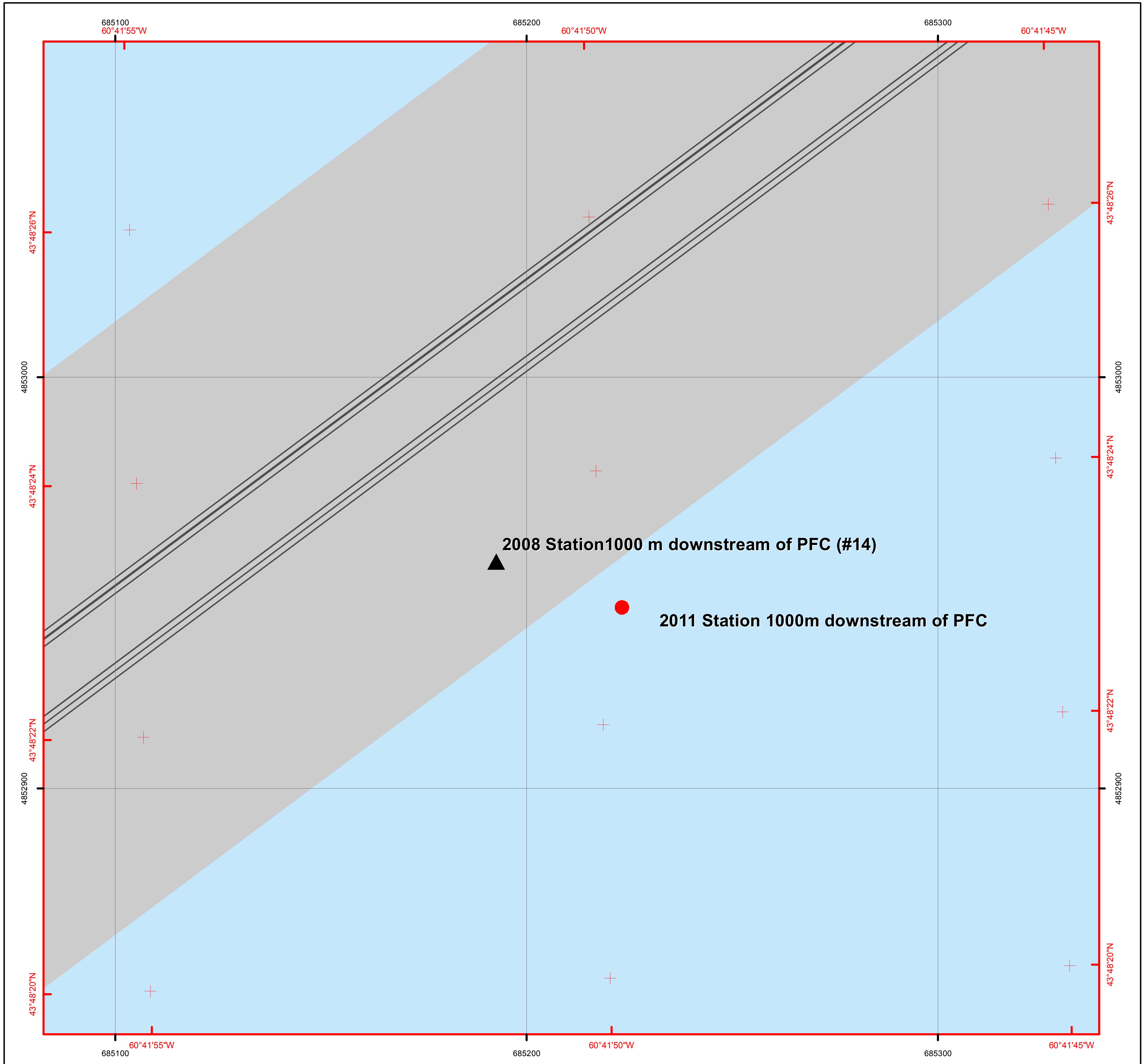
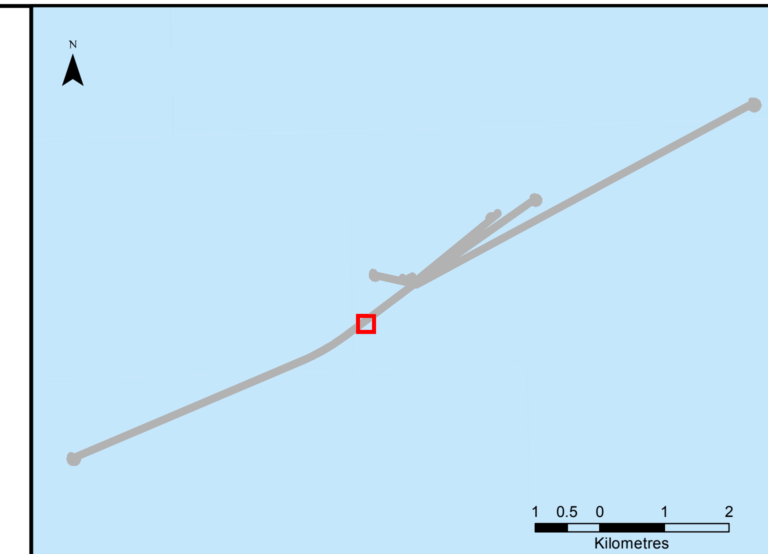
McGregor Project No.: 1113

**Figure: 4b**

Filename: ENCANA_gs




Coordinate System: WGS 1984 UTM Zone 20N
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**

▲ 2008 Sample

● 2011 Sample

Deep Panuke structures

50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas

Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

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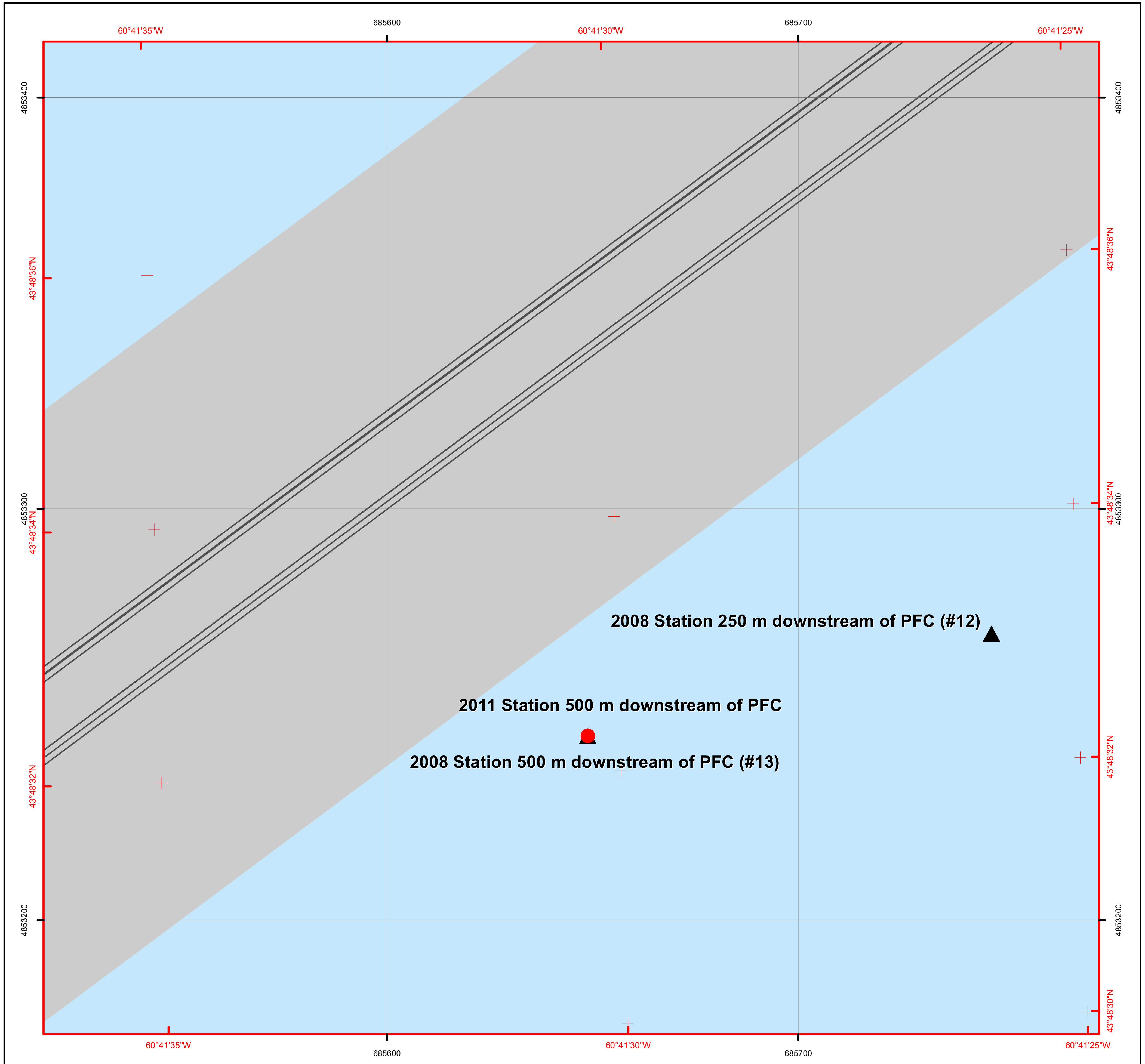
Bedford, Nova Scotia, Canada

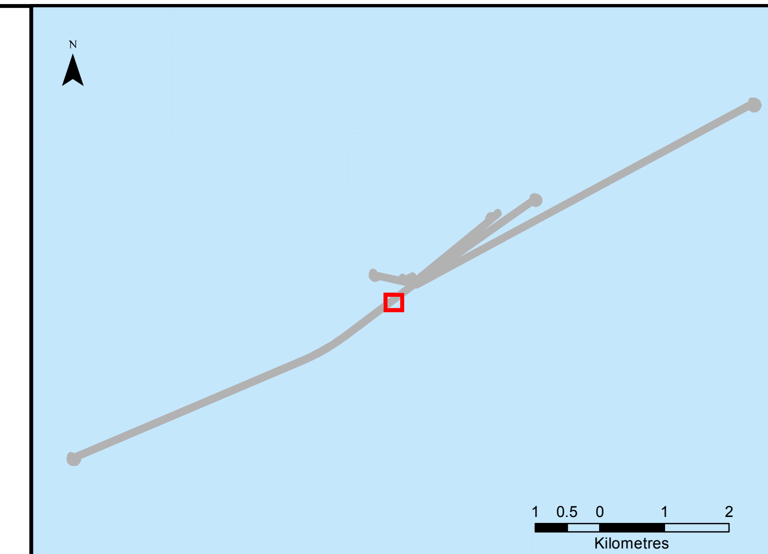
Date Saved: 26/03/2012 3:57:25 PM

McGregor Project No.: 1113

**Figure: 4c**

Filename: ENCANA_gs

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Projection: Transverse Mercator
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**
- ▲ 2008 Sample
- ● 2011 Sample

- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas — Encana

## Grab Sample Locations

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited
McGregor GeoScience Ltd.
Bedford, Nova Scotia, Canada

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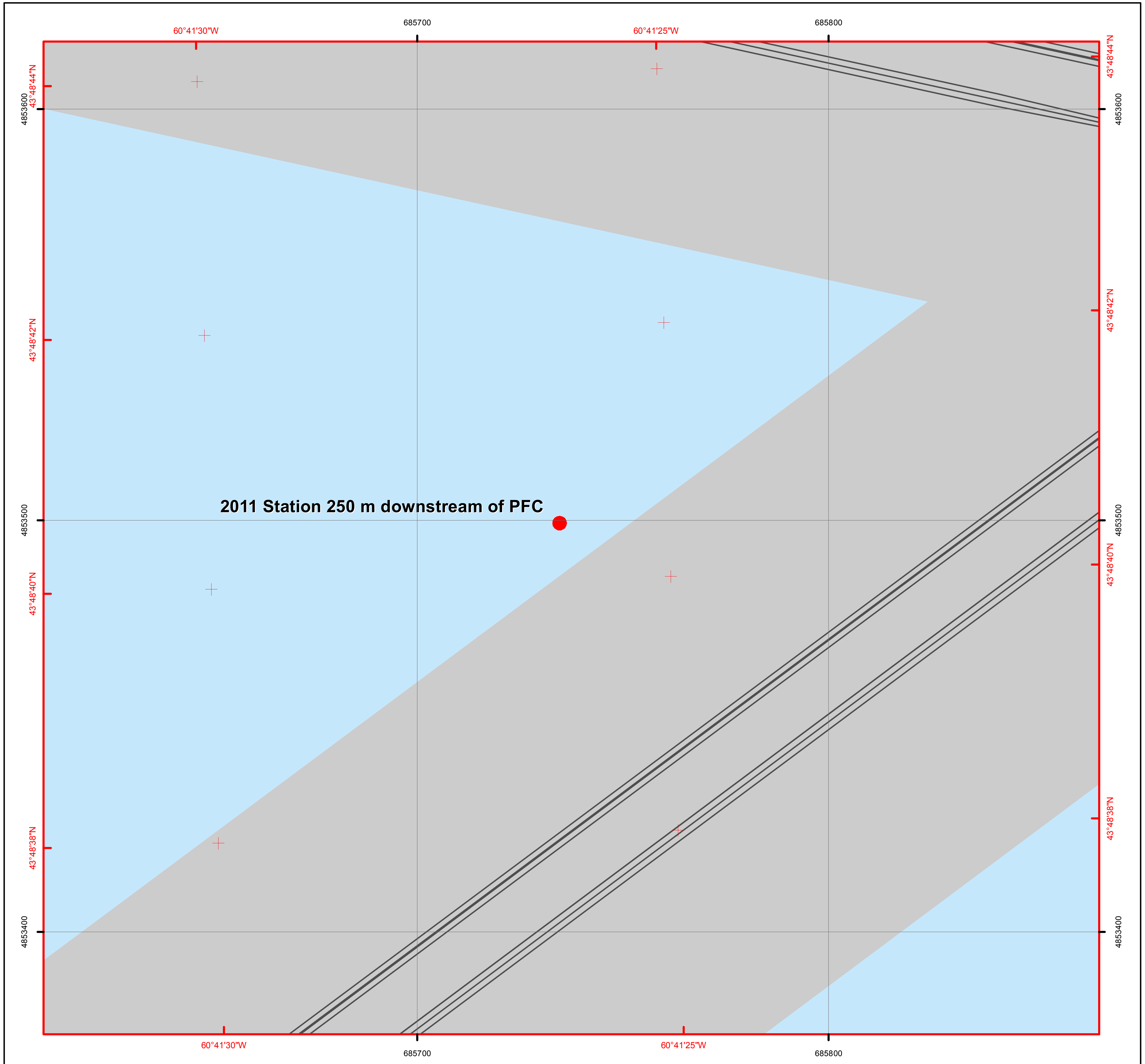
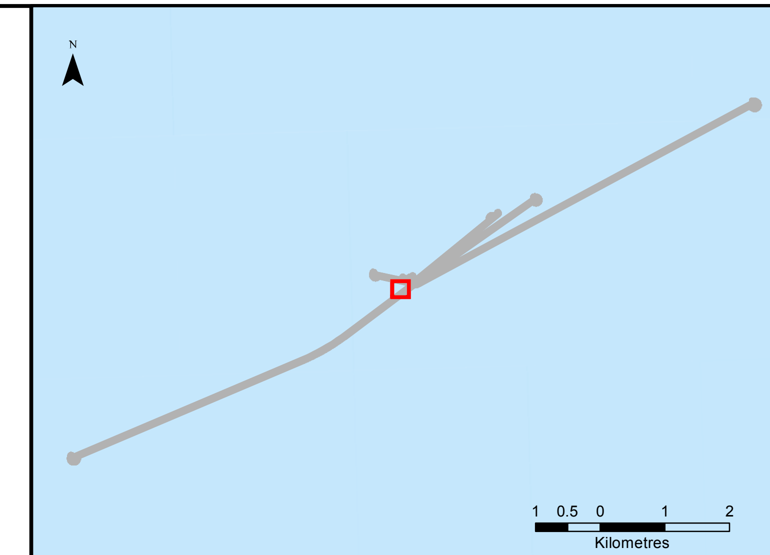
McGregor Project No.: 1113

**Figure: 4d**

Filename: ENCANA_gs

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Projection: Transverse Mercator
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**
- 2008 Sample
- 2011 Sample

- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas — Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

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Bedford, Nova Scotia, Canada

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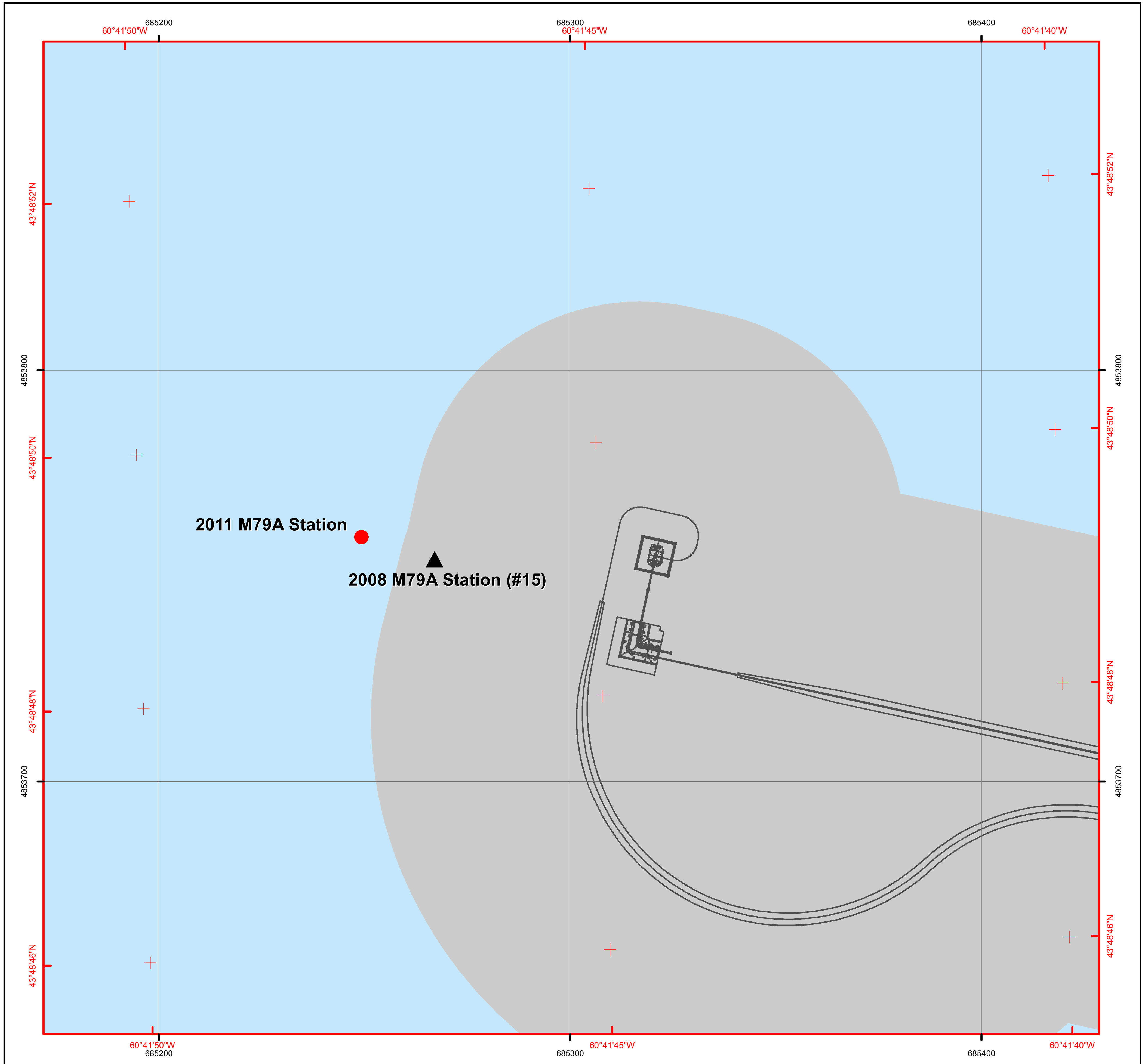
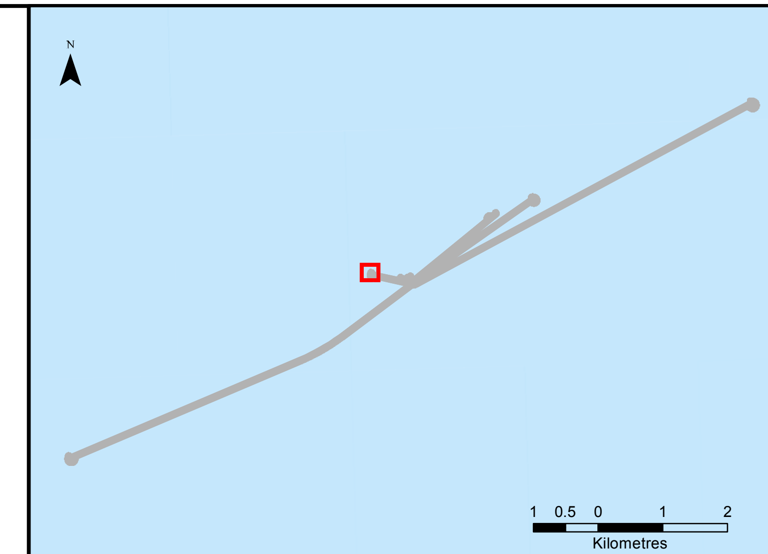
McGregor Project No.: 1113

**Figure: 4e**

Filename: ENCANA_gs




Coordinate System: WGS 1984 UTM Zone 20N
Projection: Transverse Mercator
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**
- ▲ 2008 Sample
- ● 2011 Sample
- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas — Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

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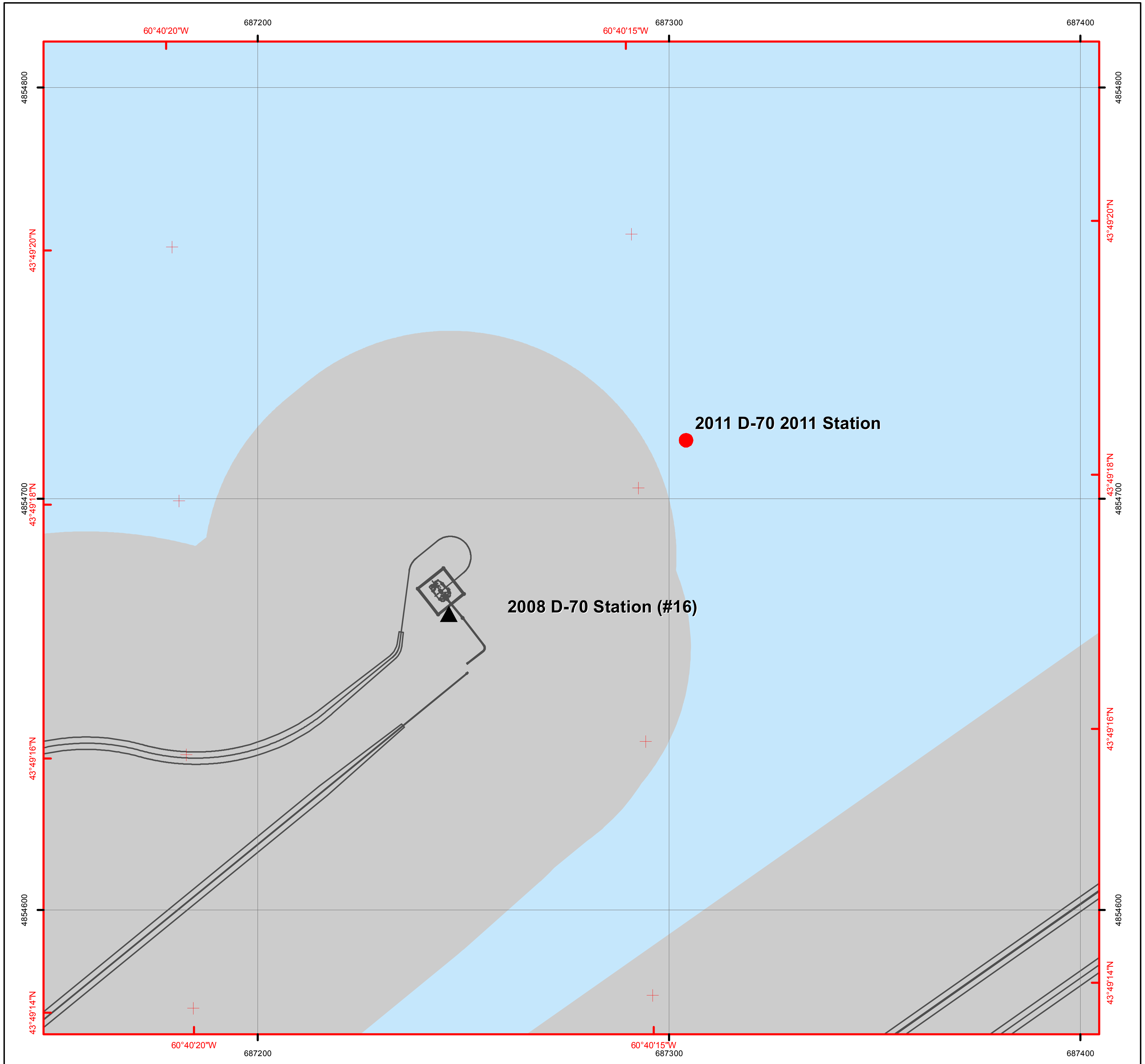
Bedford, Nova Scotia, Canada

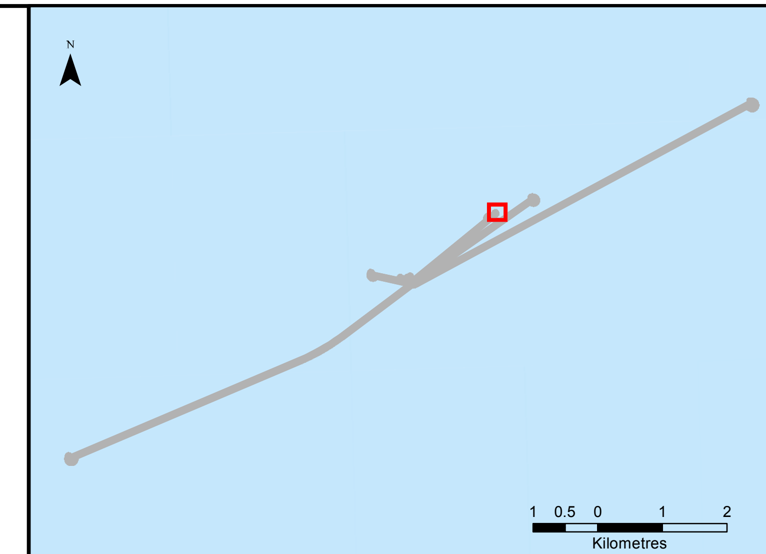
Date Saved: 26/03/2012 3:57:25 PM

McGregor Project No.: 1113

**Figure: 4f**

Filename: ENCANA_gs

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Projection: Transverse Mercator
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

0 12.5 25 50 75
Meters

**Grab Locations**

- ▲ 2008 Sample
- ● 2011 Sample
- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas

Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited

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Bedford, Nova Scotia, Canada

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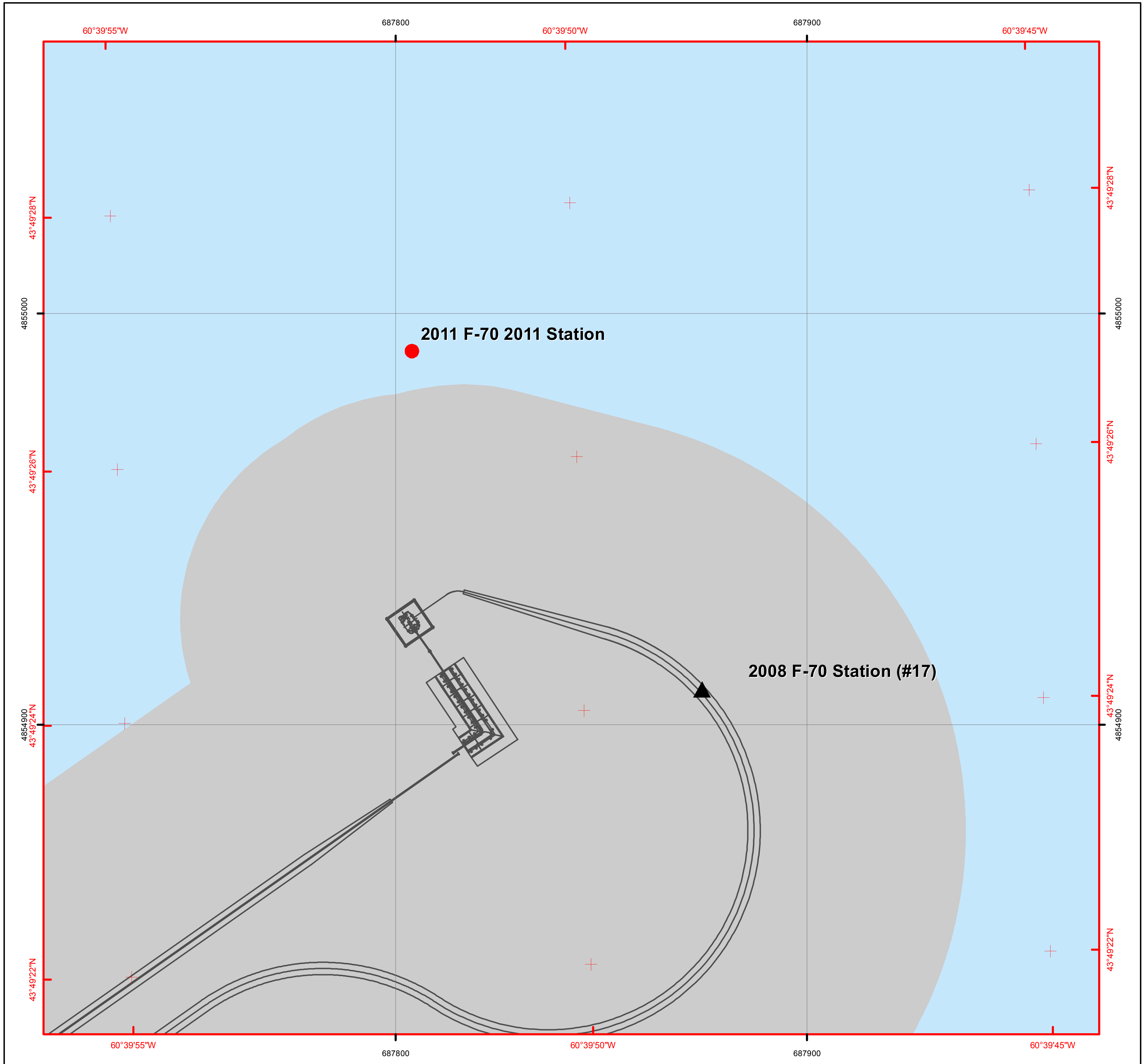
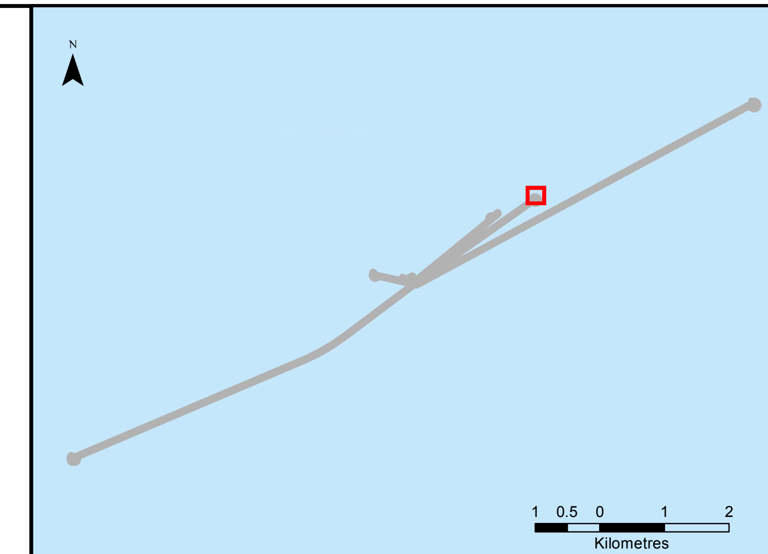
McGregor Project No.: 1113

**Figure: 4g**

Filename: ENCANA_gs




Coordinate System: WGS 1984 UTM Zone 20N
Projection: Transverse Mercator
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

0 12.5 25 50 75
Meters

**Grab Locations**

- 2008 Sample
- 2011 Sample
- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas

Encana

**Grab Sample Locations**

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited

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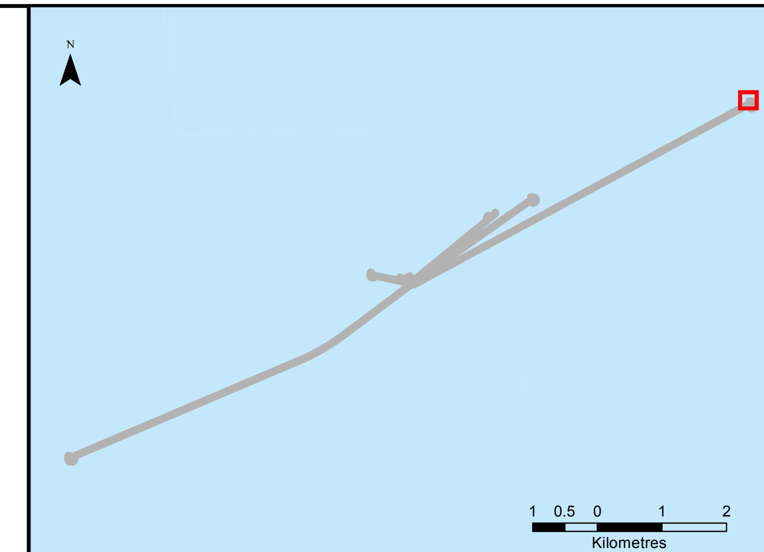
Bedford, Nova Scotia, Canada

Date Saved: 26/03/2012 3:57:25 PM

McGregor Project No.: 1113

**Figure: 4h**

Filename: ENCANA_gs


Coordinate System: WGS 1984 UTM Zone 20N
Projection: Transverse Mercator
Datum: WGS 1984
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

N W E S

0 12.5 25 50 75
Meters

**Grab Locations**
- ▲ 2008 Sample
- ● 2011 Sample

- Deep Panuke structures
- 50m Buffer Zone

*Note:*
*Map scale 1:1,000 when printed on 11x17 size paper*

encana natural gas — Encana

## Grab Sample Locations

*Deep Panuke Survey Area*

*Scotian Shelf*

McGregor GeoScience Limited — McGregor GeoScience Ltd.
Bedford, Nova Scotia, Canada

Date Saved: 26/03/2012 3:57:25 PM

McGregor Project No.: 1113

**Figure: 4i**

Filename: ENCANA_gs

## 2.4 SEDIMENT TOXICITY

### 2.4.1 Background

A variety of laboratory-based sediment toxicity bioassays were originally used in the SOEP EEM program to evaluate potential lethal and sublethal effects on organisms representing several different trophic levels - amphipod (*Rhepoxynius abronius*) survival, echinoderm (*Lytechinus pictus*) fertilization and bacterial luminescence of Vibrio fischeri (Microtox). Within a relatively short period (two to three years of sampling), the echinoderm fertilization and Microtox tests were discontinued as the results did not correlate with trends in sediment chemistry results. However, the marine amphipod survival test has proved to be the most reliable indicator of sediment contamination and continues to be a valuable monitoring parameter in the SOEP EEM program.

### 2.4.2 EEMP Goal

To validate predictions re sediment toxicity made in the 2006 Deep Panuke EA [EA predictions #1, 2, 3, 4, 5, 6, 7 & 8 in **Table 3.1** from the Offshore EEMP].

### 2.4.3 Objectives

Use a suitable indicator species to evaluate acute toxicity of sediments collected at drill sites and at the production site.

### 2.4.4 Sampling

| | |
|---|---|
| Survey Date: | December 4, 2011 |
| Platform: | M/V Atlantic Condor |
| Type of Sample: | Sediment Toxicity |

**Test Sample Locations – Field Stations:**

| Station | Time UTC | Water Depth(m) | Easting | Northing |
|---|---|---|---|---|
| D-41 | 10:02 | 48 | 691139 | 4856457 |
| F-70 | 10:48 | 49 | 687804 | 4854991 |
| E-70 | 11:15 | 47 | 687304 | 4854714 |
| M-79A | 12:36 | 49 | 685249 | 4853759 |
| 250m DS | 13:02 | 40 | 685735 | 4853499 |
| 500m DS | 13:30 | 50 | 685649 | 4853245 |
| 1000m DS | 14:12 | 48 | 685223 | 4852944 |
| 2000m DS | 14:52 | 45 | 684492 | 4852266 |
| H-08 | 15:24 | 42 | 680692 | 4850974 |
| WGS84 UTM Zone 20N | | | | |

**Test Sample Locations – Reference Stations:**

| Station: | Time UTC | Water Depth(m) | Easting | Northing |
|---|---|---|---|---|
| 5000m US NE | 09:12 | 42 | 689477 | 4857176 |
| 5000m DS SW | 16:15 | 42 | 682340 | 4850141 |
| WGS84 UTM Zone 20N | | | | |

**Number of Samples/Locations:**

Sediment samples were collected from the seafloor surface from 11 stations both upstream and downstream from the PFC. For safety reasons the 2011 sampling stations were located outside the 50m buffer zone - away from seafloor infrastructure. Sediment sampling locations are available in **Figure 4a** through **4i**. Logs are available in **Appendix A**.

Field stations:

- 250m downstream of PFC (2008 station #12);
- 500m downstream of PFC (2008 station #13);
- 1,000m downstream of PFC (2008 station #14);
- 2,000m downstream of PFC (not surveyed in 2008);
- M-79A (2008 station #15);
- E-70 (2008 station #16);
- F-70 (2008 station #17);
- D-41 (2008 station #18); and
- H-08 (2008 station #19).

Reference stations:

- 5,000 m upstream (NE) of the PFC area
- 5,000 m downstream (SW, towards the Haddock Box) of the PFC area

**Equipment:**

A stainless steel van Veen grab was deployed as the ATLANTIC CONDOR held position via DP. The onboard winch and crane were used to deploy the van Veen over the starboard side of the vessel at each sample location to capture physical samples of the surficial sediments.

| | |
|---|---|
| | Following touchdown the van Veen grab was raised to the surface and recovered via crane onboard the vessel. Retrieved samples were visually inspected, digitally photographed, fully described and logged. |
| Sample Preparation: | **Parameter** / **Preservative**: Lab-based sediment bioassay / no preservative |

### 2.4.5 Analysis

Analysis was subcontracted by Harris Industries in accordance with Environment Canada's "Biological Test Method: Reference Method for Determining Acute Lethality of Sediment to Marine or Estuarine Amphipods", EPS 1/RM/35, December 1998.

Lab method "Tox 49" was used for the bioassay. Sediment samples were kept in the dark at 4 $\pm$ 2 °C until use. Pre-sieved, control sediment was received in sealed containers with the amphipods and was kept in the dark at 4 $\pm$ 2 °C until use.

Pre-test procedure completed December 12, 2011:

- 175ml of each of the 12 test sediments were measured and added to each of five replicate exposure jars per sediment;
- 175ml of the control sediment was measured and added to each of five replicate exposure jars;
- 775ml of clean seawater, collected at high tide from Lawrencetown Bridge, (the same source as the acclimation water) with a D.O. of 90-100% saturation was added to each test jar;
- Each prepared replicate jar was held at 15 $\pm$ 2 °C and aerated overnight prior to the start of the test

#### *2.4.5.1 Parameters Analyzed*

The organism of choice for these tests was *E. estuarius* purchased from Northwestern Aquatic Sciences (NAS), Newport, Oregon. Collection took place at Yaquina Bay, Oregon on December 5th, 2011. Organisms were received in excellent health on December 8th, 2011 and held in site sediment covered with aerating seawater at test temperature (15 ± 2 °C) and salinity 29 ppt in continuous light for 5 days prior to commencement of testing.

#### *2.4.5.2 Analysis QA/QC*

- D.O., pH, salinity, temperature and ammonia were measured at the beginning and end of the 10 day test (refer to *Amphipod Toxicity Reports)* for each sample;
- The contents of each test vessel were sieved through a 0.5 mm sieve. The sieve was agitated gently in a pan of clean seawater. The organisms were pipetted from the sieve into a weigh boat with a clean glass pipette. Any immobile organisms were examined under a stereoscope for signs of life. Missing organisms were assumed dead.
- The biological endpoint for the 10-day test is the mean percent survival at ten days. Survival used in calculations is expressed as the total number of animals alive in all 5 replicates out of 100.

### 2.4.6 Results

- No organisms exhibiting unusual appearance, or undergoing unusual treatment were used in the test (**Table 2.14**);
- The samples and control sediment as tested were found to be non-toxic to the amphipod *Eohaustorius estuarius*.
- Harris Industrial's full report is available in **Appendix C**.

**Table 2.14 - Toxicity Results of *E. estuarius* Exposed to Sediments**

| Sample Location | Lab ID | Mortality | % Survival |
|---|---|---|---|
| 5000 US (NE) | 11-600A | 0/100 | 100 |
| D41 | 11-600B | 0/100 | 100 |
| F70 | 11-600C | 0/100 | 100 |
| E70 | 11-600D | 0/100 | 100 |
| M79A | 11-600E | 0/100 | 100 |
| 250 DS | 11-600F | 0/100 | 100 |
| 500 DS | 11-600G | 0/100 | 100 |
| 1000 DS | 11-600H | 0/100 | 100 |
| 2000 DS | 11-600I | 1/100 | 99 |
| H08 | 11-600J | 0/100 | 100 |
| 5000 DS (SW) | 11-600K | 0/100 | 100 |
| BLIND | 11-600L | 0/100 | 100 |
| Control Sediment | | 0/100 | 100 |

### 2.4.7 Summary and Conclusions

- All monitored parameters, DO, pH, temperature and salinity were within acceptable levels throughout the 10-day exposure period;
- 10-day survival in the control sediment exceeded the 90% requirement for a valid test;
- The reference toxicant result fell within Harris Industrial Testing Service Ltd.'s warning limits (i.e. ± 2 S.D. from mean);
- All test validity criteria for the sediment test method were satisfied;
- All collected sediments were non-toxic.

## 2.5 FISH HABITAT ALTERATION

### 2.5.1 Background

Fish habitat is predicted to be enhanced to a minor extent from a "reef" effect due to additional habitat created by the Deep Panuke subsea production structures (i.e. PFC legs, spool pieces, protective mattresses, SSIV valve, subsea wellheads and exposed sections of the subsea export pipeline to shore) and possibly a "refuge" effect associated with the creation of a safety (no fishing) zone around PFC facilities. Underwater ROV video camera surveys at the SOEP and COPAN platform areas have shown that exposed subsea structures on Sable Bank were colonized predominantly by blue mussels, starfish, sea cucumbers, sea anemones and some fish species (most likely Atlantic cod and cunners), and occasionally by crustaceans (e.g. lobsters and Jonah crabs). Sea stars were also commonly observed on subsea platform/wellhead structures in association of mussel aggregations. It is well know that mussels are a preferred prey species of sea stars. Concentrations of small redfish have been observed at most span locations along the SOEP subsea pipeline to shore and snow crabs are frequently encountered on many exposed sections of the pipeline. It is highly unlikely that the proposed subsea pipeline, where unburied, would constitute a significant concern as a physical barrier to the migration of most crustacean species (Martec Ltd et al. 2004). Snow crab is the only commercial-sized crustacean species commonly observed near/on exposed sections of the SOEP subsea pipeline to shore and cod and cunners were the two most commonly observed fish species at SOEP platforms. Hurley and Ellis (2004), in their review of EEM results of drilling, concluded that the spatial and temporal extent of discharged drill wastes appears to be related to mud type, differences in the number of wells/volume of discharges, oceanic and environmental conditions such as current speed and direction, water depth or sediment mobility at the drilling location. Changes in the diversity and abundance of benthic organisms were detected within 1,000m of drill sites, most commonly within the 50m to 500m range of drill sites. Benthic impacts in the Deep Panuke production field are anticipated to be negligible given the low biological diversity and highly mobile sand bottom characteristic of shallower areas of Sable Island Bank. Based on the results of dispersion modeling carried out for the 2006 Deep Panuke EA, discharged mud/cuttings were predicted to have smothering effects over a relatively small area (cone with a base radius of 20m from the drill site for subsea release of cuttings and with a base radius of between 30m - 160m depending on the particle settling rate for surface release of cuttings). Such effects (if any) are likely to be relatively transient (less than one year) with the marine benthic community rapidly colonizing affected areas (i.e., returning them to baseline conditions). Only one new well (disposal well E-70) was drilled as part of the 2010 drilling and completion program; the other Deep Panuke wells were drilled in 2000 (M-79A and H-08) and 2003 (F-70 and D-41) and were re-completed in 2010 (i.e. no cuttings piles involved) so no cuttings piles remain at these locations. It should also be noted that, due to the slow rate of release of mud/cuttings for the E-70 well, a visible cuttings pile may not have formed. The persistence of this pile (for up to six years following cessation of drilling multiple wells at the Thebaud platform location) was likely due to the wells being drilled primarily with a cohesive synthetic-based mud (SBM) type. In contrast, only a single well was drilled with water-based mud at each specific well location for Deep Panuke. The 2008 Baseline Benthic Study provides comparative data on benthic mega-faunal diversity as a basis for assessing potential impacts on fish habitat from the 2010 drilling and completion program and the Deep Panuke production subsea structures.

### 2.5.2 EEMP Goal

To validate predictions made in the 2006 Deep Panuke EA re fish habitat alteration from mud/cuttings piles and subsea production structures [EA predictions #1, 2, 3, 4, 5, 6, 7, 8, 9 & 10 in **Table 3.1**].

### 2.5.3 Objectives

- Compare the predicted and actual size of mud/cuttings piles (if present) formed at the new well drilled in 2010 (i.e., E-70); and
- Assess the extent of fish habitat created by new hard substrate provided by subsea production structures installed for the Deep Panuke project.

### 2.5.4 Sampling

Collect annual remotely-operated vehicle (ROV) video-camera imagery of the following:

- mud/cuttings piles (if present) at the E-70 drill site; and
- Epibenthic community near subsea production structures (i.e. PFC legs, spool pieces, protective rocks and mattresses, SSIV valve and subsea wellheads and exposed sections of the export pipeline to shore) during planned activities such as routine inspection surveys, storm scour surveys, etc.

### 2.5.5 Analysis

#### *2.5.5.1 E-70 Mud/Cuttings Piles*

Subsea inspection videos of the E-70 wellhead and surrounding seafloor were provided on external hard drive and viewed with Visual Review video software. General visual (GVI) video was analyzed for any evidence of mud/cuttings piles at and around the wellhead.

#### *2.5.5.2 Subsea Structures*

Subsea inspection videos of the wellhead areas (June and November 2011) and of the PFC area (November 2011) were provided on DVD recordable discs and viewed with video software. After initial viewing, chapter titles, length and subsea structure were recorded for each video segment. A qualified marine taxonomist analyzed the GVI with the aid of inspection drawings to identify all mega-fauna associated with each structure. Detailed notes were kept on the colonization for parts of each structure, and abundance values (SACFOR scale; Joint Nature Conservation Committee, 2011) calculated for all epifauna encountered.

Fish abundance was calculated for the subsea structures. Each species encountered was identified and given approximate estimates for abundance. For the WHPS, the ROV did not cover the entire WHPS so estimates were multiplied by the number of sides which were not viewed.

#### *2.5.5.3 Cuprotect Coated Structures*

Subsea inspection videos of structures coated with the Cuprotect antifouling products in the PFC riser/spools area (November 2011) were provided on DVD recordable discs and viewed with video software. Cuprotect coated structures include sections of pipeline spool covers, flange covers, vortex induced vibration (VIV) strakes, disposal flowline and export pipeline in the PFC riser caisson area. After initial viewing, chapter titles, length and subsea structure were recorded for each video segment. A qualified marine taxonomist analyzed the general visual (GVI) video with the aid of inspection drawings to identify all mega-fauna associated with each structure. Detailed notes were kept on the colonization for parts of each structure, and abundance values (SACFOR scale; Joint Nature Conservation Committee, 2011) calculated for all epifauna encountered.

Fish abundance was calculated for the base of the subsea rising caisson. Each species encountered was identified and given approximate estimates for abundance.

#### *2.5.5.4 GEP and Flowlines*

Videos of the export pipeline subsea inspection survey (June 2011) were provided on external hard drive and viewed with Visual Review video software. After initial viewing, exposed and unexposed sections of GEP and production flowlines were recorded for each video segment. A qualified marine taxonomist analyzed the video with the aid of inspection drawings to identify all fish and mega-fauna associated with each pipeline. Thirty six videos associated with exposed pipeline were analyzed and quantitative values were recorded for all fish and epifauna encountered. Small organisms, (i.e. shrimp and polychaetes) were given abundance values due to their sometimes large numbers and small size.

Video was subsampled for the GEP video footage to analyze all exposed sections of the pipeline. Ten kilometre intervals were chosen starting at KP 23.222 and qualitative data was standardised to 1 km reaches. Fauna was assessed by major group in 8 videos across the exposed GEP for graphical analysis.

### 2.5.6 Analysis QA/QC

All identifications were reviewed by a second taxonomist for validation. All structures shown in the video were identified using the commentary on the video for validation.

### 2.5.7 Results

#### *2.5.7.1 E-70 Mud/Cuttings Piles*

- Video surveys of the wellhead site at E-70 showed no cuttings piles around the structure. The substrate consisted of shell debris and medium sand (**Figure 5.5**). No cuttings piles were observed at any of the remaining wellhead sites (**Figure 5.1-5.4**);

#### *2.5.7.2 Subsea Structures*

- Although abundances differed, species composition was similar at each wellhead location. Common species included the blue mussel (*Mytilus edulis*), orange-footed sea cucumber (*Cucumaria frondosa),* frilled anemone (*Metridium* sp.), common sea stars (*Asterias vulgaris*), and occasional Jonah crabs (*Cancer borealis*), on the substrate beneath the WHPS (**Table 2.15; Figure 5**);
- Zonation was observed occurring on each WHPS/tree in different locations. The bottom zone was colonized by algal vegetation and sea cucumbers (*Cucumaria frondosa*) in varying densities, and the top zone was colonized by blue mussels (*Mytilus edulis*) (**Table 2.15; Figure 5**). Colonization of blue mussels extended from 0.5 metres above the seafloor to the top of the structure at H-08 (**Figure 5.1**), but at D-41, they extended from 7.5m above the seafloor to the top of the structure (**Figure 5.4**). Total fouling of the WHPS was estimated to be between 75% to 90% for all structures;

- At F-70, Atlantic cod (*Gadus morhua*) and sculpin (*Myoxocephalus* sp.) were observed in the June survey (**Table 2.15**). Unidentified fish were observed at D-41, although the distance from the school made identification difficult. Video footage showed Atlantic cod feeding on high densities of shrimp in the water column in the early morning hours. After 0500, the shrimp and the cod were not recorded;
- Very high numbers of Atlantic cod were observed in the November survey around all wellhead sites (**Table 2.15, Figure 6**). The differences between fish numbers in the June and November survey could be due to the seasonality at which cod spawn. Although migrational patterns are more commonly studied in the Gulf of St. Lawrence populations of cod, the Scotian Shelf population may participate in migration on a minor scale related to water depths;
- The few species of epifauna found around the Cuprotect coated surfaces were colonizing the concrete protection mats and sandbags;
- One occurrence of a sea star was observed on the SPU insulation of the F-70 flowline, however this section was not coated with Cuprotect (**Figure 7, flow line for F-70**);
- Atlantic cod were observed swimming underneath the riser caisson and amongst the flowlines. Greater numbers of cod were found along the protection tunnels of the flowlines and in the frond mats;
- Sculpin were the only other fish species observed in smaller numbers;
- Orange-footed sea cucumbers were commonly observed colonizing all concrete protection tunnels around the PFC. Sea stars were the only other rarely observed epifauna found in the videos.

### Table 2.15 - Fish Habitat: Video Survey Analysis of Subsea Structures

| June 2011 Video Assessment | | | | | |
|---|---|---|---|---|---|
| **Wellhead Site** | **Structure** | **Fauna** | **Abundance*** | **Number** | **Description** |
| H-08 (Fig 5.1) | WHPS | *Mytilus edulis* | S | | • Mussels cover entire structure (fewer below 0.5m)<br>• Sea cucumber and Jonah crab only dominant at base of legs |
| | | *Cucumaria frondosa* | A | | |
| | | *Asterias vulgaris* | C | | |
| | | *Metridium* sp. | F | | |
| | | *Cancer borealis* | O | | |
| | | Algal vegetation | A | | |
| | Subsea Tree | Algal vegetation | A | | • Approximately 80% fouling by algal vegetation over the entire structure<br>• Mussels and sea cucumber only found on tree guide funnel |
| | | *Mytilus edulis* | O | | |
| | | *Cucumaria frondosa* | O | | |
| M-79A (Fig 5.2) | WHPS | *Mytilus edulis* | A | | • Mussels extended upwards from 4.0 m on legs<br>• High density of sea cucumbers colonizing the base of the structure |
| | | *Cucumaria frondosa* | A | | |
| | | *Asterias vulgaris* | C | | |
| | | *Metridium* sp. | O | | |
| | | Algal vegetation | A | | |
| | Subsea Tree | *Cucumaria frondosa* | S | | • 95% fouling by algal vegetation over the entire structure<br>• High density of sea cucumber colonizing the tree guide funnel |
| | | *Asterias vulgaris* | R | | |
| | | Algal vegetation | S | | |
| F-70 (Fig 5.3) | WHPS | *Gadus morhua* | | 160 | • Mussels extended upwards from 5.5 m on legs and covering inside of structure<br>• Sea anemones recorded throughout entire structure, somewhat higher density at top of structure<br>• Fish observed feeding during early morning survey tasks (0035 - 0445) |
| | | *Myoxocephalus sp.* | | 1 | |
| | | *Mytilus edulis* | A | | |
| | | *Cucumaria frondosa* | O | | |
| | | *Asterias vulgaris* | F | | |
| | | *Metridium* sp. | O | | |
| | | Algal vegetation | A | | |
| | Subsea Tree | *Mytilus edulis* | C | | • 75% fouling by algal vegetation over the entire structure<br>• Epifauna and higher density of algal growth located on top of structure |
| | | *Asterias vulgaris* | C | | |
| | | *Metridium* sp. | R | | |
| | | Algal vegetation | A | | |
| D-41 (Fig 5.4) | WHPS | Unidentified Fish | | 20 | • Mussels extended upwards from ~7.5m on legs<br>• High density of sea stars on the horizontal braces of level 2<br>• Fish observed in small school at base of structure |
| | | *Myoxocephalus sp.* | | 1 | |
| | | *Mytilus edulis* | C | | |
| | | *Cucumaria frondosa* | F | | |
| | | *Asterias vulgaris* | A | | |
| | | *Metridium* sp. | O | | |
| | | Algal vegetation | A | | |
| | Subsea Tree | *Metridium* sp. | A | | • 50% fouling by algal vegetation over the entire structure<br>• High density of sea anemone colonizing the tree guide funnel |
| | | Algal vegetation | F | | |
| | | Unid. Fish | | 1 | |
| E-70 (Fig 5.5) | WHPS | *Mytilus edulis* | A | | • Mussels extended upwards from 5.0 m on legs and occasionally on inside of structure<br>• Anemones and sea stars encountered all over structure |
| | | *Asterias vulgaris* | F | | |
| | | *Metridium sp.* | O | | |
| | | Algal vegetation | A | | |

| | | | | | |
|---|---|---|---|---|---|
| | Subsea Tree | *Mytilus edulis* | O | | • 50% fouling by algal vegetation over the entire structure<br>• Mussels found only on top of subsea tree |
| | | Algal vegetation | F | | |

***** Abundance values are based on the SACFOR scale (S = superabundant; A = abundant; C = common; F = frequent; O = occasional; R = rare)

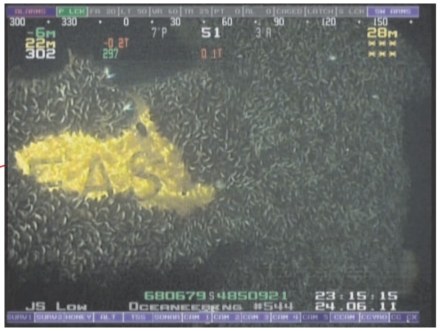
| **November 2011 Video Assessment** | | | | | |
|---|---|---|---|---|---|
| **Wellhead Site** | **Structure** | **Fauna** | **Abundance*** | **Number** | **Description** |
| H-08 (Fig 6) | WHPS/Subsea Tree | *Gadus morhua* | | ~4000 | • Atlantic cod were estimated due to limited ROV footage |
| | | *Tautogolabrus adspersus* | | 19 | |
| | Concrete protection mats | *Gadus morhua* | | ~4000 | • Atlantic cod were estimated due to limited ROV footage |
| | | *Asterias vulgaris* | C | | |
| | | *Cancer borealis* | R | | |
| | Concrete protection tunnel | *Gadus morhua* | | >1000 | • Atlantic cod were estimated due to limited ROV footage |
| | | *Tautogolabrus adspersus* | | 1 | |
| M-79A | WHPS/Subsea Tree | *Gadus morhua* | | 114 | • Cod observed around the base of subsea tree |
| | | *Tautogolabrus adspersus* | | 3 | |
| | Concrete protection tunnel | *Gadus morhua* | | 1 | • Lowest numbers of Atlantic cod observed on the protection tunnels<br>• Highest abundance of sea cucumbers |
| | | *Cucumaria frondosa* | S | | |
| | | Algal vegetation | A | | |
| E-70 | WHPS/Subsea Tree | *Gadus morhua* | | ~250 | • Cod observed around the base of subsea tree |
| | | *Tautogolabrus adspersus* | | 1 | |
| F-70 (Fig 6) | WHPS/Subsea Tree | *Gadus morhua* | | ~650 | • Highest number of cunners observed<br>• Cod observed around the base of subsea tree |
| | | *Tautogolabrus adspersus* | | 26 | |
| | | *Myoxocephalus* sp. | | 1 | |
| | Concrete protection tunnel | *Gadus morhua* | | 159 | • No sea cucumbers observed in video survey |
| | | Algal vegetation | A | | |
| D-41 | WHPS/Subsea Tree | *Gadus morhua* | | ~250 | • Cod observed around the base of subsea tree |
| | | *Tautogolabrus adspersus* | | 3 | |
| | Concrete protection tunnel | *Gadus morhua* | | 130 | • High densities of sea cucumbers present in video survey |
| | | *Cucumaria frondosa* | A | | |
| | | *Cancer borealis* | R | | |
| PFC (non-cuprotect surfaces) (Fig 7) | Protection mats (R-2) | *Gadus morhua* | | 38 | • Large school of Atlantic cod swimming around mats |
| | | *Myoxocephalus* sp. | | 5 | |
| | Protection mats (R-5) | *Myoxocephalus* sp. | | 3 | • Sculpin laying on mats |
| | Base of rising caisson | *Gadus morhua* | | 74 | • Large school of Atlantic cod swimming underneath flowlines and around riser caisson |
| | | *Cancer borealis* | R | | |
| | Protection tunnel (M-79A) | *Gadus morhua* | | 243 | • Large schools of Atlantic cod swimming through frond mats and over concrete tunnels |
| | | *Myoxocephalus sp.* | | 1 | |
| | | *Cucumaria frondosa* | C | | |
| | Protection tunnel (H08) | *Gadus morhua* | | 336 | • Large schools of Atlantic cod swimming through frond mats and over concrete tunnels |
| | | *Myoxocephalus sp.* | | 3 | |
| | | *Cucumaria frondosa* | C | | |
| | | *Asterias sp.* | R | | |

| | | | | | |
|---|---|---|---|---|---|
| PFC (non-cuprotect surfaces) (Fig 7) | Protection tunnel (D41) | *Gadus morhua* | | 368 | • Large schools of Atlantic cod swimming through frond mats and over concrete tunnels |
| | | *Myoxocephalus sp.* | | 2 | |
| | | *Cucumaria frondosa* | C | | |
| | Protection tunnel (F70) | *Gadus morhua* | | 562 | • Large schools of Atlantic cod swimming through frond mats and over concrete tunnels<br>• Orange footed sea cucumber observed in great numbers. |
| | | *Myoxocephalus sp.* | | 2 | |
| | | *Cucumaria frondosa* | A | | |
| | Protection tunnel (E70) | *Gadus morhua* | | 158 | • Large schools of Atlantic cod swimming through frond mats and over concrete tunnels |
| | | *Myoxocephalus sp.* | | 1 | |
| | | *Cucumaria frondosa* | C | | |
| | Protection tunnel (GEP) | *Cucumaria frondosa* | S | | |

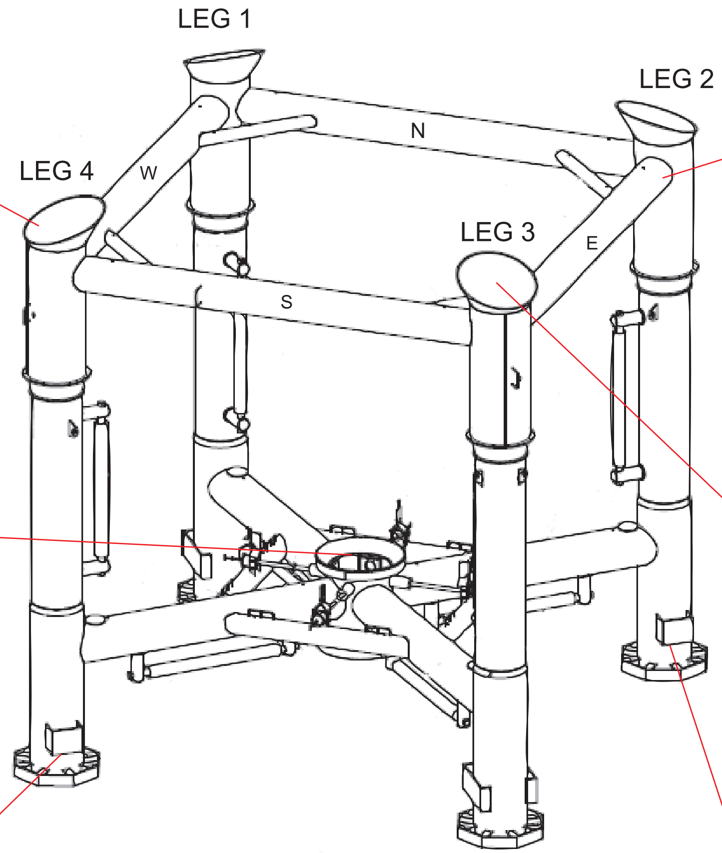
* Abundance values are based on the SACFOR scale (S = superabundant; A = abundant; C = common; F = frequent; O = occasional; R = rare)

# Station H-08

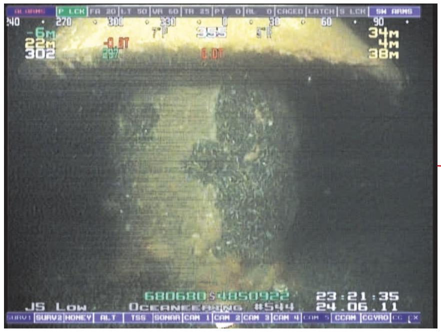
Blue mussels colonizing top of Leg 4 with sea star



East horizontal brace colonized by mussels

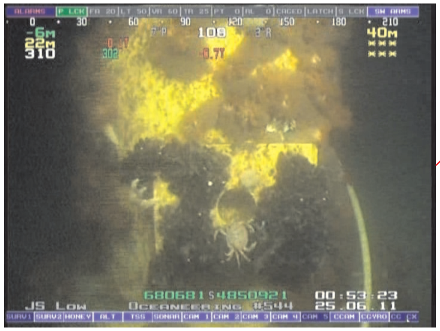



Wellhead Protection Structure

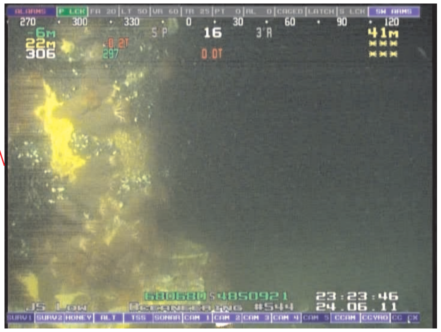


Blue mussel patches at base of Subsea Tree

Blue mussels colonizing top of Leg 3



Base of Leg 4 with blue mussel, sea cucumber and Jonah crab



Sea cucumbers and blue mussels on base of Leg 2

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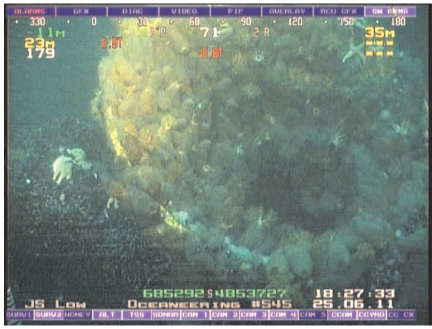
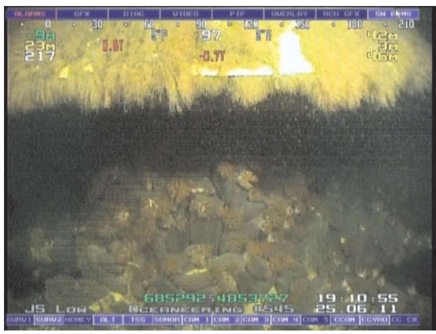
Figure 5.1 Wellhead Protection Structures and Associated Fauna at H-08

# Station M-79A

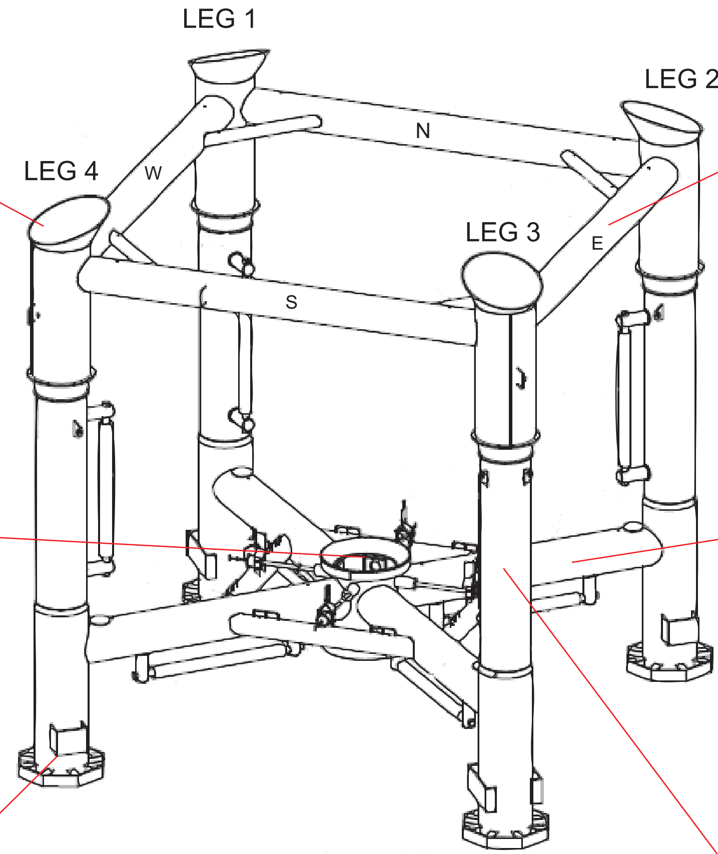


High density of sea cucumbers at top of Leg 4



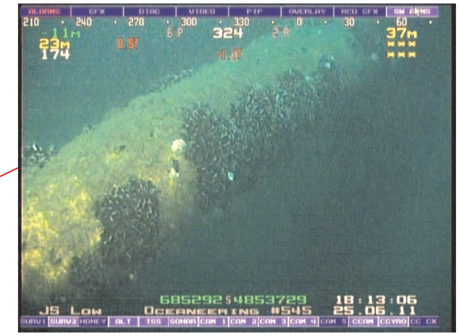
High density of sea cucumbers at base of Subsea Tree

Sea cucumbers at base of Leg 4

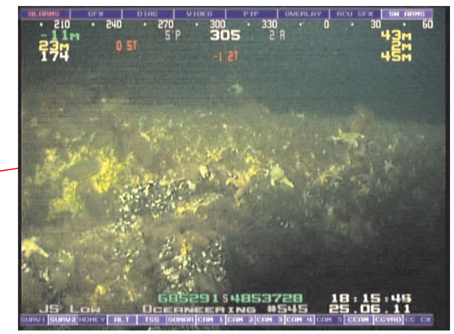




Wellhead Protection Structure



East horizontal bracket with algae and patches of blue mussels



Horizontal bracket HB01-2 with sea cucumbers, algae, and sea stars

Blue mussels and sea stars colonizing Leg 3 and anode

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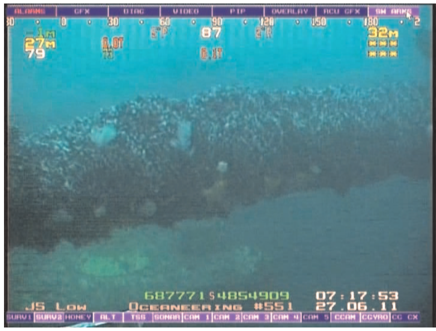
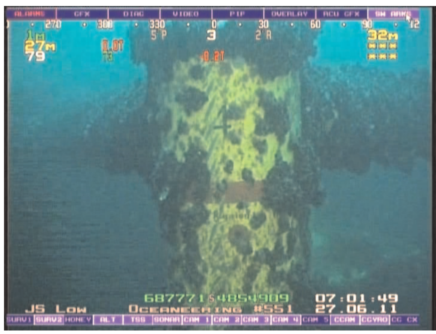
 Wellhead Protection Structures and Associated Fauna at M-79A Figure 5.2

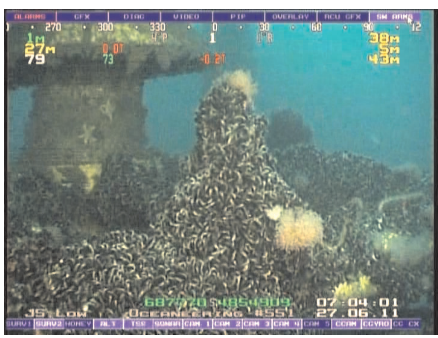
# Station F-70



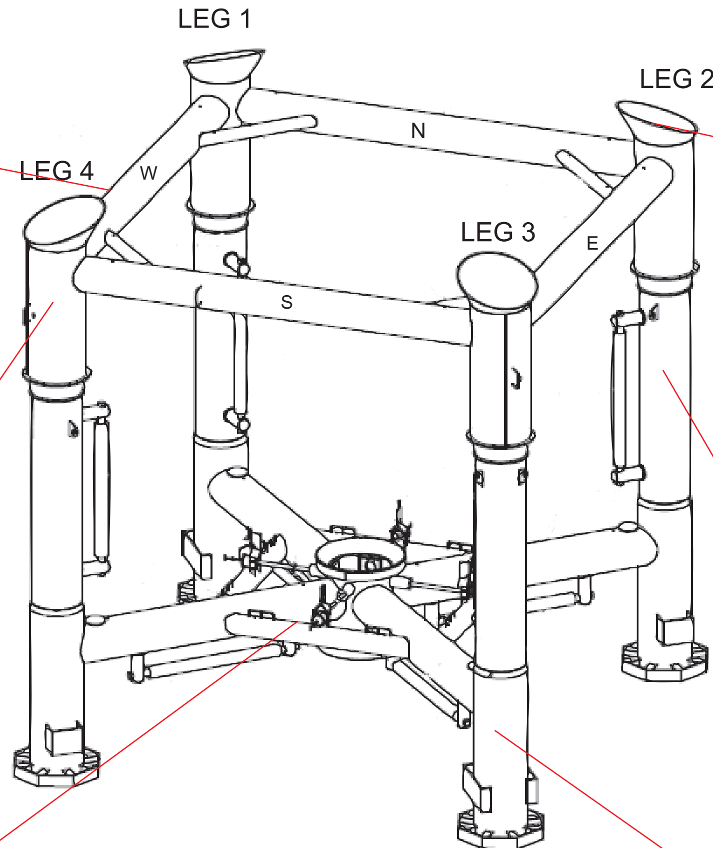
West horizontal bracket colonized by blue mussels



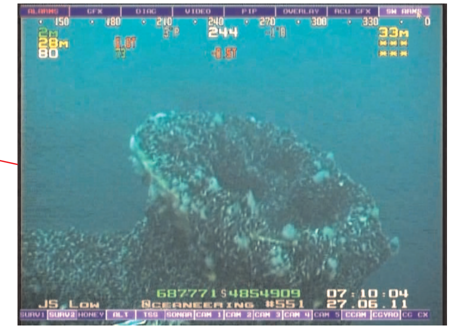
Top of Leg 4 with patches of blue mussels



Blue mussels on HB01-7 with sea stars on base of Subsea Tree in the background

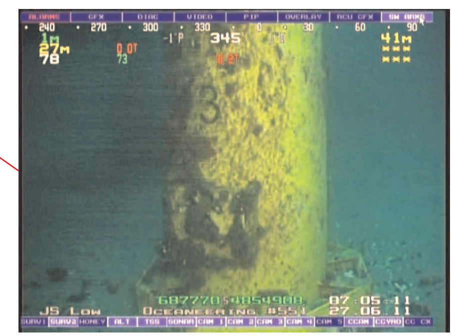



Wellhead Protection Structure



Blue mussels and algal vegetation at top of Leg 2

Blue mussels colonizing Leg 2 with occasional sea stars



Base of Leg 3 with little marine growth

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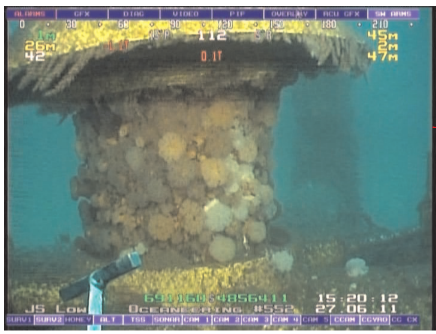
Figure 5.3 Wellhead Protection Structures and Associated Fauna at F-70

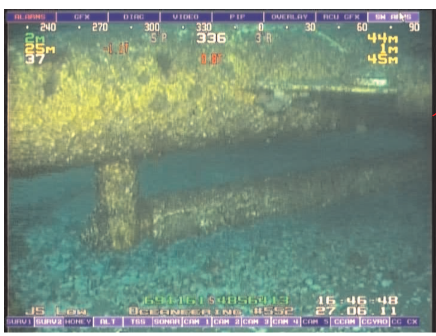
Figure 5.3

# Station D-41

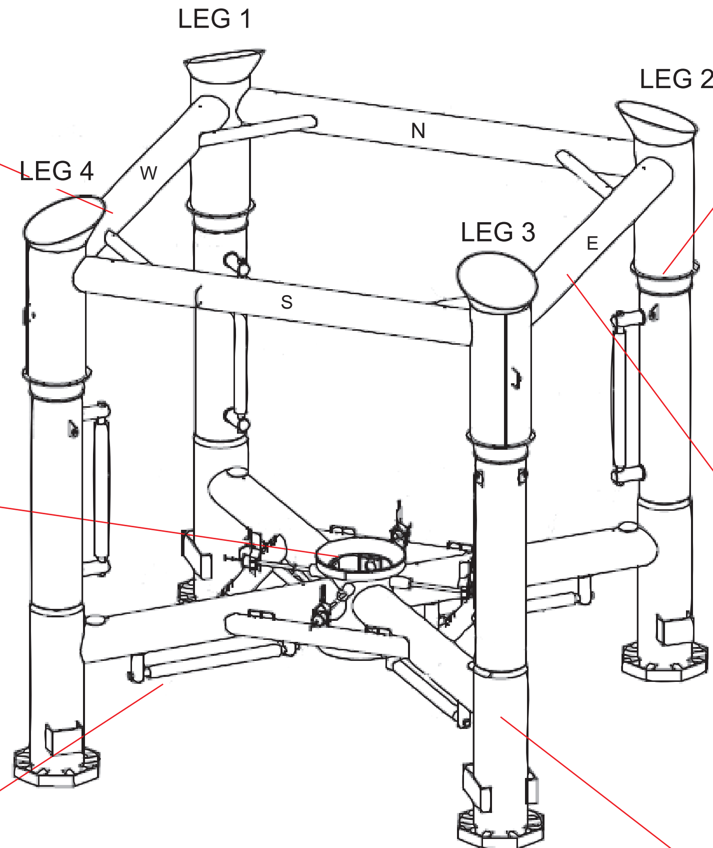
West horizontal brace with few patches of blue mussels



Base of Subsea Tree with a dense colony sea anemones



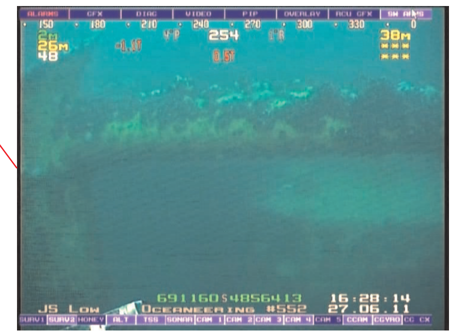
Little marine growth on AN04 and HB01-4





Wellhead Protection Structure

Patches of blue mussels and sea anemone on upper section of Leg 2



Patches of blue mussels and sea stars on East horizontal brace

Sea cucumbers on base of Leg 3

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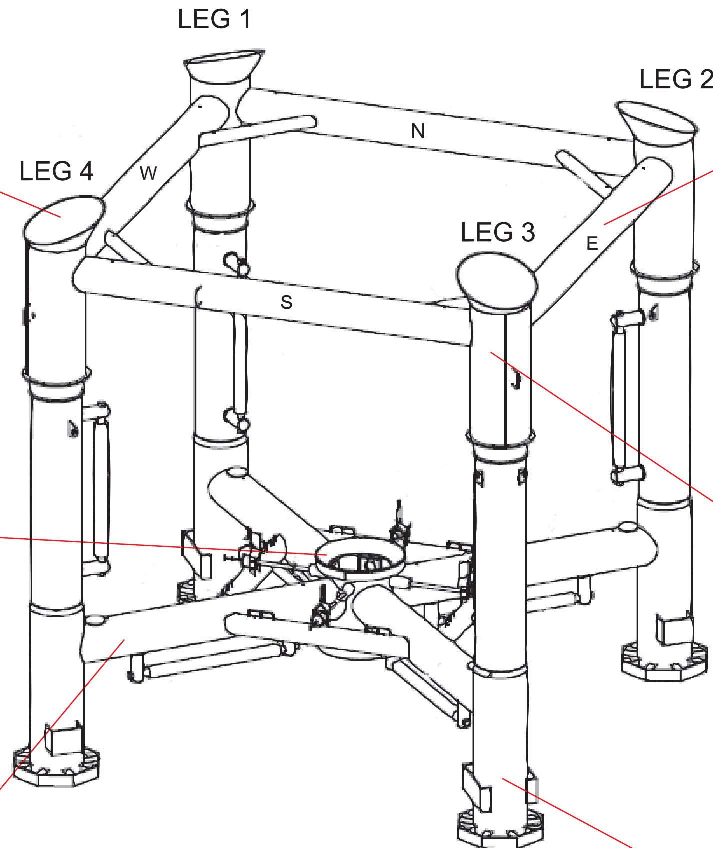
Figure 5.4 Wellhead Protection Structures and Associated Fauna at D-41

Figure 5.4

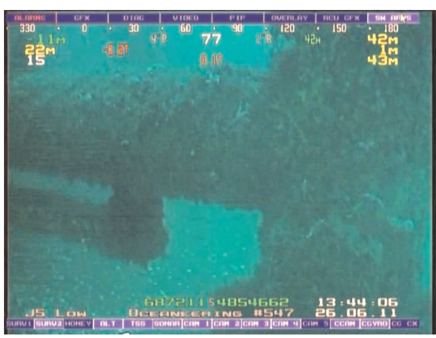
# Station E-70



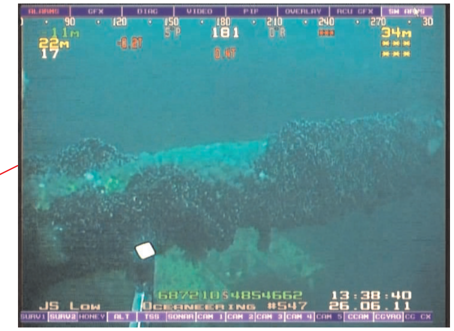

Wellhead Protection Structure

Occasional mussels on top of Leg 4

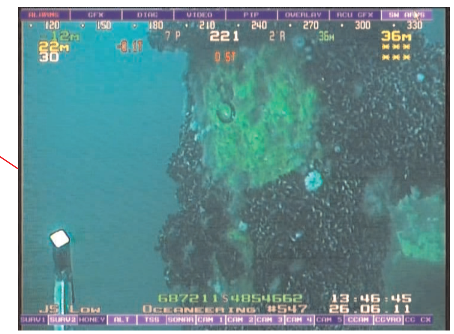
Algal growth and mussels at base of Subsea Tree



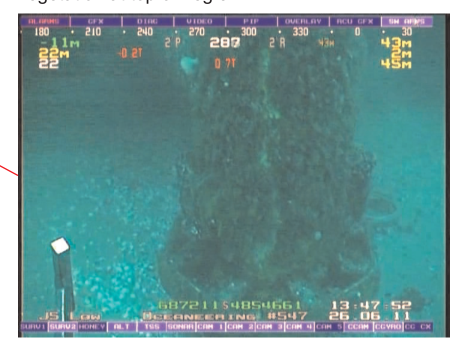
Algal growth and sea stars at base of structure



Abundant mussel growth and algal vegetation on East horizontal bracket



Dense colonies of blue mussels and algal vegetation at top of Leg 3



Marine growth on base of Leg 3

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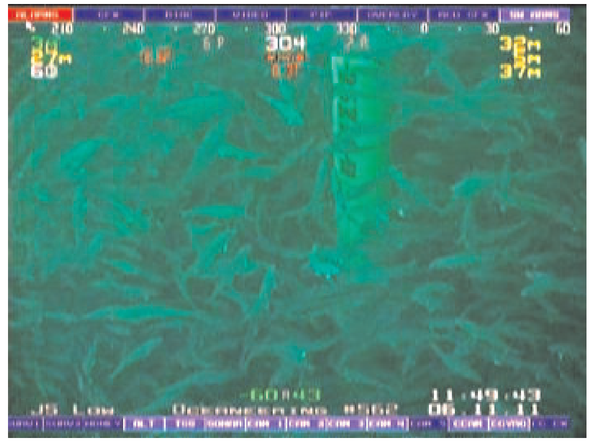
Limited

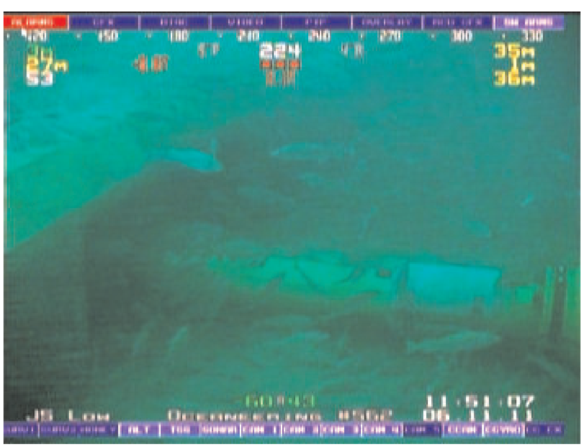
Small school of cunner surrounding support leg of wellhead site F-70



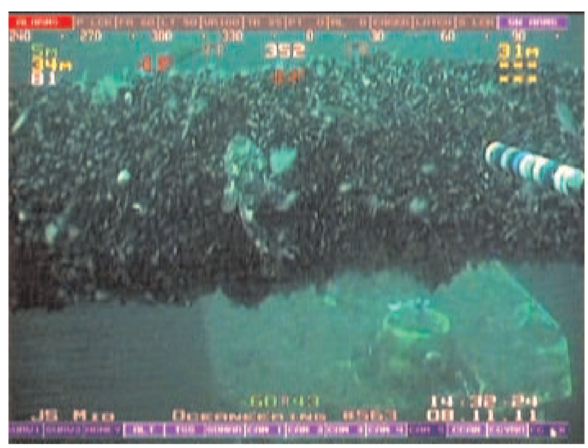
Large school of Atlantic cod around flow line at wellhead site H-08

Atlantic cod around the base of H-08 Subsea Tree

Cunner at H-08 wellhead protection structure



Atlantic cod swimming over concrete protection structure at H-08 wellhead site



Sculpin using a horizontal brace as an artificial reef on wellhead protection structure F-70

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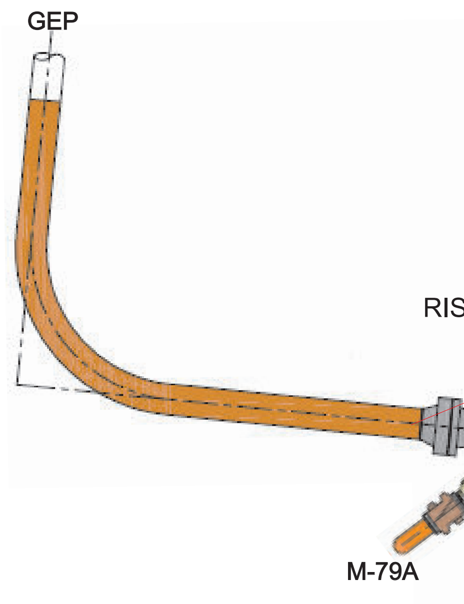
#### *2.5.7.4 Cuprotect Coated Structures*

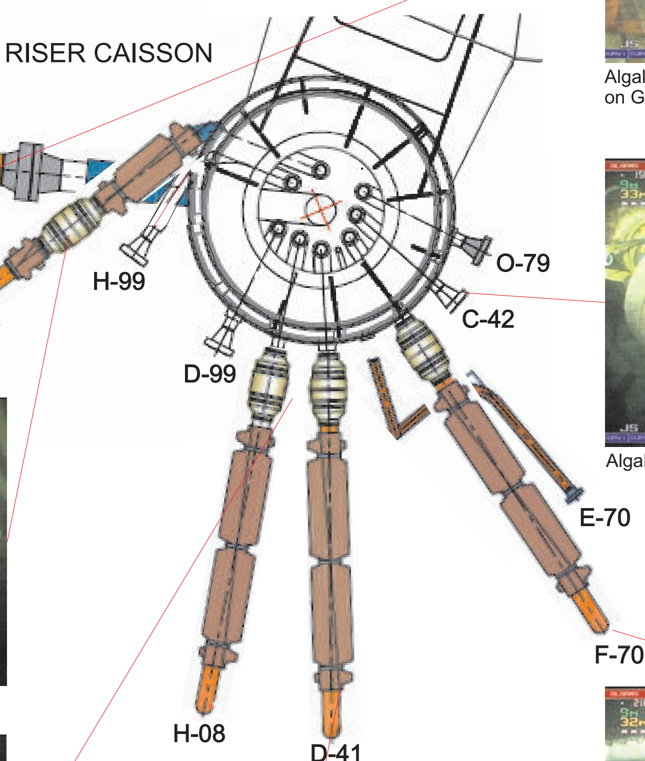
- Surfaces with Cuprotect coating remained untouched by marine growth. Algal vegetation, where observed, was found only on non-coated Inconel 625 straps (**Table 2.16**, **Figure 7**);
- Algal growth was found colonizing future flange caps. The flange caps were not treated with Cuprotect coating, as shown in the inspection drawings (**Table 2.16**, **Figure 7**);
- As mentioned in the Subsea Structure section, (Section 2.5.7.2), some fish and benthic species were observed in the immediate vicinity of surface areas coated with Cuprotect.

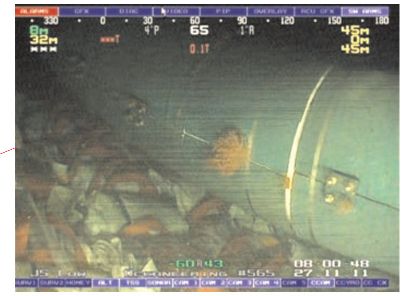
**Table 2.16 - Fish Habitat: Faunal Analysis of Cuprotect Coated Structures**

| November 2011 Video Assessment - PFC | | | | |
|---|---|---|---|---|
| **Structure** | **Fauna** | **Abundance** | **Number** | **Description** |
| GEP | *Gadus morhua* | | 73 | • Algal vegetation present only on stainless steel band clamp |
| | Algal vegetation | O | | |
| | | | | |
| R-2 Insulation Cover | Algal vegetation | O | | • Present only on stainless steel band clamp |
| SPU Insulation (R-7) | *Asterias* sp. | R | | • Fauna observed around flow line |
| | *Cancer borealis* | R | | |
| Flange Caps (R3,4,8,9) | Algal vegetation | A | | • Flange caps with varying degrees of algal growth only on non-Cuprotect surfaces |

# PFC Subsea Riser Caisson

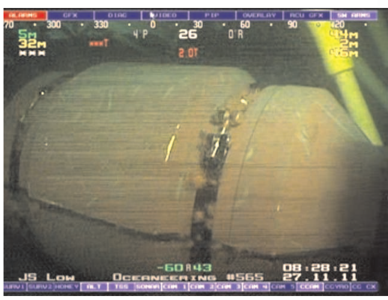




Algal growth on stainless steel strap and cod on GEP

Algal growth on flange cap of C-42 (R8)



Algal growth on stainless steel straps of insulation cover for M-79A (R2)

Insulation covers of H-08 and D-41 with no marine growth

Limited marine growth on SPU insulation of F-70 (R7)

No marine growth on cuprotect coating of D-41 (R6)

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GeoScience
Limited

#### *2.5.7.5 GEP and Flow Lines*

- In all videos analyzed, marine life appears to be abundant and diverse around the GEP in relation to the surrounding ocean floor (**see Appendix D, Fish Habitat Alteration Video Assessments; Figure 8**);
- In 34 of 36 videos analyzed, over 2500 Snow crabs (*Chionoecetes opilio*) were counted, which were the only commercial crustacean encountered (**Figure 9**). Other crustaceans found in varied abundances include Jonah crab (*Cancer borealis*), northern stone crab (*Lithodes maja*), Hermit crab (*Pagurus* sp.) and shrimp;
- Evidence from the video shows crustaceans sitting on top and on the sides of the pipeline where the pipe sat fully out of the sediment (**Figure 8, KP 83.060**);
- Redfish (*Sebastes* sp.) were found in large numbers (10,600) throughout the stretch of exposed pipeline. Other common fish species observed were Pollock (*Pollachius virens*), Flounder (Pleuronectidae), Atlantic cod (*Gadus morhua*), and Hagfish (*Myxine glutinosa*);
- Other invertebrates included echinoderms (sea cucumber, sea stars and sea urchins), anthozoans (sea anemones), gastropods and polychaetes. Sponges and soft corals did not colonize the pipeline but were observed around the base on rocks and on the ocean floor;
- A corraline-like organism was observed in two videos on top of the pipeline, (KP 31 and 33), but could not be identified further due to the distance from the ROV camera (**Figure 8, KP 33.106**);
- Flowlines from the PFC to the wellheads, as well as the GEP from KP 1 to 23, and KP 98 to 168 were either buried under the ocean floor or intermittently exposed;
- The only fauna identified on top of exposed sections of the GEP and flowlines were orange-footed sea cucumbers (*Cucumaria frondosa*) in large densities and numbers (**Figure 10)**;
- No fauna was observed on buried sections of the GEP and flowline. Only discernable features were disarticulated bivalve shells (**Figure 10, D-41 Flowline**).

### 2.5.8 Summary and Conclusions

#### *2.5.8.1 E-70 Mud/Cuttings Piles*

- No mud/cuttings piles were observed in the video at and around the E-70 drill site and wellhead. No mud/cuttings piles were observed around any of the remaining wellheads and drill sites. In agreement with the sediment chemistry data in Section 2.3, there were no traces of muds/cuttings piles at any of the wellheads.

#### *2.5.8.2 Subsea Structures*

- Epifauna colonization of WHPS/subsea trees at all well site locations observed had vertical zonation for each wellhead structure. Species composition was homogenous across all wellhead sites;
- Atlantic cod found at F-70 and not at any other wellhead sites in the June 2011 survey may be related to the presence of a food source (shrimp). Fish and shrimp had both disappeared at the same time;
- Presence of high numbers of Atlantic cod in the November 2011 survey could have a spawning/migration connection;
- Wellheads and protective structures appear to be acting as an artificial reef/refuge as evidenced by the colonization of the structures as mentioned in the 2006 EA predictions. The structures are attracting fish from the surrounding areas and providing shelter in an otherwise relatively featureless seafloor.

#### *2.5.8.3 Cuprotect Coated Structures*

- Cuprotect coated surfaces deterred the growth of marine life. The only surfaces which were colonized by marine life were the non-coated Inconel 625 steel straps which held insulation covers in place;
- Epifauna encountered around the base of the rising caisson colonized structures such as the future flange caps, sandbags and concrete protection mats which were not treated with Cuprotect coating;
- Structures provide a reef effect as evidenced by large numbers of Atlantic cod observed.

#### *2.5.8.4 GEP and Flowlines*

- The GEP acts as an artificial reef to provide shelter and protection for many species of fish (i.e. Redfish) and invertebrates;
- Commercial fish species recorded from the video analysis were Atlantic cod, pollock, flounder, haddock, hake, herring, skate, Atlantic wolffish and the redfish;
- The only commercial crustaceans observed in the analyzed video were snow crabs;
- The GEP does not act as a barrier to crustacean movement, as the evidence of several crab species sitting on top of the pipeline when it is fully unburied suggests.

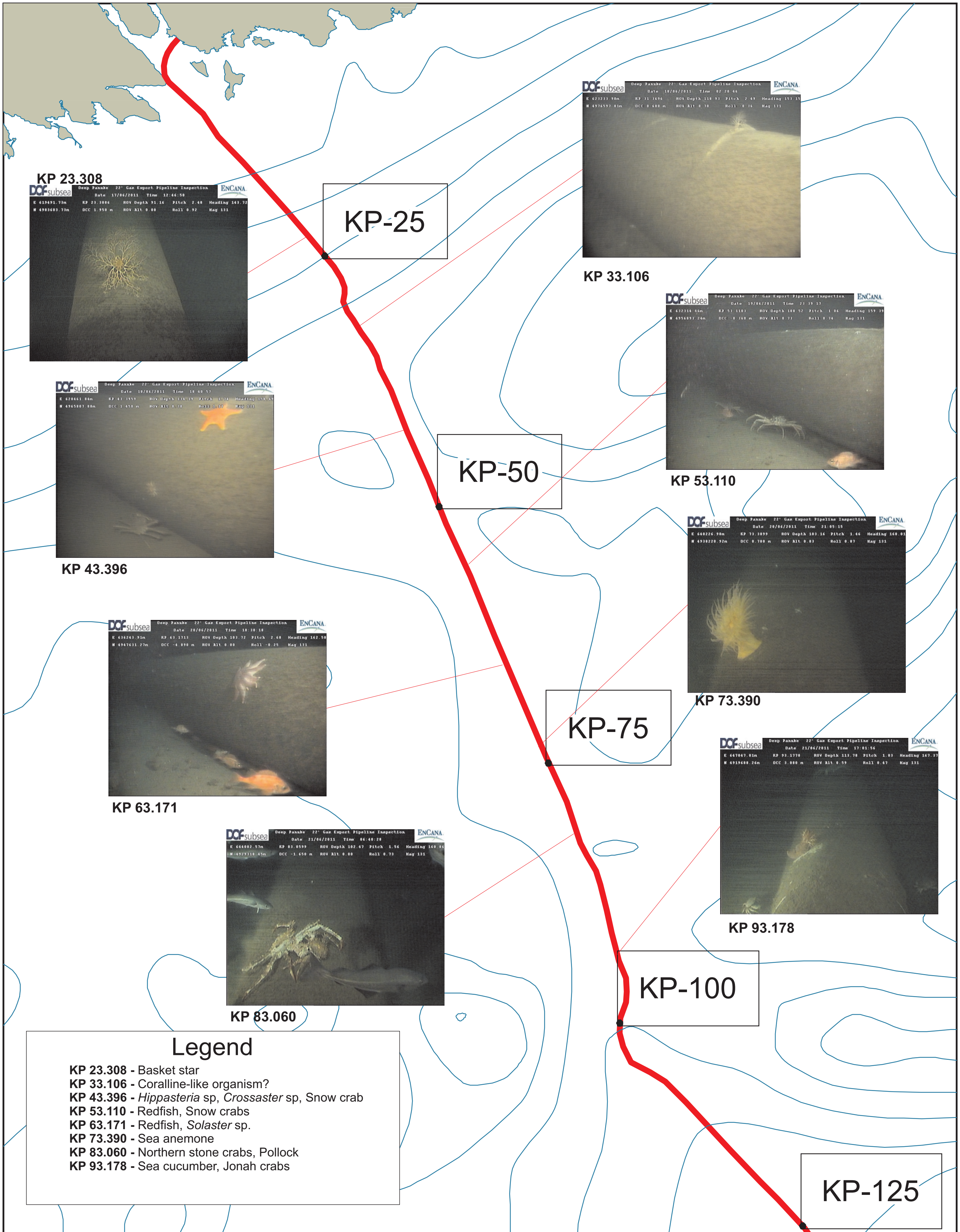


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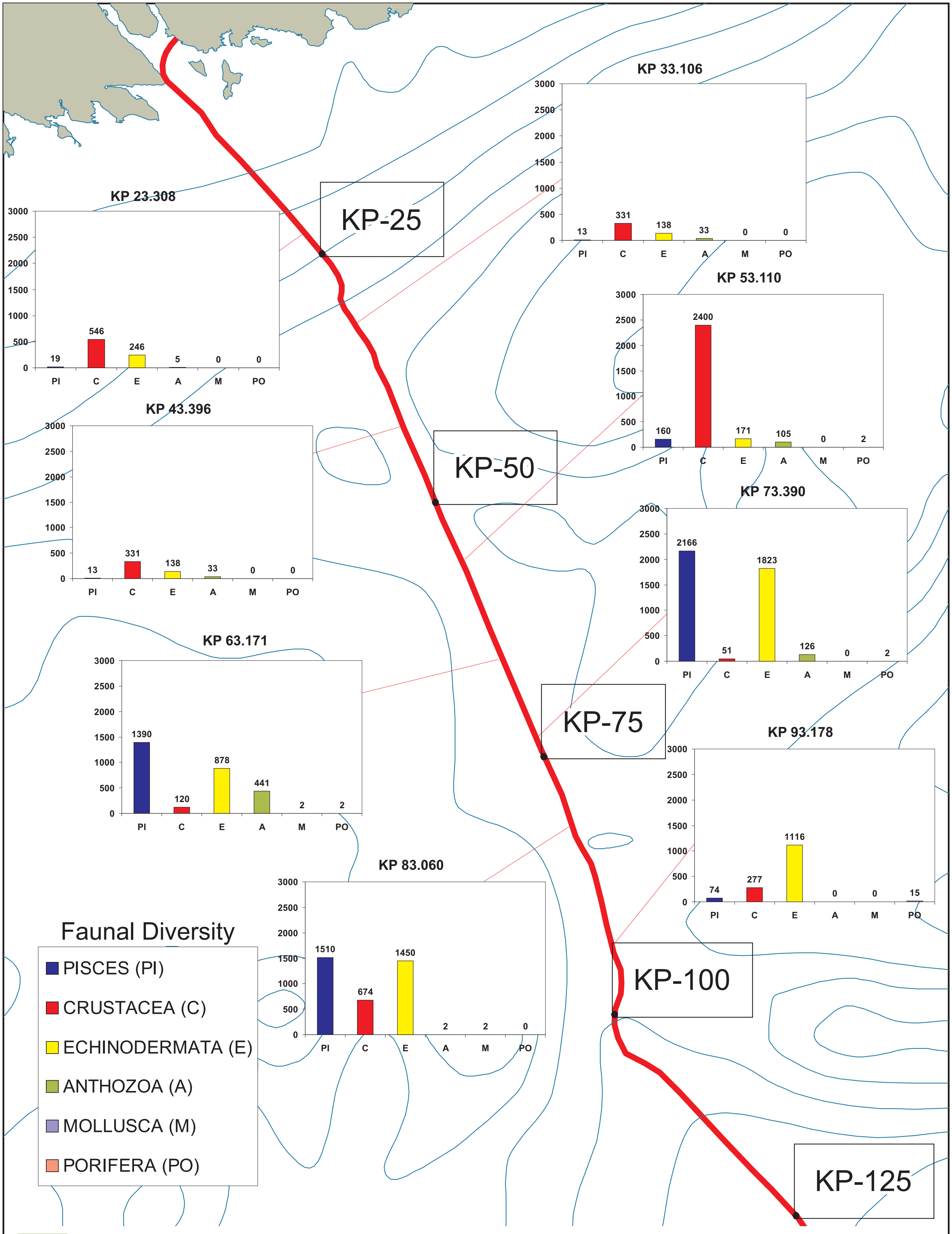
Figure 8 Representative Stills from ROV Footage Along GEP Figure 8

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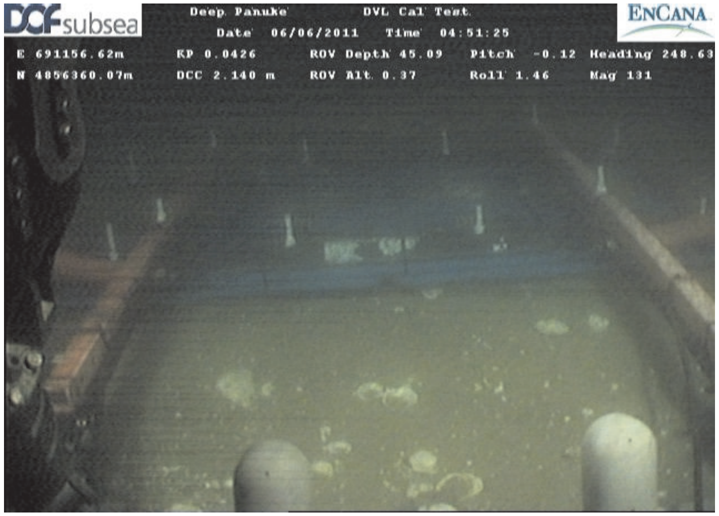
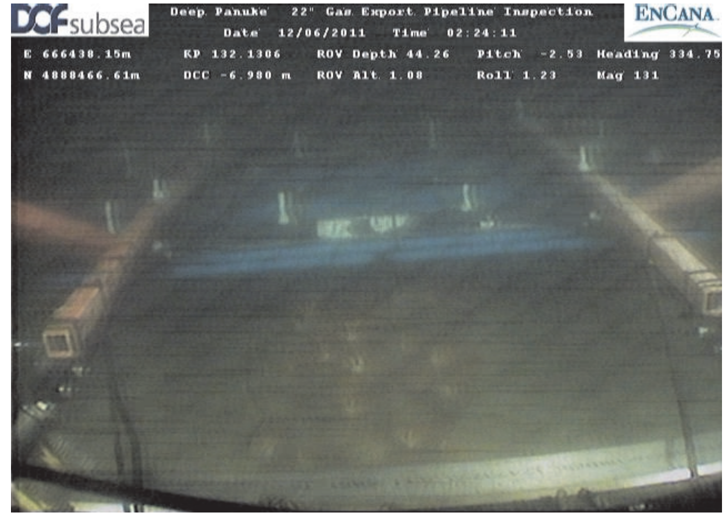
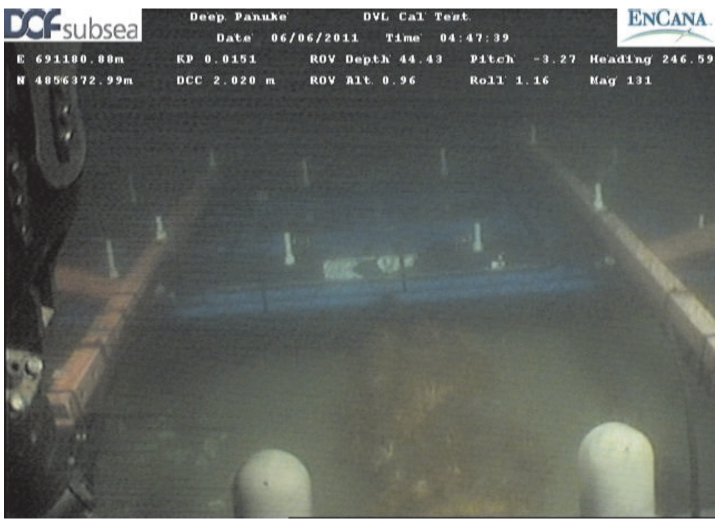
 Standardized Faunal Composition of Exposed GEP at 10 km Intervals Figure 9



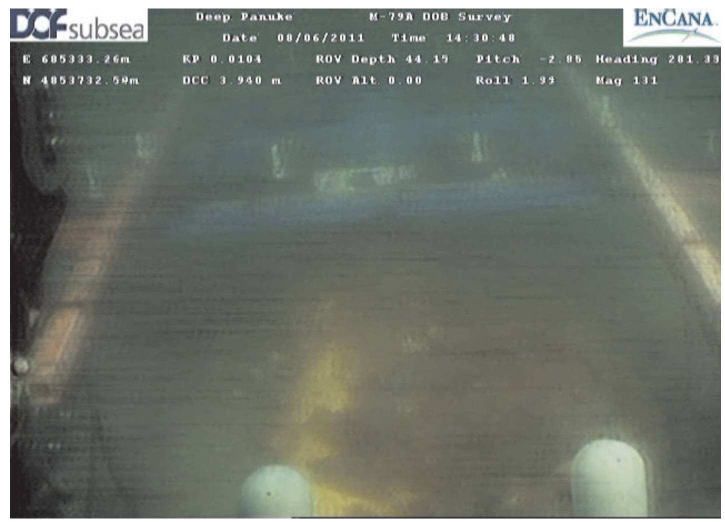

Buried flowline to wellhead D-41 with sandy seafloor and shell hash




Exposed GEP pipeline with 100% fouling of the sea cucumber *Cucumaria frondosa*




Exposed flowline to wellhead D-41 with 100% fouling of the sea cucumber *Cucumaria frondosa*




Exposed flowline to wellhead M-79A with 80% fouling of the sea cucumber *Cucumaria frondosa*

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Figure 10 Buried and Exposed GEP and Wellhead Flowlines with Associated Fauna Figure 10

## 2.6 MARINE WILDLIFE OBSERVATIONS

### 2.6.1 Background

*Marine Mammal/Sea Turtle Observations*

In recent studies, baleen whales, toothed whales, seals and sea turtles have been observed in the vicinity of production platforms and drill rigs but the animals provided no evidence of avoidance or attraction to platform operations (Encana, 2011: DMEN-X00-RP-EH-90-0003). Cetacean species, including their young, have been seen feeding. Additionally, based on the behavior of marine mammals and sea turtles observed around production platforms, it is suggested that they are not negatively affected by an altered acoustic environment which may be a result of platform operations.

*Seabird Observations*

Studies have shown that birds are attracted to offshore platforms, drilling rigs, and support vessels for roosting sites and foraging opportunities (Assessment of bird-human interactions at offshore installations **Appendix E1**). They may also be attracted to platforms as a result of disorientation caused by light sources on the rigs. Due to difficulties observing birds directly from offshore platforms and the episodic nature of bird-platform interactions, there is limited documentation of bird activities and behaviours at offshore installations. It has therefore been suggested that instrument-based approaches should be incorporated into bird monitoring programs around offshore platforms. To address this, an ongoing instrument-based bird-monitoring study is being conducted by Acadia University in partnership with Encana at the Deep Panuke offshore site. The study combines multiple, automated instrument-based monitoring techniques, including telemetry and bird-radar deployment, which are being used to quantify patterns of individual and population level bird activities on and around the PFC. For a complete description of this project, please refer to Assessment of bird-human interactions at offshore installations (**Appendix E1**).

Recently, a transect-gradient approach was adopted involving systematic observations of seabirds by Canadian Wildlife Service (CWS) biologists along supply vessel transits to and from SOEP offshore platforms (Encana, 2011: DMEN-X00-RP-EH-90-0003). This approach allows changes in the density of seabirds with respect to distance from offshore platforms to be monitored. It provides an opportunity to evaluate whether the platform provides birds with additional foraging or refuge opportunities. This program has yet to provide conclusive evidence on the effect of offshore platforms on seabird behavior.

Seabird mortality due to chronic oiling in proximity to the PFC was also monitored. Beached bird surveys carried out on Sable Island from January 1993 to present have allowed prevalence, severity and trends of oiling, in addition to data on species composition and seasonality, and species-specific oiling rates to be monitored. Results from these surveys have shown that the composition of oil found on bird corpses suggest contaminants are a consequence of cargo tank washings and bilge discharges from large ocean-going vessels travelling along shipping routes to and from the Gulf of St. Lawrence. There have been no incidences of oiled birds linked to oil and gas production activities (Greenhorse Society Website: http://www.greenhorsesociety.com/Beached_Birds/beached_birds.htm Encana, 2011: DMEN-X00-RP-EH-90-0003.)

### 2.6.2 EEMP Goal

- To detect effects on marine wildlife in the in the vicinity of Deep Panuke PFC [EA predictions #11, 12 and 13 in **Table 3.1**].

### 2.6.3 Objectives

- Estimate the seasonal densities of seabirds in the vicinity of the Deep Panuke PFC;
- Record any stranded (live or dead) birds on the platform;
- Identify the oil type/source on feathers of beached seabirds found on Sable Island;
- Record the behaviour of any marine mammals and sea turtles observed in the vicinity of the Deep Panuke PFC; and

- Support an integrated bird management research study with CWS and Acadia University to develop/adapt tracking technologies to assess seabird movement, distribution and abundance patterns at offshore installations, anthropogenic influences, and measures to mitigate risks to wildlife.

### 2.6.4 Sampling

Seasonal visual observations of seabird densities by independent trained observers situated on the Deep Panuke PFC and/or support vessels;

- Record any stranded (live or dead) birds found on the Deep Panuke PFC;
- Carry out regular surveys of beached seabirds on Sable Island;
- Seasonal visual observations of marine mammals and sea turtles in the vicinity of the Deep Panuke PFC; and
- Integrated bird management research study:
    - Develop and adapt soft and hardware interfaces with existing RADAR systems to monitor real-time round-the-clock bird activity;
    - Use radio-transmitter and solar-powered satellite tags to study movement patterns of birds during the breeding season, focusing specifically on timing of and factors affecting visits to offshore platforms; and
    - Explore relationship between anthropogenic factors (i.e. light through manipulation of non-navigational light sources) on the behaviour of birds and the availability of their prey species.

### 2.6.5 Analysis

- Seabird data collected by the observer are to be entered into a computerized database designed by the CWS; determine specific interactions (if any) of seabird with Deep Panuke offshore vessels/PFC;
- Determine the oil type on feathers from beached seabirds representing various seabird species collected on Sable Island;
- Marine mammal and sea turtle data collected by the observer are to be entered into recording forms and data summarized on an annual basis; determine specific interactions (if any) of marine mammals and sea turtles with Deep Panuke offshore vessels/PFC; and
- Bird management research study: see **Appendix E1.**

## 2.6.6 Parameters Analyzed

### Table 2.17 - Marine Wildlife Observations

| | Sampling | | Analysis | |
|---|---|---|---|---|
| **Location** | **Type/Method** | **Frequency/Duration** | **Type/Method** | **Parameters** |
| **Seabird Observations** | | | | |
| PFC | Implementation of Williams and Chardine protocol for stranded birds<br><br>Visual monitoring of seabirds, marine mammals and sea turtles around PFC | As required (systematic daily deck sweeps to be conducted for stranded birds)<br><br>In conjunction with daily deck sweeps for stranded birds | Yearly bird salvage report submitted to CWS<br><br>Direct observations | Species; condition; action taken; fate of bird<br><br>Species, counts and behavioural observations (e.g. any congregation of wildlife will be reported) |
| Transects between PFC and shoreline | Visual monitoring of seabird distributions between the PFC and the shoreline | As part of OGOP programs and of Acadia bird monitoring research | CWS protocol | CWS protocol |
| Sable Island | Beach bird surveys | Approx. 10 surveys/year | Based on CWS protocol | Oiling rate (standardized approach) |
| Sable Island and PFC area (Acadia research study) | Bird monitoring with RADAR technology; radio and satellite transmitters; camera and acoustic monitoring systems | Expected two-year program (2011 to 2013) | Analysis of radar, transmitters and camera and acoustic data | Specific research/analysis parameters to be developed |
| **Oil and Gas Observers Program (OGOP)** | | | | |
| **Tow Program** | | | | |
| Mulgrave to platform location | Visual monitoring of seabirds and marine mammals | Throughout the tow | Direct observations | Species and behaviour |
| **Rock Placement Program** | | | | |
| Between Mulgrave and platform location | Visual monitoring of seabirds and marine mammals | Throughout the duration of the program | Direct observations | Species and behaviour |
| **Umbilicals Program** | | | | |
| Mulgrave and around umbilicals | Visual monitoring of seabirds and marine mammals | Throughout the duration of the program | Direct observations | Species and behaviour |
| **Direct Marine Marine/Turtles Observations from PFC** | | | | |
| PFC | Visual monitoring | Throughout the duration of the program | Direct Observation | Species and behaviour |

## 2.6.7 Results

### *2.6.7.1 Marine Mammal, Sea Turtle, and Fish Observations*

- The following table was compiled from the OGOP Oil and Gas Observation Program Report from the Tow Program. The complete report can be found in **Appendix E**;

**Table 2.18 - OGOP Tow Program Report Summary**

| Date | Species Observes | Quantity | Observations |
|---|---|---|---|
| July 23, 2011 | Humpback | 2 adult | Swimming slowly East |
| July 23, 2011 | Common Dolphin | 4 | Jumping while moving East |
| July 24, 2011 | Fin Whale | 1 adult | Swimming fast East |
| July 24, 2011 | Humpback Whale | 2 | Swimming slowly East |
| July 25, 2011 | Minke Whale | 3 adult | Feeding |
| July 25, 2011 | Minke Whale | 1 adult | Feeding |
| July 25, 2011 | Pilot Whale | 4 adult, 1 juvenile | Swimming slowly West |
| July 25, 2011 | Common Dolphins | 10 adult, 2 juvenile | Feeding |

- The following table was compiled from the OGOP Oil and Gas Observation Program Report from the Rock Placement Program. The complete report can be found in **Appendix E**;

**Table 2.19 - OGOP Rock Placement Report Summary**

| Date | Species Observes | Quantity | Observations |
|---|---|---|---|
| July 24, 2011 | Pilot Whale | 6 adult, 2 juvenile | Swimming fast |
| July 25, 2011 | Pilot Whale | 3 adult, 1 juvenile | Swimming fast |
| July 25, 2011 | Minke Whale | 1 adult | Swimming fast |
| July 26, 2011 | Minke Whale | 1 adult | Swimming fast |
| July 27, 2011 | Minke Whale | 1 adult | Swimming fast |
| July 29, 2011 | Minke Whale | 1 adult | Swimming fast |
| July 30, 2011 | Minke Whale (probable) | 1 adult | Swimming fast |
| July 30, 2011 | Minke Whale (probable) | 1 adult | Feeding |
| July 31, 2011 | Minke Whale | 1 adult | Acting curious around vessel |
| July 31, 2011 | Minke Whale | 1 adult | Swimming fast |
| Aug 2, 2011 | Common Dolphin | 9 adult, 6 juvenile | Bow riding, swimming fast |
| Aug 2, 2011 | Pilot Whale | 4 adult, 2 juvenile | Swimming slowly and resting |

- The following table was compiled from the OGOP Oil and Gas Observation Program Report from the Umbilicals Program. The complete report can be found in **Appendix E**;

**Table 2.20 - OGOP Umbilicals Report Summary**

| Date | Species Observes | Quantity | Observations |
|---|---|---|---|
| July 11, 2011 | Fin Whale (probable) | 3 adult | Swimming and feeding |
| July 12, 2011 | Fin Whale | 6 | Swimming fast |
| July 12, 2011 | Fin Whale | 8 | Feeding |
| July 14, 2011 | Fin Whale | 2 | Feeding |
| July 14, 2011 | Fin Whale | 2 | Feeding |
| July 15, 2011 | Harbour Porpoise | 1 | Swimming around vessel |
| July 15, 2011 | Minke | 1 | Swimming |
| July 16, 2011 | Fin Whale | 2 | Swimming and diving |
| July 16, 2011 | Minke Whale | 1 | Swimming and blowing |

- The only marine wildlife other than birds identified from the PFC was a single blue shark sighted near the PFC on August 31, 2011 (**Appendix E3**).

#### 2.6.7.2 Seabird Observations

**OGOP Tow Programs Sightings**

- A Great Black-blacked Gull and a Herring Gull were observed during the Tow program.

**OGOP Rock Placement Sightings**

- A Great Black-backed Gull, Greater Shearwater, Herring Gull, Northern Fulmar, Northern Gannet, and a Sooty Shearwater were observed during the Rock Placement program.

**OGOP Umbilicals Program**

- A Black-legged Kittiwake, Great Black-backed Gull, Greater Shearwater and Herring Gull were observed during the Umbilicals Program.

**Acadia Research Study: Telemetry**

- Receivers on Sable Island documented the presence of gulls during the breeding and post-breeding period, until expected tag failure (Nov, 2011). Four Herring Gulls were detected continuously from June through August. Adjustments to improve antenna strength and attachment methods will be made for deployments in 2012;
- Six tag detections were confirmed by receivers deployed on vessels in the Sable Island area;
- One Herring Gull (tag 36) was detected on two nights in September by the Panuke Sea supply vessel which was adjacent to the Thebaud platform 9km from Sable Island;
- Tagged storm-petrels were not detected from offshore receivers during the study period.

**Acadia Research Study: Colour Banding**

- 50 birds (29 Great Black-backed Gull chicks and 21 Herring Gulls) were marked with color bands with gulls being re-sighted. See Assessment of bird-human interactions at offshore installations Report in **Appendix E1**

## Acadia Research Study: Bird-Radar Deployment

- Due to Radar Beacon (RACON) interference with the proposed bird-radar, alternate sensors are currently being investigated for the Deep Panuke bird monitoring program;
- For complete results, refer to Assessment of bird-human interactions at offshore installations (January, 2012), **Appendix E1**.

## Seabird Stranding Summary

**Table 2.21 - Seabird Strandings Summary 2011**

| Date | Vessel | Location | Results |
|---|---|---|---|
| **Subsea Asset Inspection Survey** | | | |
| May 2011 | Atlantic Condor | Between PFC and well locations (H-08, M-79A, F-70, D-41 and E-70) and export pipeline route | No seabirds observed |
| **Umbilical Installation Program** | | | |
| July 2011 | M/V Acergy Falcon | Between PFC and well locations (H-08, M-79A, F-70, D-41 and E-70) | No seabirds observed |
| **Rock Placement Program** | | | |
| July-Aug 2011 | Tideway Rollingstone | On sections of the flowlines, sections of the export pipeline and at PFC | No seabirds observed |
| **PFC Tow and Installation** | | | |
| July 2011 | PFC<br>Skandi Skolten<br>Boa Barge | PFC Area | No seabirds observed |
| **PFC Hookup and Commissioning** | | | |
| July 2011 - ongoing | Ryan Leet | PFC Area | No seabirds observed |
| | Atlantic Condor | PFC Area | Purple Gallinule discovered in good condition on July 30, 2011. See event description below. |
| **Diving Program** | | | |
| July - Nov 2011 | Acergy Discovery | PFC Area | No seabirds observed |

- A rare bird, the Purple Gallinule, was found on the Atlantic Condor on July 30, 2011;
- The bird was caught, placed in a cage and transported back to shore where it was released back into the wild.

For complete description of events, refer to Report of “Live” Migratory Seabird Salvaged Under the Authority of a Federal Migratory Bird Permit, **Appendix E1**.

## Sable Island Beached Bird Survey

- During 2011 413 beached fulmars, shearwaters, gannets, Larus gulls, and alcids were collected on Sable Island (**Appendix E5**)
- 0.7% of shearwaters and 13.0% of Alcids (including Razorbill and Atlantic Puffin) were oiled.

**Table 2.22 - Seabird Corpses Collected on Sable Island 2011**

| Bird Species and Groups | Total[1] Corpses | Winter[2] | Summer[2] | #/km Winter[2] | #/km Summer[2] | Oiling[2] % |
|---|---|---|---|---|---|---|
| Northern Fulmar | 70 | 8 | 50 | 0.024 | 0.094 | 0 |
| Shearwater | 209 | 0 | 149 | 0 | 0.279 | 0.7 |
| Northern Gannet | 13 | 1 | 10 | 0.003 | 0.019 | 0 |
| Larus Gulls | 28 | 12 | 10 | 0.037 | 0.019 | 0 |
| Alcids | 93 | 23 | 0 | 0.061 | 0 | 13.0 |
| Common and Thick-billed Murres | 10 | 5 | 0 | 0.015 | 0 | 0 |
| Dovekies | 48 | 14 | 0 | 0.043 | 0 | 0 |

1. - Total corpses
2. - Intact Corpses

### 2.6.8 Summary and Conclusions

- Oil and Gas Observer Program (OGOP) was successfully carried out during the Tow Program, the Rock Placement Program and the Umbilicals Program;
- 60+ sightings of marine mammals were noted with some feeding and the majority transiting through the area;
- A single bird stranding occurred with the bird being returned to its natural habitat unharmed;
- The bird monitoring program, Assessment of Bird-Human Interactions at Offshore Installations, is underway;
- Improvements to bird monitoring technologies (bird radar and telemetry tags) are being developed to increase the capabilities of the bird monitoring program.
- The 2011 oiling rate is 13.0% compared to 5.3% observed 2010. However, this rate is consistent with previous <15% recorded over the last four years. Six samples of oil were collected in 2011, and likely represented four separate discharge events. None of the six samples contained light or mid-ranged distillate fuels, or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms off Sable Island.

# 3 ENVIRONMENTAL ASSESSMENT (EA) PREDICTIONS

## Table 3.1 - EEM Related Environment Assessment (EA) Predictions and 2011 Results

| # | *EA Predictions* | *Relevant Section of 2006 EA* | *VEC(s)* | *EEM Component(s)* | *2011 Plan* | *2011 Results* |
|---|---|---|---|---|---|---|
| 1 | No significant adverse effects are predicted on marine receptors that are linked to water quality due to various levels of treatment of produced water on the PFC platform and rapid dilution of discharged water. | 8.2.4<br>8.3.4<br>8.4.4<br>8.5.4 | - Marine Water Quality<br>- Marine Benthos<br>- Marine Fish<br>- Marine Mammals and Sea Turtles | - Produced Water Chemistry and Toxicity<br>- Marine Water Quality<br>- Monitoring<br>- Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | Use Niskin bottles to collect water samples in order to determine baseline levels of metals; non-metals (nitrogen, phosphorus, sulphur, oxygen); TPH, PAHs and APs; nutrients; H2S; salinity; pH and temperature; as per Deep Panuke's Production EPCMP (DMEN-X00-RP-EH 90-0002) | 2011 results represent baseline condition prior to the PFC becoming operational. Metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental quality guidelines) where available. Therefore, background-levels indicate no current sources of contaminants, with negligible current risk to biota, their functions, or any interactions that are integral to sustaining the health of the ecosystem and the designated resource uses they support. |
| 2 | Mortality of benthic organisms due to exposure of the diluted brine plume is unlikely due to the short duration of exposure coupled with the high dilution factor. In the case of limited mortality of benthic organisms, habitat would be re-colonized from adjacent areas. | 8.3.4.1 | - Marine Benthos | - Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration | Suitable marine amphipod species such as *Rhepoxynius abronius* or *Eohaustoriux estuaries* in order to determine sediment toxicity baseline levels.<br><br>Inspection of ROV video data to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | Inspection of ROV video data at each well-head location revealed no visible signs of drill cuttings. Benthic communities were well developed at each of the wellheads, with a dense and diverse epifaunal fouling community on the wellhead protection structures. Dense fish aggregations were also observed, suggesting no negative impacts, and possible "reef" affects attracting mobile organisms into the vicinity of the subsea structures. Bioassay test results reported no organisms exhibiting unusual appearance. Samples and control sediment as tested were found to be non-toxic to the amphipod *Eohaustorius estuarius*. |
| 3 | The discharged water will have a maximum “end of pipe” temperature anomaly of 25°C. The temperature anomaly will be a maximum of a 2.5°C upon | 8.4.4.2<br>8.3.4.2 | - Marine Fish<br>- Marine Benthos | - Produced Water Chemistry and Toxicity<br>- Marine Water Quality Monitoring<br>- Sediment Chemistry | Produced water discharge to commence in 2012. | Produced water discharge to commence in 2012. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | contact with the seafloor. Beyond 130 m, the temperature anomaly will be less than that 1°C and will fall below 0.4°C at a distance of 500m. The temperature anomalies are not predicted to exceed temperature tolerance thresholds of fish species except in the immediate area (i.e., tens of metres) from the end of pipe discharge. The benthic organisms of the study area are capable of withstanding variable temperatures and the predicted 2.5°C temperature anomaly in unlikely to exceed tolerance thresholds of benthic species present. | | | and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | | |
| 4 | The maximum salinity anomaly of the plume upon contact with the seafloor will be about 0.7 PSU. Upon spreading of the plume, the maximum salinity anomaly will fall below 0.6 PSU within 100 m of the site (seafloor) and 0.1 with 500 m. Similar to the effects of the bulk discharge of completion fluid, the predicted salinity anomaly of the plume upon contact with the bottom is minor and is unlikely to exceed tolerance thresholds of benthic organisms or fish. | 8.3.4.2<br>8.4.4.2 | - Marine Benthos<br>- Marine Fish | - Produced Water Chemistry and Toxicity<br>- Marine Water Quality<br>- Monitoring<br>- Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | Produced water discharge to commence in 2012. | Produced water discharge to commence in 2012. |
| 5 | Treating the produced water at several levels (including continuous polishing) prior to discharge and the rapid dilution of the plume implies that benthic organisms will be exposed to very low concentrations of contaminants that are unlikely to elicit measurable effects. | 8.3.4.2 | - Marine Benthos | - Produced Water<br>- Chemistry and Toxicity<br>- Marine Water Quality Monitoring<br>- Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | Produced water discharge to commence in 2012. | Produced water discharge to commence in 2012. |
| 6 | Experimental data pertinent to the toxicity of H2S on fish suggest that the concentrations of H2S that fish will likely be | 8.4.4.2 | - Marine Fish | - Produced Water<br>- Chemistry and<br>- Toxicity<br>- Marine Water Quality | Produced water discharge to commence in 2012. | Produced water discharge to commence in 2012. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | exposed to at Deep Panuke are much less than the concentrations required to cause chronic or acute effects, including at the point of discharge. The full-time "polishing" of produced water on the MOPU and the rapid dilution of the plume will result in fish being exposed to extremely low concentrations of Alkylatedphenols that are unlikely to elicit measurable effects. | | | Monitoring<br>- Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | | |
| 7 | The effects of cuttings and WBM are most likely to affect demersal fishes as drilling wastes will fall out of suspension and settle on the seafloor or be held in the benthic boundary layer. | 4.4.4.1 | - Marine Fish | - Sediment Chemistry and Toxicity<br>- Fish Habitat Alteration<br>- Fish Health Assessment | ROV video data to be inspected in order to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc.<br><br>Collect sediments samples from D-41, F-70, E-70, M-79A, 250m DS, 500m DS, 1000m DS, 2000m DS, H-08 in order to determine grain size and baseline levels for: TOC, metals, non-metals, hydrocarbons; TPH, PAHs, APs, and sulphides. | Inspection of ROV video data at each well-head location revealed no visible signs of drill cuttings. Metal and non-metal concentrations measured from sediments collected within the vicinity of the well heads were all found to fall below threshold levels as defined by the Canadian EQG (Environmental quality guidelines) where available. Therefore, there is negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of the ecosystem and the designated resource uses they support. |
| 8 | Overall, cuttings piles are not expected to persist for more than a year due to the dynamic and energetic environment (i.e. currents and storm events) of Sable Island Bank. Following dissipation of the cuttings pile, the benthic community is expected to recover within 2 to 3 years through recruitment from adjacent areas. | 8.3.4<br>8.4.4 | - Marine Benthos<br>- Marine Fish | - Sediment Chemistry<br>- and Toxicity<br>- Fish Habitat Alteration | ROV video data to be inspected in order to determine signs of drill cuttings and development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | No mud/cuttings piles were observed in the video content at and around the E-70 drill site and wellhead. |
| 9 | Marine life will benefit to a minor extent from a "reef" effect due to additional habitat created by PFC facilities and exposed sections of the subsea pipeline to shore and a "refuge" effect associated with the creation of a safety (no fishing) | 8.2.4<br>8.3.4<br>8.4.4<br>8.5.4 | - Marine Benthos<br>- Marine Fish<br>- Marine Mammals and Turtles | - Fish Habitat Alteration | ROV video data to be inspected in order to determine and interpret the development of benthic communities at the wellheads, wellhead protection structures, pipelines etc. | There was evidence that the PFC facility was causing a "reef" effect due to the habitat created by the physical sub-sea structures. Epifauna colonization of WHPS at all well site locations observed displayed vertical epifaunal community zonation for each |

| | | | | | | |
|---|---|---|---|---|---|---|
| | zone around PFC facilities. | | | | | wellhead structure. Dense epifaunal colonization was recorded on many of the subsea structures, with the exception of those protected by anti-fouling coatings. Presence of high numbers of Atlantic Cod in November survey, and other fish species recorded at the PFC facilities and exposed sections of the subsea pipeline to shore suggest that the structures are acting as a "refuge" for some commercial species. Seasonal trends in the abundance of cod between ROV surveys conducted in June and November could have a spawning/migration connection. |
| 10 | It is highly unlikely that the proposed subsea pipeline, where unburied, would constitute a significant concern as a physical barrier to crustacean movement. | 8.3.4<br>8.4.4 | - Marine Benthos<br>- Marine Fish | - Fish Habitat Alteration | ROV video data to be inspected in order to determine and interprtet the development of benthic communities along the pipeline. | The subsea pipeline does not constitute a physical barrier to crustacean movement as evidenced by multiple species of crabs on top and on the sides of the exposed structure. |
| 11 | Marine Mammals and Sea Turtles may be attracted to the PFC area due to the availability of increased prey species (“reef/refuge” effects) or thermal plume (in winter). | 8.2.4<br>8.4.4<br>8.5.4 | - Marine Water<br>- Quality<br>- Marine Fish<br>- Marine Mammals and Turtles | - Marine Water Quality<br>- Monitoring<br>- Marine Wildlife<br>- Observations | Summarize observations from the OGOP, Tow program, Rock Placement Program, and Umbilicals Program. | - Oil and Gas Observer Program (OGOP) was successfully carried out during the Tow Program, the Rock Placement Program and the Umbilicals Program.<br>- 60+ sightings of marine mammals were noted with some feeding and the majority transiting through the area.<br>- No attraction of wildlife have been observed at the PFC with the exception of a blue shark (*Prionace glauca)* August 31st, 2011. |
| 12 | Birds, such as gulls and tubenoses, can be attracted by macerated sewage and food waste, although this was not observed at the Cohasset Project. Overall, the potential effects of the presence of project related lighting and flares will be low. | 6.3.6.4<br>(2002 CSR) | - Marine Related<br>- Birds | - Marine Wildlife<br>- Observations | Summarize observations and findings from OGOP, Acadia University Telemetry, Acadia University Colour Banding, Acadia University Bird-Radar Development (RACON), Sable Island Beach Surveys and vessel observations. | - The bird monitoring program, Assessment of Bird-Human Interactions at Offshore Installations, is underway.<br>- Improvements to bird monitoring technologies (radar, tagging, camera and acoustic monitoring) are being developed to increase the capabilities of the bird monitoring program. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | The potential for oiling of birds and/or contamination of their food sources from discharged produced water is unlikely since a sheen, if it did occur, would be very short lived and would be unlikely to produce any oiling of bird plumage. | 8.2.4<br>8.6.4 | - Marine Water<br>- Quality<br>- Marine Related<br>- Birds | - Marine Water Quality<br>- Monitoring<br>- Marine Wildlife<br>- Observations | Summarize observations and findings from Sable Island Beach Surveys and vessel observations. | Produced water discharge to commence in 2012. |
| 14 | Routine operations can be conducted with sufficient mitigation to ensure that effects on air quality are not significant. | 8.1.4 | - Air Quality | - Air Quality Monitoring | Air monitoring program being discussed with Environment Canada and NSE. Data to be provided by Encana in 2012. | Air monitoring program being discussed with Environment Canada and NSE. Data to be provided by Encana in 2012. |
| 15 | Air quality modeling for accidental events indicates exposure levels to receptors on Sable Island remain not significant. | 8.1.4 | - Air Quality<br>- Sable Island | - Air Quality Monitoring | Air monitoring program being discussed with Environment Canada and NSE. Data to be provided by Encana in 2012. | Air monitoring program being discussed with Environment Canada and NSE. Data to be provided by Encana in 2012. |

# 4 RECOMMENDED EEM PROGRAM FOR 2012

## Table 4.1 - Summary of Deep Panuke Offshore EEMP Sampling Activities, Analysis, and 2012 Recommendations

| EEMP Component | Sampling | | | Analysis | | 2012 Recommendations |
|---|---|---|---|---|---|---|
| | Location | Type/Method | Frequency/Duration | Type/Method | Parameters | |
| **Produced Water Chemistry and Toxicity** | PFC (prior to mixing with seawater system discharge) | Niskin Bottle | Twice annually after First Gas | Water quality composition | Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters | Start produced water sampling in 2012; to be collected and analyzed twice a year. |
| | | | Annually after First Gas | LC49 bioassay acute toxicity analysis | | Continue LC49 bioassay collection into 2012. |
| **Marine Water Quality Monitoring** | Triplicate seawater samples at 5 near-field downstream sites and 2 upstream sites along tide direction | Niskin Bottle | In 2011 (prior to First Gas), then annually for the three following years | Water quality composition | Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters | Continue annual water sampling program into 2012. |
| **Sediment Chemistry and Toxicity** | 9 near-field benthic sampling locations and 2 far-field reference sites | Grab Sample | In 2011 (prior to First Gas and post 2010 drilling and completion activities), then annually for the following three years | Chemical composition | Sediment grain size and TOC; suite of metals and hydrocarbons measured in 2008 Benthic Baseline Study; TPH, PAHs and APs; and sulphides. | Continue with annual 10 near-field benthic sample locations into 2012. |
| | | | | LC49 bioassay acute toxicity analysis | Suitable marine amphipod species such as *Rhepoxynius abronius* or *Eohaustoriux estuaries* | Continue LC49 bioassay into 2012 |
| **Fish Habitat** | E-70 drill site and subsea production structures | ROV video- camera Survey | Annually (using planned activities, e.g. routine inspection and storm scour surveys) | Videotape analysis | Cutting piles at E-70 (if any): evaluate size and rate of piles dispersal and whether piles are serving as new habitat by epibenthic mega-fauna Subsea production structures: evaluate the extent of marine colonization | Discontinue E-70 cuttings pile monitoring.<br><br>Continue fish habitat analysis near subsea production structures into 2012 with annual ROV footage of wellsite structures and pipeline. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fish Health Assessment** | Mussels: PFC SW leg97<br>Fish: immediate vicinity of PFC and suitable far-field reference sites98 | Mussels: scraping<br>Fish: angling | Mussels: annually after First Gas Fish: every 3 years after First Gas | Mussels: body burden<br>Fish: enzyme induction, pathology | Mussels: body burden analysis for potential petroleum contaminants (e.g. PAHs, APs, sulphides) Fish: body burden analysis for potential petroleum contaminants (e.g. PAHs, APs, sulphides) and enzyme activity; haematology; EROD activity; gross and tissue (particularly liver/gill) histopathology *Note*: standard characteristics of mussels/fish will also be Collected (e.g. length, weight, sex, etc). | Start mussel health assessment in 2012. (Fish health assessment to start three years after First Gas) |
| **Marine Wildlife Observations** | PFC | Implementation of Williams and Chardine protocol for stranded birds | As required (systematic daily deck sweeps to be conducted For stranded birds) | Yearly bird salvage report to be submitted to CWS | Species; condition; action taken; fate of bird | Continue all observation programs and analysis into 2012 |
| | Transects between PFC and shoreline | Visual monitoring of seabirds, marine mammals and sea turtles around PFC | In conjunction with daily deck sweeps for stranded birds | Direct Observations | Species, counts and behavioural observations (e.g. any congregation of wildlife will be reported) | |
| | Sable Island | Visual monitoring of seabird distributions between the PFC and the shoreline | Determined in collaboration with CWS | To be determined In collaboration with CWS | To be determined in collaboration with CWS | |
| | Sable Island and PFC | Beach bird surveys | Approx. 10 surveys/year | Based on CWS protocol | Oiling rate (standardized approach) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Bird monitoring with RADAR technology; radio and satellite transmitters; light manipulation | Expected two-year program (2011 to 2013) | Analysis of radar, transmitters and light data | Specific research/analysis parameters to be developed | |
| **Air Quality Monitoring** | Sable Island Air Quality Monitoring Station<br><br>PFC | Air quality monitoring instrumentation<br><br>Visual observations of flare plume | Continuous<br><br>Twice daily | Compare flare Plume anomalies with Sable Island air quality and meteorological records | Fine and ultra-fine particulates; Volatile Organic Carbons (VOCs), Sulphur dioxide (SO2); Hydrogen sulphide (H2S); Nitrogen oxides (NOx); Ozone (O3); Flare smoke shades | Data not available in 2011. Air emission monitoring program being discussed with Environment Canada and NSE. Expected to start in 2012.<br><br>PFC plume observations to start once flaring has started. |

# APPENDICES

# APPENDIX A

McGregor Field Logs and Sample Photographs 2011

McGregor GeoScience Limited

Datum: WGS84 Projection: Zone 20N

Site: 5000 US (NE) Core: 5000 US (NE) R1 Date: Dec. 4, 2001 Time (UTC): 9:12

Position: N 4853499 E 685735

Depth (m bsl): 42 Penetration (cm): 13cm Sampling Method: VV

Sediment Composition: SAND - Fine to Medium


Sediment Features: Burrows? Tubes? Casts? Smell _______ Color _Brown_ Sediment Stratification_No______

Sediment Anoxia: **None** Streaks Patches Layer Depth of Layer from Surface ________

Notes:

Samples Collected:
Bioassay 1L Bag: **A** **B** Metals Clear 250ml: **A** **B** PSA Clear 250ml: **A** **B**
BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A** **B**
Photo Taken: **Yes** No

**McGregor GeoScience Limited**

**Datum: WGS84 Projection: Zone 20N**

**Site:** **D-41** **Core:** **D-41 R1** **Date:** **Dec. 4, 2001** **Time (UTC):** **10:02**

Position: **N 4856457** **E 691139**

Depth (m bsl): 48 Penetration (cm): 12cm Sampling Method: VV

Sediment Composition: SAND - Fine to Medium


Sediment Features: Burrows? Tubes? Casts? Smell _______ Color _Brown_ Sediment Stratification_Yes____

Sediment Anoxia: None Streaks **Patches** Layer Depth of Layer from Surface _4cm____

Notes:

Samples Collected:

Bioassay 1L Bag: **A** **B** Metals Clear 250ml: **A** **B** PSA Clear 250ml: **A** **B**

BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A** **B**

Photo Taken: **Yes** No

**McGregor GeoScience Limited**

**Datum: WGS84 Projection: Zone 20N**

| | | | |
|---|---|---|---|
| **Site:** **F-70** | **Core:** **F-70-R1** | **Date:** **Dec. 4, 2001** | **Time (UTC):** **10:48** |

Position: **N 4854991** **E 687804**

Depth (m bsl): 49 Penetration (cm): 12cm Sampling Method: VV

Sediment Composition: SAND - Fine to Medium


| | |
|---|---|
| Sediment Features: | Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification________ |
| Sediment Anoxia: | None Streaks Patches Layer Depth of Layer from Surface ________ |
| Notes: | Organic debris on surface of sediment |
| Samples Collected: | Bioassay 1L Bag: **A** **B** Metals Clear 250ml: **A** **B** PSA Clear 250ml: **A** **B**<br>BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A** **B**<br>Photo Taken: **Yes** No |

McGregor GeoScience Limited

Datum: WGS84 Projection: Zone 20N

| Site: E-70 | Core: E-70-R1 | Date: Dec. 4, 2001 | Time (UTC): 11:15 |
|---|---|---|---|

Position: **N 4854714** **E 687304**

Depth (m bsl): 47 Penetration (cm): 12cm Sampling Method: VV

Sediment Composition: SAND - Fine to Medium rippled SAND


Sediment Features: Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification_______

Sediment Anoxia: None Streaks Patches Layer Depth of Layer from Surface ________

Notes: Organic debris on surface of sediment including shell fragments

Samples Collected:

Bioassay 1L Bag: A B Metals Clear 250ml: A B PSA Clear 250ml: A B

BTEX/TPH/PAH 60ml: A Sulphide Clear 120ml: A Alkylated Phenols Amber 250ml: A B

Photo Taken: Yes No

**McGregor GeoScience Limited**

**Datum: WGS84 Projection: Zone 20N**

| | | | |
|---|---|---|---|
| **Site:** M-79A | **Core:** M-79A-R3 | **Date:** Dec. 4, 2001 | **Time (UTC):** 12:36 |

Position: **N 4853759** **E 685249**

Depth (m bsl): 49 Penetration (cm): 13cm Sampling Method: VV

Sediment Composition: Fine to Coarse rippled SAND - organic matter on surface


Sediment Features: Burrows? Tubes? Casts? Smell _No_ Color _Brown_ Sediment Stratification____

Sediment Anoxia: **None** Streaks Patches Layer Depth of Layer from Surface ________

Notes:

Samples Collected:

| | | |
|---|---|---|
| Bioassay 1L Bag: **A B** | Metals Clear 250ml: **A B** | PSA Clear 250ml: **A B** |
| BTEX/TPH/PAH 60ml: **A** | Sulphide Clear 120ml: **A** | Alkylated Phenols Amber 250ml: **A B** |
| Photo Taken: **Yes** No | | |

**McGregor GeoScience Limited**

Datum: WGS84 Projection: Zone 20N

| Site: 250 DS | Core: 250 DS-R1 | Date: Dec. 4, 2001 | Time (UTC): 13:02 |
|---|---|---|---|

Position: **N 4853499** **E 685735**

Depth (m bsl): 50 Penetration (cm): 12cm Sampling Method: VV

Sediment Composition: Fine to Medium rippled - SAND


Sediment Features: **Burrows Tubes** Casts? Smell _No____ Color _Brown_ Sediment Stratification_No_____

Sediment Anoxia: None Streaks **Patches** Layer Depth of Layer from Surface ________

Notes: Organic materia on surface, faunal debris - shells

Samples Collected:
Bioassay 1L Bag: **A** **B** Metals Clear 250ml: **A** **B** PSA Clear 250ml: **A** **B**
BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A** **B**
Photo Taken: **Yes** No

**McGregor GeoScience Limited**

**Datum: WGS84 Projection: Zone 20N**

**Site:** **500 DS** | **Core:** **500 DS-R1** | **Date:** **Dec. 4, 2001** | **Time (UTC):** **13:30**

Position: **N 4853245** **E 685649**

Depth (m bsl): 50 | Penetration (cm): 12cm | Sampling Method: VV

Sediment Composition: Fine to Medium rippled - SAND


Sediment Features: Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification________

Sediment Anoxia: **None** Streaks Patches Layer Depth of Layer from Surface ________

Notes: Organic debris on surface of sediment

Samples Collected:
- Bioassay 1L Bag: **A** **B**
- Metals Clear 250ml: **A** **B**
- PSA Clear 250ml: **A** **B**
- BTEX/TPH/PAH 60ml: **A**
- Sulphide Clear 120ml: **A**
- Alkylated Phenols Amber 250ml: **A** **B**
- Photo Taken: **Yes** No

**McGregor GeoScience Limited**

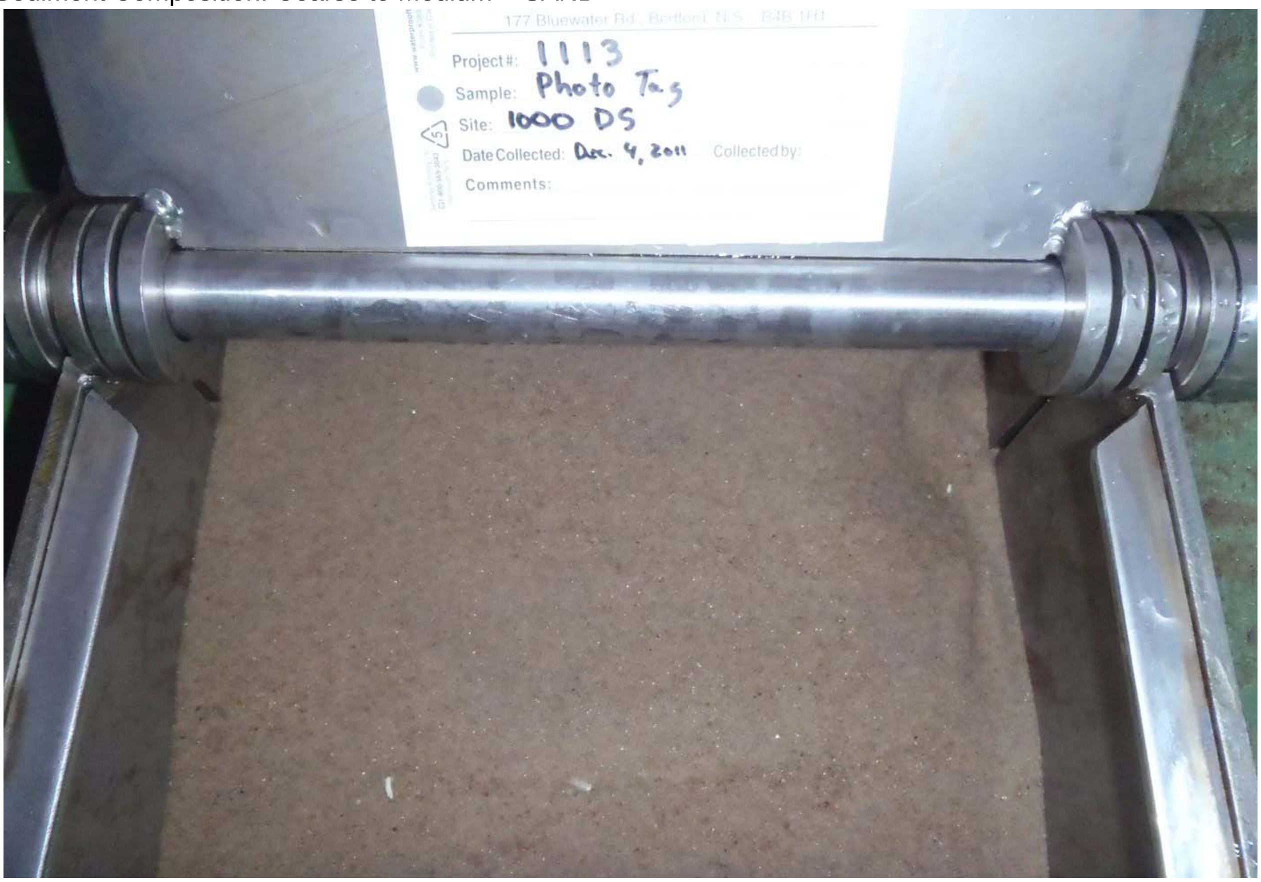
**Datum: WGS84 Projection: Zone 20N**

| | | | |
|---|---|---|---|
| **Site:** 1000 DS | **Core:** 1000 DS-R1 | **Date:** Dec. 4, 2001 | **Time (UTC):** 14:12 |

Position: **N 4852944** **E 685223**

Depth (m bsl): 48 Penetration (cm): 7cm R1, 15cm R2 Sampling Method: VV

Sediment Composition: Coarse to Medium - SAND




| | |
|---|---|
| Sediment Features: | Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification_______ |
| Sediment Anoxia: | **None** Streaks Patches Layer Depth of Layer from Surface ________ |
| Notes: | R1 = Bioassay samples, R2 = Chemistry samples |
| Samples Collected: | Bioassay 1L Bag: **A B** Metals Clear 250ml: **A B** PSA Clear 250ml: **A B**<br>BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A B**<br>Photo Taken: **Yes R2** |

**McGregor GeoScience Limited**

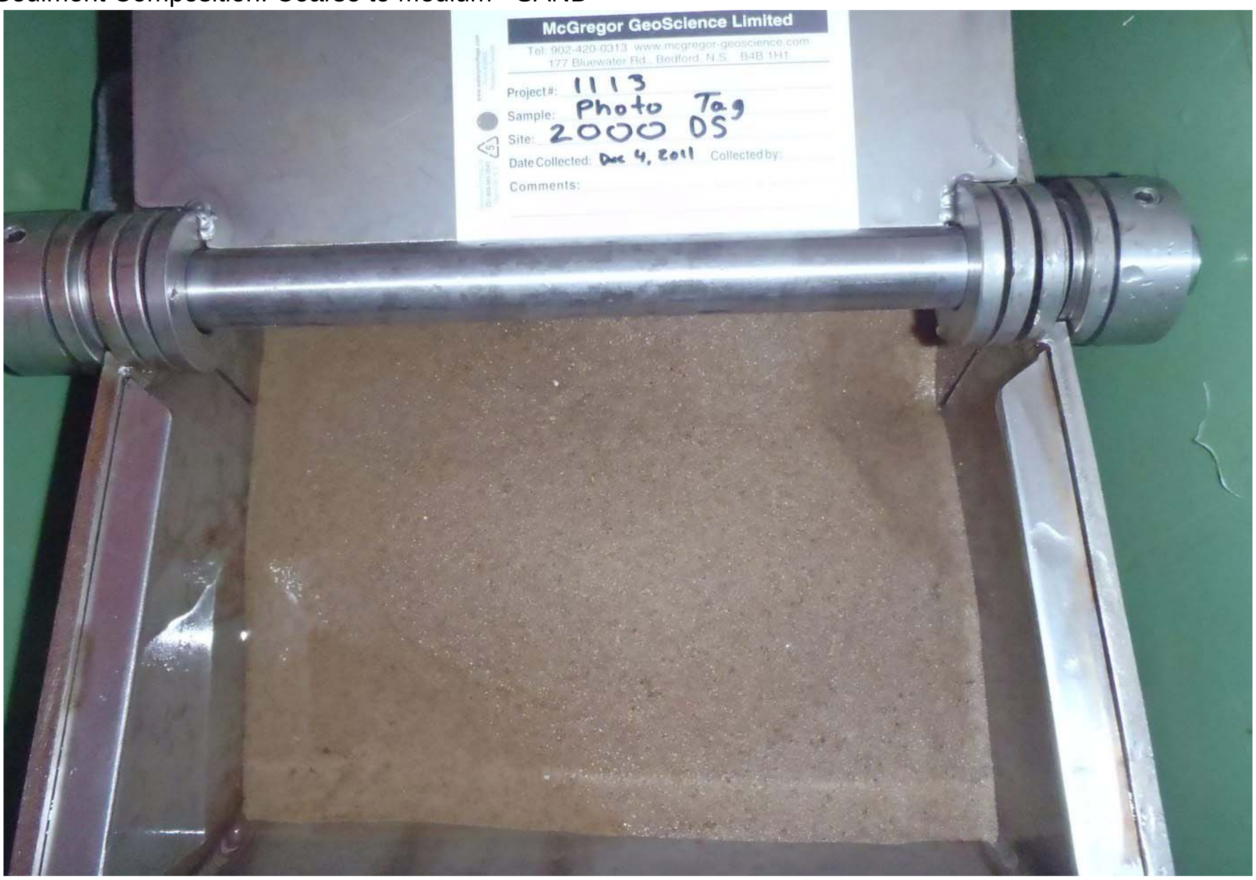
**Datum: WGS84 Projection: Zone 20N**

**Site:** **2000 DS** **Core:** **2000 DS-R2** **Date:** **Dec. 4, 2001** **Time (UTC):** **14:52**

Position: **N 4852266** **E 684492**

Depth (m bsl): 45 Penetration (cm): 12cm Sampling Method: VV

Sediment Composition: Coarse to Medium - SAND




Sediment Features: Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification_No____

Sediment Anoxia: **None** Streaks Patches Layer Depth of Layer from Surface ________

Notes: R1 = no sample, R2 = Chemistry samples

Samples Collected:
Bioassay 1L Bag: **A** **B** Metals Clear 250ml: **A** **B** PSA Clear 250ml: **A** **B**
BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A** **B**
Photo Taken: **Yes R2**

**McGregor GeoScience Limited**

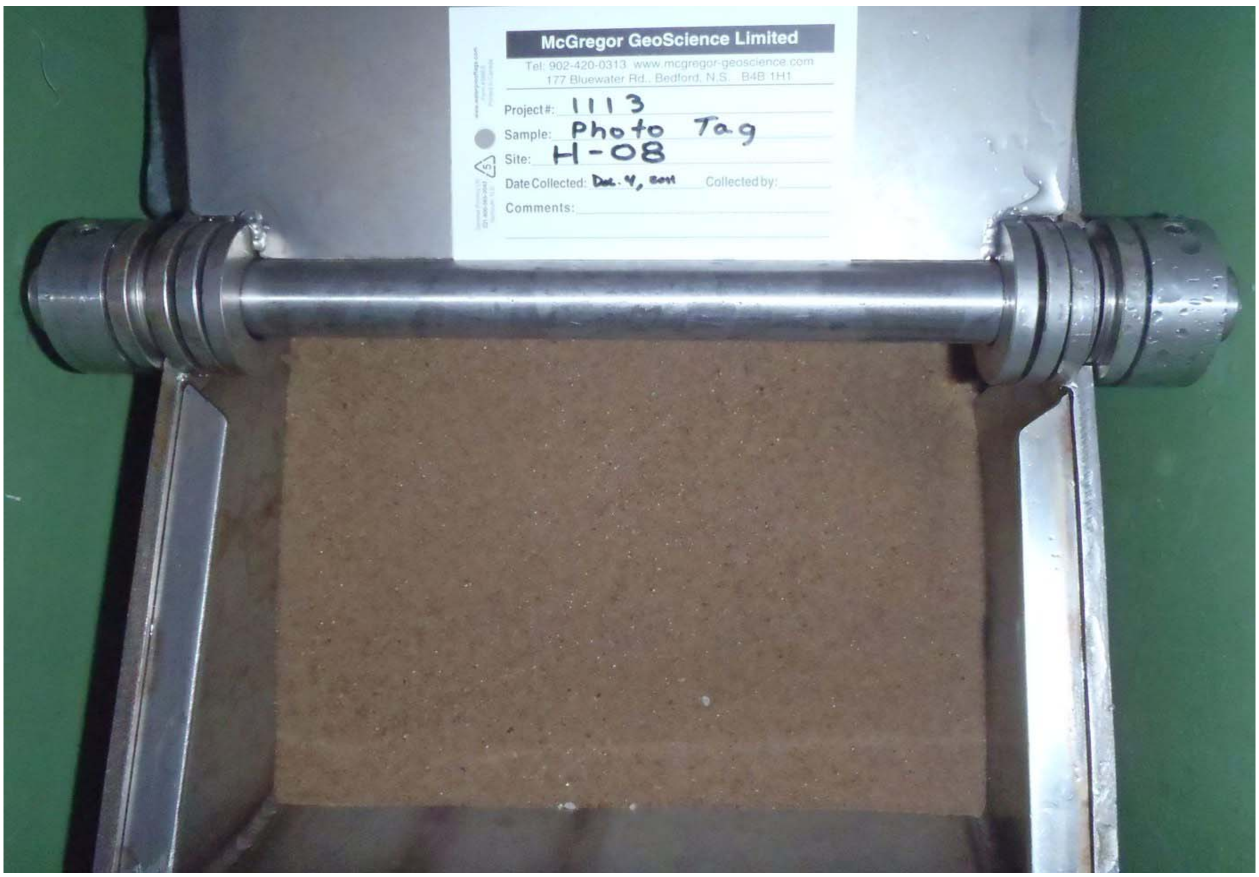
**Datum: WGS84 Projection: Zone 20N**

| | | | |
|---|---|---|---|
| **Site:** H-08 | **Core:** H-08-R1 | **Date:** Dec. 4, 2001 | **Time (UTC):** 15:24 |

Position: **N 4850974** **E 680692**

Depth (m bsl): 42 Penetration (cm): 14 Sampling Method: VV

Sediment Composition: Coarse to Medium - SAND



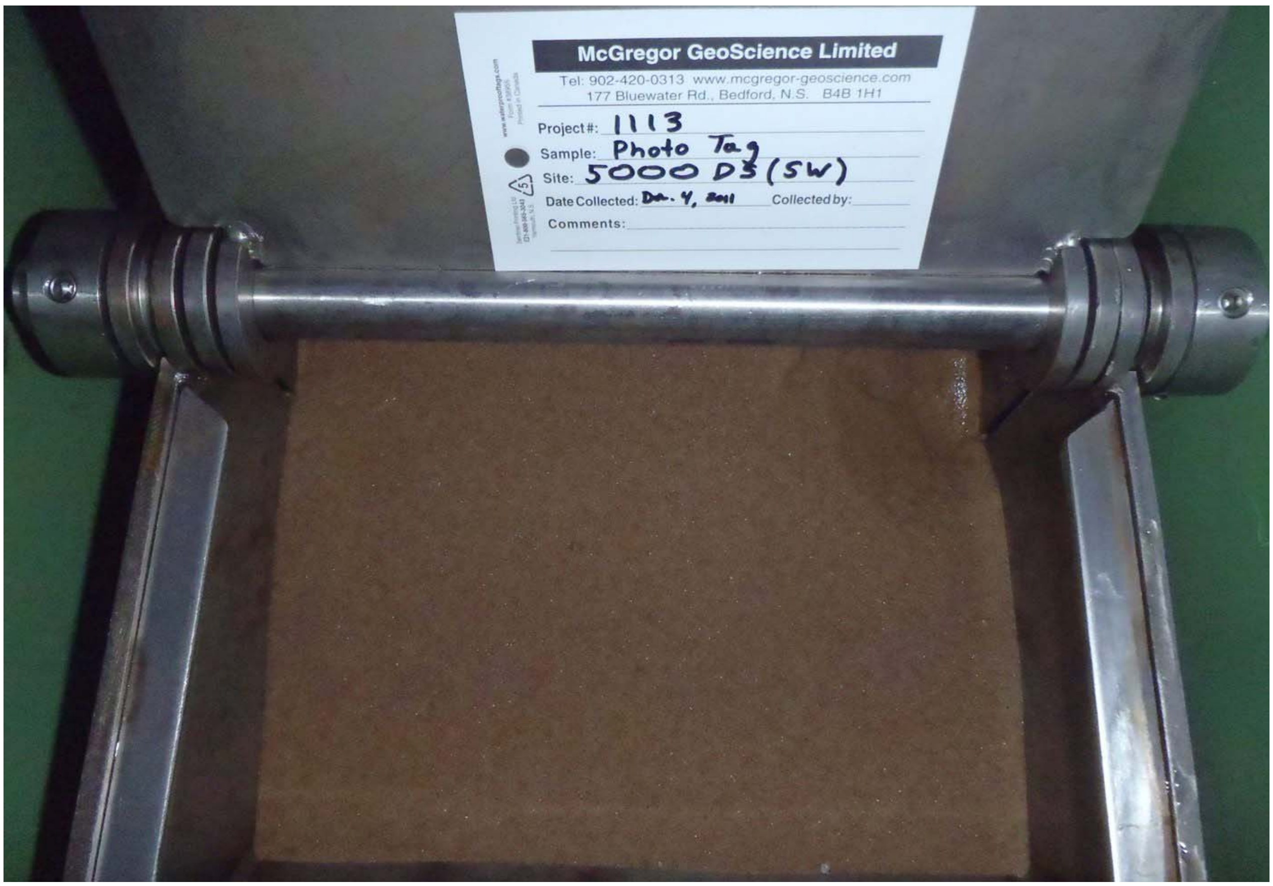

| | |
|---|---|
| Sediment Features: | Burrows? Tubes? Casts? Smell _No___ Color _Brown_ Sediment Stratification_No___ |
| Sediment Anoxia: | **None** Streaks Patches Layer Depth of Layer from Surface ________ |
| Notes: | Scallop spat |
| Samples Collected: | Bioassay 1L Bag: **A B** Metals Clear 250ml: **A B** PSA Clear 250ml: **A B**<br>BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A B**<br>Photo Taken: **Yes** |

McGregor GeoScience Limited

Datum: WGS84 Projection: Zone 20N

| Site: 5000 DS (SW) | Core: 5000 DS (SW) R1 | Date: Dec. 4, 2001 | Time (UTC): 16:15 |
|---|---|---|---|
| Position: N 4850141 | | E 682340 | |
| Depth (m bsl): 42 | Penetration (cm): 14 | | Sampling Method: VV |

Sediment Composition: Coarse to Medium - SAND




Sediment Features: Burrows? Tubes? Casts? Smell _No____ Color _Brown_ Sediment Stratification_No_____

Sediment Anoxia: **None** Streaks Patches Layer Depth of Layer from Surface ________

Notes:

Samples Collected:
Bioassay 1L Bag: **A B** Metals Clear 250ml: **A B** PSA Clear 250ml: **A B**
BTEX/TPH/PAH 60ml: **A** Sulphide Clear 120ml: **A** Alkylated Phenols Amber 250ml: **A B**
Photo Taken: **Yes**

# APPENDIX B

CEQG Guidelines for the Protection of Aquatic Life

# Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

**SUMMARY TABLES**

**Update 2002**

**Table 1. Interim freshwater sediment quality guidelines (ISQGs; dry weight), probable effect levels (PELs; dry weight), and incidence (%) of adverse biological effects in concentration ranges defined by these values.[*]**

| Substance | ISQG | PEL | % = ISQG | ISQG < % < PEL | % = PEL |
|---|---|---|---|---|---|
| Acenaphthene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Acenaphthylene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Aroclor 1254 [See Polychlorinated biphenyls (PCBs)] | | | | | |
| Arsenic | 5.9 mg·kg$^{-1}$ | 17.0 mg·kg$^{-1}$ | 5 | 25 | 12 |
| Benz*(a)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Benzo*(a)*pyrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Cadmium | 0.6 mg·kg$^{-1}$ | 3.5 mg·kg$^{-1}$ | 11 | 12 | 47 |
| Chlordane | 4.50 µg·kg$^{-1}$ | 8.87 µg·kg$^{-1}$ | 2 | 17 | 70 |
| Chromium | 37.3 mg·kg$^{-1}$ | 90.0 mg·kg$^{-1}$ | 2 | 19 | 49 |
| Chrysene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Copper | 35.7 mg·kg$^{-1}$ | 197 mg·kg$^{-1}$ | 4 | 38 | 44 |
| DDTs | | | | | |
| DDD[†] (2,2-Bis(*p*-chlorophenyl)-1,1,-dichloroethane; Dichloro diphenyl dichloroethane) | 3.54 µg·kg$^{-1}$ | 8.51 µg·kg$^{-1}$ | 3 | 30 | 85 |
| DDE[†] (1,1-Dichloro-2,2,bis(*p*-chlorophenyl)-ethene; Diphenyl dichloro ethylene) | 1.42 µg·kg$^{-1}$ | 6.75 µg·kg$^{-1}$ | 6 | 20 | 47 |
| DDT[†] (2,2-Bis(*p*-chlorophenyl)-1,1,1-trichloroethane; Dichloro diphenyl trichloroethane) | 1.19 µg·kg$^{-1}$ [‡] | 4.77 µg·kg$^{-1}$ [§] | 8 | 5 | 59 |
| Dibenz*(a,h)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Dieldrin | 2.85 µg·kg$^{-1}$ | 6.67 µg·kg$^{-1}$ | 1 | 10 | 60 |
| Endrin | 2.67 µg·kg$^{-1}$ | 62.4 µg·kg$^{-1}$ | 1 | 64 | 59 |
| Fluoranthene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Fluorene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |

*Continued.*

**Table 1. Continued.**

| Substance | ISQG | PEL | % = ISQG | ISQG < % < PEL | % = PEL |
|---|---|---|---|---|---|
| Heptachlor epoxide | 0.60 μg·kg$^{-1}$ | 2.74 μg·kg$^{-1}$ | 3 | 12 | 67 |
| Hexachlorocyclohexane [See Lindane] | | | | | |
| Lead | 35.0 mg·kg$^{-1}$ | 91.3 mg·kg$^{-1}$ | 5 | 23 | 42 |
| Lindane (Hexachlorocyclohexane) | 0.94 μg·kg$^{-1}$ | 1.38 μg·kg$^{-1}$ | 0 | 50 | 49 |
| Mercury | 0.17 mg·kg$^{-1}$ | 0.486 mg·kg$^{-1}$ | 8 | 34 | 36 |
| 2-Methylnaphthalene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Naphthalene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Nonylphenol and its ethoxylates | 1.4 mg·kg$^{-1}$ [†††,***] | | | | |
| PAHs [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| PCBs [See Polychlorinated biphenyls (PCBs)] | | | | | |
| PCDD/Fs [see Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans] | | | | | |
| Phenanthrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Polychlorinated biphenyls (PCBs) | | | | | |
| Aroclor 1254 | 60 μg·kg$^{-1}$ [#] | 340 μg·kg$^{-1}$ [**] | | | |
| Total PCBs | 34.1 μg·kg$^{-1}$ | 277 μg·kg$^{-1}$ | 4 | 40 | 50 |
| Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans | 0.85 ng·TEQ/kg dw [§§] | 21.5 ng·TEQ/kg dw [§§] | 0[##] | 24[##] | 46[##] |
| Polycyclic aromatic hydrocarbons (PAHs) | | | | | |
| Acenaphthene | 6.71 μg·kg$^{-1}$ [‡] | 88.9 μg·kg$^{-1}$ [§] | | | |
| Acenaphthylene | 5.87 μg·kg$^{-1}$ [‡] | 128 μg·kg$^{-1}$ [§] | | | |
| Anthracene | 46.9 μg·kg$^{-1}$ [‡] | 245 μg·kg$^{-1}$ [§] | | | |
| Benz*(a)*anthracene | 31.7 μg·kg$^{-1}$ | 385 μg·kg$^{-1}$ | 13 | 6 | 38 |
| Benzo*(a)*pyrene | 31.9 μg·kg$^{-1}$ | 782 μg·kg$^{-1}$ | 11 | 16 | 30 |
| Chrysene | 57.1 μg·kg$^{-1}$ | 862 μg·kg$^{-1}$ | 8 | 14 | 25 |
| Dibenz*(a,h)*anthracene | 6.22 μg·kg$^{-1}$ [‡] | 135 μg·kg$^{-1}$ [§] | | | |
| Fluoranthene | 111 μg·kg$^{-1}$ | 2355 μg·kg$^{-1}$ | 8 | 23 | 49 |
| Fluorene | 21.2 μg·kg$^{-1}$ [‡] | 144 μg·kg$^{-1}$ [§] | | | |
| 2-Methylnaphthalene | 20.2 μg·kg$^{-1}$ [‡] | 201 μg·kg$^{-1}$ [§] | | | |
| Naphthalene | 34.6 μg·kg$^{-1}$ [‡] | 391 μg·kg$^{-1}$ [§] | | | |
| Phenanthrene | 41.9 μg·kg$^{-1}$ | 515 μg·kg$^{-1}$ | 4 | 17 | 44 |
| Pyrene | 53.0 μg·kg$^{-1}$ | 875 μg·kg$^{-1}$ | 7 | 16 | 32 |
| Pyrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Toxaphene | 0.1 μg·kg$^{-1}$ [††] | — [‡‡] | | | |
| Zinc | 123 mg·kg$^{-1}$ | 315 mg·kg$^{-1}$ | 5 | 32 | 36 |

* ISQGs and PELs presented here have been calculated using a modification of the NSTP approach (CCME 1995).
† Sum of *p,p′* and *o,p′* isomers.
‡ Provisional; adoption of marine ISQG.
§ Provisional; adoption of marine PEL.
\# Provisional; adoption of lowest effect level from Ontario (Persaud et al. 1993).
** Provisional; 1% TOC; adoption of severe effect level of 34 μg·g$^{-1}$ TOC from Ontario (Persaud et al. 1993).
†† Provisional; 1% TOC; adoption of the chronic sediment quality criterion of 0.01 μg·g$^{-1}$ TOC of the New York State Department of Environmental Conservation (NYSDEC 1994).
‡‡ No PEL derived.
§§ Values are expressed as toxic equivalency (TEQ) units, based on WHO 1998 TEF values for fish.

[##] Expressed on a TEQ basis using NP TEFs; assumes 1% TOC.
[***] Provisional; use of equilibrium partitioning approach.
[†††] Note that the incidence of adverse biological effects below the TEL, between the TEL and PEL, and above the PEL were 22%, 24% and 65%, respectively, prior to the application of a safety factor.

**Table 2. Interim marine sediment quality guidelines (ISQGs; dry weight), probable effect levels (PELs; dry weight), and incidence (%) of adverse biological effects in concentration ranges defined by these values.***

| Substance | ISQG | PEL | % = ISQG | ISQG < % < PEL | % = PEL |
|---|---|---|---|---|---|
| Acenaphthene [See Polycyclic aromatic hydrocarbons; (PAHs)] | | | | | |
| Acenaphthylene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Aroclor 1254 [See Polychlorinated biphenyls (PCBs)] | | | | | |
| Arsenic | 7.24 $mg \cdot kg^{-1}$ | 41.6 $mg \cdot kg^{-1}$ | 3 | 13 | 47 |
| Benz*(a)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Benzo*(a)*pyrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Cadmium | 0.7 $mg \cdot kg^{-1}$ | 4.2 $mg \cdot kg^{-1}$ | 6 | 20 | 71 |
| Chlordane | 2.26 $\mu g \cdot kg^{-1}$ | 4.79 $\mu g \cdot kg^{-1}$ | 9 | 12 | 17 |
| Chromium | 52.3 $mg \cdot kg^{-1}$ | 160 $mg \cdot kg^{-1}$ | 4 | 15 | 53 |
| Chrysene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Copper | 18.7 $mg \cdot kg^{-1}$ | 108 $mg \cdot kg^{-1}$ | 9 | 22 | 56 |
| DDTs | | | | | |
| DDD† (2,2-Bis(*p*-chlorophenyl)-1,1,-dichloroethane; Dichloro diphenyl dichloroethane) | 1.22 $\mu g \cdot kg^{-1}$ | 7.81 $\mu g \cdot kg^{-1}$ | 4 | 11 | 46 |
| DDE† (1,1-Dichloro-2,2,bis(*p*-chlorophenyl)-ethene; Diphenyl dichloro ethylene) | 2.07 $\mu g \cdot kg^{-1}$ | 374 $\mu g \cdot kg^{-1}$ | 5 | 16 | 50 |
| DDT† (2,2-Bis(*p*-chlorophenyl)-1,1,1-trichloroethane; Dichloro diphenyl trichloroethane) | 1.19 $\mu g \cdot kg^{-1}$ | 4.77 $\mu g \cdot kg^{-1}$ | 8 | 5 | 59 |
| Dibenz*(a,h)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Dieldrin | 0.71 $\mu g \cdot kg^{-1}$ | 4.30 $\mu g \cdot kg^{-1}$ | 4 | 13 | 50 |
| Endrin | 2.67 $\mu g \cdot kg^{-1}$ ‡ | 62.4 $\mu g \cdot kg^{-1}$ § | | | |
| Fluoranthene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Fluorene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Heptachlor epoxide | 0.60 $\mu g \cdot kg^{-1}$ ‡ | 2.74 $\mu g \cdot kg^{-1}$ § | | | |
| Hexachlorocyclohexane [See Lindane] | | | | | |
| Lead | 30.2 $mg \cdot kg^{-1}$ | 112 $mg \cdot kg^{-1}$ | 6 | 26 | 58 |
| Lindane (Hexachlorocyclohexane) | 0.32 $\mu g \cdot kg^{-1}$ | 0.99 $\mu g \cdot kg^{-1}$ | 3 | 21 | 26 |

*Continued.*

**Table 2. Continued.**

| Substance | ISQG | PEL | % = ISQG | ISQG < % < PEL | % = PEL |
|---|---|---|---|---|---|
| Mercury | 0.13 mg·kg$^{-1}$ | 0.70 mg·kg$^{-1}$ | 8 | 24 | 37 |
| 2-Methylnaphthalene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Naphthalene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Nonylphenol and its ethoxylates | 1.0 mg·kg$^{-1}$ ‡‡,§§ | | | | |
| PAHs [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| PCBs [See Polychlorinated biphenyls (PCBs)] | | | | | |
| PCDD/Fs [see Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo furans | | | | | |
| Phenanthrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Polychlorinated biphenyls (PCBs) | | | | | |
| Aroclor 1254 | 63.3 µg·kg$^{-1}$ | 709 µg·kg$^{-1}$ | 1 | 24 | 76 |
| Total PCBs | 21.5 µg·kg$^{-1}$ | 189 µg·kg$^{-1}$ | 16 | 37 | 55 |
| Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo furans | 0.85 ng TEQ/kg dw++ | 21.5 ng TEQ/kg dw++ | | | |
| Polycyclic aromatic hydrocarbons (PAHs) | | | | | |
| Acenaphthene | 6.71 µg·kg$^{-1}$ | 88.9 µg·kg$^{-1}$ | 8 | 29 | 57 |
| Acenaphthylene | 5.87 µg·kg$^{-1}$ | 128 µg·kg$^{-1}$ | 7 | 14 | 51 |
| Anthracene | 46.9 µg·kg$^{-1}$ | 245 µg·kg$^{-1}$ | 9 | 20 | 75 |
| Benz*(a)*anthracene | 74.8 µg·kg$^{-1}$ | 693 µg·kg$^{-1}$ | 9 | 16 | 78 |
| Benzo*(a)*pyrene | 88.8 µg·kg$^{-1}$ | 763 µg·kg$^{-1}$ | 8 | 22 | 71 |
| Chrysene | 108 µg·kg$^{-1}$ | 846 µg·kg$^{-1}$ | 9 | 19 | 72 |
| Dibenz*(a,h)*anthracene | 6.22 µg·kg$^{-1}$ | 135 µg·kg$^{-1}$ | 16 | 12 | 65 |
| Fluoranthene | 113 µg·kg$^{-1}$ | 1 494 µg·kg$^{-1}$ | 10 | 20 | 80 |
| Fluorene | 21.2 µg·kg$^{-1}$ | 144 µg·kg$^{-1}$ | 12 | 20 | 70 |
| 2-Methylnaphthalene | 20.2 µg·kg$^{-1}$ | 201 µg·kg$^{-1}$ | 0 | 23 | 82 |
| Naphthalene | 34.6 µg·kg$^{-1}$ | 391 µg·kg$^{-1}$ | 3 | 19 | 71 |
| Phenanthrene | 86.7 µg·kg$^{-1}$ | 544 µg·kg$^{-1}$ | 8 | 23 | 78 |
| Pyrene | 153 µg·kg$^{-1}$ | 1 398 µg·kg$^{-1}$ | 7 | 19 | 83 |
| Pyrene [See Polycyclic aromatic hydrocarbons (PAHs)] | | | | | |
| Toxaphene | 0.1 µg·kg$^{-1}$ # | —** | | | |
| Zinc | 124 mg·kg$^{-1}$ | 271 mg·kg$^{-1}$ | 4 | 27 | 65 |

[*] ISQGs and PELs presented here have been calculated using a modification of the NSTP approach (CCME 1995).

[†] Sum of *p,p′* and *o,p′* isomers.

[‡] Provisional; adoption of freshwater ISQG.

[§] Provisional; adoption of freshwater PEL.

[#] Provisional; 1% TOC; adoption of the chronic sediment quality criterion of 0.01 µg·g$^{-1}$TOC of the New York State Department of Environmental Conservation (NYSDEC 1994).

[**] No PEL derived.

[++] Values are expressed as toxic equivalency (TEQ) units, based on WHO 1998 TEF values for fish.

‡‡ Expressed as a TEQ basis using NP TEF; assumes 1% TOC.

§§ Provisional; use of equillibrium partitioning approach.

## References

CCME (Canadian Council of Ministers of the Environment) 1995. Protocol for the derivation of Canadian sediment quality guidelines for the protection of aquatic life. CCME EPC-98E. Prepared by Environment Canada, Guidelines Division, Technical Secretariat of the CCME Task Group on Water Quality Guidelines, Ottawa. [Reprinted in Canadian environmental quality guidelines, Chapter 6, Canadian Council of Ministers of the Environment, 1999, Winnipeg.]

NYSDEC (New York State Department of Environmental Conservation). 1994. Technical guidance for screening contaminated sediments. Prepared by the Division of Fish and Wildlife and the Division of Marine Resources. November 22, 1993. New York.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment, Water Resources Branch, Toronto.

Reference listing:

Canadian Council of Ministers of the Environment. 2002. Canadian sediment quality guidelines for the protection of aquatic life: Summary tables. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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# APPENDIX C

Harris Industrial Ecotoxicology Report 2011

**Toxicity results for *Eohaustorius estuarius* exposed to sediments from Encana Deep Panuke.**

For:

**McGregor GeoScience Ltd.**
177 Bluewater Rd.
Bedford NS
B4H 1H1

Submitted by:

HITS
AQUATIC TOXICITY TESTING

Harris Industrial Testing Service Ltd.
1320 Ashdale Road
South Rawdon, NS
B0N 1Z0

Authorized by:

Gary Harris
January 6, 2012

## TABLE OF CONTENTS

## 1.0 Introduction

McGregor GeoScience of Bedford, NS, supplied Harris Industrial Testing Service Ltd. (HITS), with the following samples collected at Encana Deep Panuke on December 4th, 2011:

| Sample Location | Lab ID |
|---|---|
| PFC 1113 – 5000 US (NE) | 11-600-A |
| PFC 1113 – D41 | 11-600-B |
| PFC 1113 – F70 | 11-600-C |
| PFC 1113 – D70 | 11-600-D |
| PFC 1113 – M79A | 11-600-E |
| PFC 1113 – 250 DS | 11-600-F |
| PFC 1113 – 500 DS | 11-600-G |
| PFC 1113 – 1000 DS | 11-600-H |
| PFC 1113 – 2000 DS | 11-600-I |
| PFC 1113 – H08 | 11-600-J |
| PFC 1113 – 5000 DS (SW) | 11-600-K |
| PFC 1113 - BLIND | 11-600-L |

Samples were tested for acute lethality using the estuarine amphipod *Eohaustorius estuarius.*

## 2.0 Materials and Methods

These tests were conducted in accordance with Environment Canada's "Biological Test Method: Reference Method for Determining Acute Lethality of Sediment to Marine or Estuarine Amphipods", EPS 1/RM/35, December 1998.

The organism of choice for these tests is *E. estuarius.* The grain size analysis and TOC was conducted by the client.

HITS Lab Method "Tox 49" is held on file in the lab. This method describes the following:

- reception and acclimation of amphipods;
- preparation of control sediment;
- preparation of samples;
- preparation of reference toxicant;
- conduct of testing.

*E. Estuarius* (Batch #10) were purchased from Northwestern Aquatic Sciences (NAS), Newport, Oregon. Collection took place at Yaquina Bay, OR on December 5th, 2011. Organisms were received in excellent health on December 8th, 2011 and were held in site sediment covered with aerating seawater at test temperature (15 ± 2 °C) and salinity 29 ppt in continuous light for five days prior to the commencement of testing.

Sediment samples were kept in the dark at 4 ± 2 °C until use.

Pre-sieved, control sediment was received in sealed containers with the amphipods and was kept in the dark at 4 ± 2 °C until use.

### 2.1 *Pre-test Procedure*

Pre-test procedures conducted on Dec. 12th, 2011 were as follows:

- 175 ml of each of the 12 test sediments were measured and added to each of five replicate exposure jars per sediment;
- 175 ml of the control sediment was measured and added to each of five replicate exposure jars;
- 775 ml of clean seawater, collected at high tide from Lawrencetown Bridge, (the same source as the acclimation water) with a D.O. of 90 – 100% saturation was added to each test jar;
- Each prepared replicate jar was held at 15 ± 2 °C and aerated overnight prior to the start of the test.

### 2.2 *Test Initiation Procedure*

Test initiation on Dec. 13th, 2011 was as follows:

- 20 *E. estuarius* amphipods were added to all test chambers;
- Dissolved oxygen (D.O.), pH, salinity, ammonia and temperature were measured for each sample;
- A reference toxicant test using Cadmium Chloride was initiated on Batch #10 organisms in seawater only (as per EPS 1/RM/35).

### 2.3 *Test Conditions*

Test conditions were as follows:

- The reference toxicant test was conducted for 96 hours with no exposure to light and no aeration;
- The amphipod test was conducted for a 10-day period under continuous fluorescent lighting at 15 ± 2 °C with minimal aeration;
- D.O., pH, salinity, and temperature were measured on non-consecutive days throughout the 10-day test and at termination for each sample.

### 2.4 *Test Termination Procedure*

Test termination on Dec. 23rd, 2011 was as per the following procedure:

- D.O., pH, salinity, temperature and ammonia were measured (refer to *Amphipod Toxicity Reports)*for each sample;
- The contents of each test vessel were sieved through a 0.5 mm sieve. The sieve was agitated gently in a pan of clean seawater. The organisms were pipetted from the sieve into a weigh boat with a clean glass pipette. Any immobile organisms were examined under a stereoscope for signs of life. Missing organisms were assumed dead.

- The biological endpoint for the 10-day test is the mean percent survival at ten days. Survival used in calculations is expressed as the total number of animals alive in all 5 replicates out of 100.

## 3.0 Results and Conclusions

- All monitored parameters, D.O., pH, temperature and salinity were within acceptable levels throughout the 10-day exposure period;
- 10-day survival in the control sediment exceeded the 90% requirement for a valid test;
- The reference toxicant result fell within this lab's warning limits (*i.e.*, ± 2 S.D. from the mean);
- All test validity criteria for the sediment test method were satisfied;
- No organisms exhibiting unusual appearance, or undergoing unusual treatment were used in the test;
- The samples and control sediment as tested were found to be non-toxic to the amphipod *Eohaustorius estuarius* (refer to *Table 1*).

**Table 1**: Toxicity Results of *E. Estuarius* exposed to sediments

| Sample Location | Lab ID | Mortality | % Survival |
|---|---|---|---|
| PFC 1113 – 5000 US (NE) | 11-600-A | 0/100 | 100 |
| PFC 1113 – D41 | 11-600-B | 0/100 | 100 |
| PFC 1113 – F70 | 11-600-C | 0/100 | 100 |
| PFC 1113 – D70 | 11-600-D | 0/100 | 100 |
| PFC 1113 – M79A | 11-600-E | 0/100 | 100 |
| PFC 1113 – 250 DS | 11-600-F | 0/100 | 100 |
| PFC 1113 – 500 DS | 11-600-G | 0/100 | 100 |
| PFC 1113 – 1000 DS | 11-600-H | 0/100 | 100 |
| PFC 1113 – 2000 DS | 11-600-I | 1/100 | 99 |
| PFC 1113 – H08 | 11-600-J | 0/100 | 100 |
| PFC 1113 – 5000 DS (SW) | 11-600-K | 0/100 | 100 |
| PFC 1113 - BLIND | 11-600-L | 0/100 | 100 |
| Control Sediment | | 0/100 | 100 |

## 4.0 References

Environment Canada. 1998. Biological Test Method: Reference Method for Determining Acute Lethality of Sediment to Marine or Estuarine Amphipods. Report EPS 1/RM/35. Environment Canada, Environmental Protection, Ottawa, December 1998.

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# APPENDIX D

Fish Habitat Alteration Video Assessments 2011

| | Start KP | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fauna** | **23.222** | **24.235** | **25.873** | **27.495** | **29.211** | **31.134** | **32.984** | **35.072** | **36.864** | **38.646** | **40.627** | **42.787** | **44.807** |
| Sculpin | 1 | 3 | 1 | | 1 | 1 | 9 | 1 | | 1 | 2 | 1 | 3 |
| Sea Raven | | | | | | | | | | | | | |
| Atlantic cod | 1 | | 2 | 7 | 2 | 5 | | | | | | | 2 |
| Flounder | 2 | | | | | 1 | | | 1 | | 1 | 2 | |
| Redfish | | | 9 | 16 | 6 | 15 | 5 | | | 4 | 14 | | 14 |
| Pollock | | | | | | | | 1 | | | | | |
| Haddock | | | | | | | | | | | 1 | | |
| Rock Gunnel | | | | | | | | | | | 2 | 2 | |
| Skate | | | | | | | | | | | | | |
| Eelpout | | | | | | | | | | | | | |
| Hagfish | | | | | | | | | | | | | |
| Blenny? | | | | | | | | | | | | | |
| Hake | | | | | | | | | | | | | |
| Herring | | | | | | | | | | | | | |
| Atlantic wolf fish | | | | | | | | | | | | | |
| Monkfish | | | | | | | | | | | | | |
| Unid. Fish | | | | | 2 | | | 2 | | | 1 | | 2 |
| Hermit crab | 1 | | | | | 1 | | | | | | | |
| Toad crab? | | | | | | | | | | | | | |
| Snow crab | 47 | 102 | 42 | 41 | 78 | 49 | 69 | 27 | 25 | 79 | 115 | 101 | 102 |
| Lithodes maja | | | | | | | | | | | | | |
| Sea urchin | 65 | 430 | 323 | 395 | 3 | 10 | 3 | | | 2 | | | 642 |
| Jonah crab | | | | | | | 3 | 19 | 1 | 3 | 19 | 31 | 5 |
| Sea cucumber | 2 | 5 | | | | | | | | | 2 | 3 | 5 |
| Feather star | 1 | | | | | | | | | | | | |
| Basket star | 39 | 31 | | | 3 | 1 | 1 | | | | 1 | 9 | 6 |
| *Henricia* sp. | 3 | 2 | 28 | 46 | 6 | 1 | 20 | 22 | 15 | 18 | | 2 | 4 |
| *Solaster* sp. | 4 | | 1 | 2 | | 1 | 1 | 3 | 2 | 4 | 4 | 9 | 9 |
| *Crossaster* sp. | 2 | 7 | 1 | | 1 | | | | | | 10 | 15 | 14 |
| *Hippasteria* sp. | | | | 1 | | 1 | 4 | 5 | 9 | 13 | 4 | 17 | 17 |
| *Ceramaster* sp. | | | | | | | | | | | | | |
| *Asterias* sp | | | | | | | | | | 1 | 2 | | |
| *Cerianthus* sp* | | | | | | | | | | | | | |
| Sea anemone | 1 | 45 | 4 | 5 | 19 | 14 | 13 | 143 | 34 | 24 | 13 | 13 | 19 |
| Octopus? | | | | | | | | | | | | | |
| Gastropod | | | | | | | 1 | | | | | | |
| *Stylocordyla borealis* | | | | | | | | | | | | | |
| Porifera* | | 1 | | | | | 2 | 1 | | | | | |
| Encrusting sponge | | | | | | | | | | | | | |
| Stalked tunicate | | | | | | | | | | | | | |
| Soft Coral* | | | | | 9 | 1 | 8 | 3 | | | | | |
| Coralline organism | | | | | | 2 | 3 | | | | | | |
| Shrimp | S | S | | | S | 1 | | 9 | | S | S | S | S |
| Polychaete | S | S | | | | | | | | | | 1 | |
| *Observed around pipeline | **23.429** | **24.573** | **26.317** | **27.893** | **29.689** | **31.517** | **33.497** | **35.450** | **37.354** | **39.101** | **41.140** | **43.186** | **45.175** |
| S = superabundant taxa | **End KP** | | | | | | | | | | | | |

| | Start KP | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fauna** | **46.370** | **48.567** | **50.746** | **52.480** | **54.717** | **56.772** | **59.236** | **61.669** | **63.882** | **66.430** | **68.353** | **70.947** | **73.297** |
| Sculpin | 1 | 1 | 1 | | 1 | | | | | | | | |
| Sea Raven | | | | | | | | | | | 1 | | |
| Atlantic cod | 3 | 8 | 2 | 6 | 8 | 15 | 15 | 10 | 7 | 4 | 7 | 18 | 10 |
| Flounder | | | 2 | | | | | | | | | | |
| Redfish | 169 | 436 | 13 | 67 | 220 | 438 | 848 | 400 | 814 | 839 | 611 | 1133 | 1227 |
| Pollock | | | | | | | 4 | | | | | | |
| Haddock | | | | | | | | | | | | | |
| Rock Gunnel | | | 2 | | 2 | 1 | 3 | | 1 | | | | |
| Skate | | | | | | 1 | | | | | | | |
| Eelpout | | | | | | | | | | | 2 | | |
| Hagfish | | | | | | | | | | | | | 1 |
| Blenny? | | | | | | | | | | | | | |
| Hake | | | | | | | | | | | | | |
| Herring | | | | | | | | | | | | | |
| Atlantic wolf fish | | | | | | | | | | | | | |
| Monkfish | | | | | | | | | | | | | |
| Unid. Fish | 1 | | | | 1 | 1 | 1 | | 1 | | | | 1 |
| Hermit crab | | | | 1 | 1 | | 1 | | 2 | 1 | 4 | 5 | 6 |
| Toad crab? | | | 198 | 72 | >1000 | >500 | 130 | 114 | 5 | 5 | 9 | 18 | 4 |
| Snow crab | 48 | 45 | 18 | 16 | 17 | 5 | | | | | | | |
| Lithodes maja | | | | | | | 1 | | | | | | |
| Sea urchin | 313 | 231 | >1000 | >1000 | >1000 | >500 | >500 | 35 | 62 | | 3 | 1 | 7 |
| Jonah crab | 1 | 15 | 5 | 8 | 16 | | 6 | 2 | 2 | | 2 | 6 | 12 |
| Sea cucumber | 1 | 8 | 20 | 10 | 6 | 17 | 5 | 15 | 4 | 6 | 15 | 5 | 2 |
| Feather star | 1 | 5 | | | | | 1 | | 1 | | | | |
| Basket star | | 1 | | | | | | | | | | | |
| *Henricia* sp. | 26 | 32 | 5 | 33 | 239 | 326 | 204 | >500 | >500 | >500 | >500 | >500 | >1000 |
| *Solaster* sp. | 2 | | 4 | 7 | 1 | | 5 | 6 | | 4 | 3 | 7 | 7 |
| *Crossaster* sp. | 29 | 2 | 1 | 5 | 6 | 15 | 3 | 4 | | | | | |
| *Hippasteria* sp. | 6 | 2 | 1 | 1 | 18 | 32 | 8 | 22 | 13 | 7 | 2 | 1 | 3 |
| *Ceramaster* sp. | | | | | | | | | | | | | |
| *Asterias* sp | 9 | 17 | | 22 | 33 | 18 | 47 | | 2 | 1 | | 5 | 31 |
| *Cerianthus* sp* | | | | | | | | | | | | | |
| Sea anemone | 96 | 25 | 44 | 48 | 38 | 38 | 175 | 231 | 261 | 122 | 272 | 253 | 72 |
| Octopus? | | | | | | | | | | | | | |
| Gastropod | 5 | 5 | 1 | | 1 | 3 | 2 | 1 | 1 | | 5 | 1 | |
| *Stylocordyla borealis* | | | | | | | | | | | | | |
| Porifera* | 4 | S | 4 | 1 | 1 | | | | | 1 | 1 | 3 | 1 |
| Encrusting sponge | | S | | | | | | 2 | 1 | | | | |
| Stalked tunicate | | | | | | | | | | | | | |
| Soft Coral* | | 3 | | | | | | | | | | | |
| Coralline organism | | | | | | | | | | | | | |
| Shrimp | S | S | S | | | 3 | | | | | | | |
| Polychaete | | | | | | | | | | | | | 2 |
| *Observed around pipeline | **46.864** | **49.013** | **51.175** | **52.937** | **55.190** | **57.295** | **59.795** | **62.170** | **64.474** | **66.852** | **68.952** | **71.478** | **73.869** |
| S = superabundant taxa | **End KP** | | | | | | | | | | | | |

| | Start KP | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fauna** | **75.587** | **78.183** | **80.354** | **83.016** | **85.448** | **88.109** | **90.347** | **92.825** | **95.361** | **97.378** |
| Sculpin | | | | | | 1 | | | | |
| Sea Raven | | | | 2 | 2 | 1 | 2 | | | 2 |
| Atlantic cod | 2 | 5 | 13 | 31 | 1 | 5 | 3 | 14 | 1 | |
| Flounder | 22 | 1 | 3 | 8 | | 5 | 1 | 4 | 7 | 2 |
| Redfish | 457 | 296 | 526 | 216 | 531 | 331 | 917 | 12 | 12 | 4 |
| Pollock | | >500 | >500 | >500 | | | | | | |
| Haddock | | | | | | | | | 1 | 1 |
| Rock Gunnel | | | | | | | | | | |
| Skate | | | | | | | | | | |
| Eelpout | | | 2 | | | | | 5 | 1 | 1 |
| Hagfish | 2 | 5 | 9 | 14 | | | 1 | 2 | 1 | |
| Blenny? | | | 7 | 13 | | | | | | 5 |
| Hake | | | 5 | 10 | | | | 2 | 4 | 1 |
| Herring | | | | 1 | | | | | | |
| Atlantic wolf fish | | | | 1 | 3 | 1 | | | | |
| Monkfish | | | | | | 1 | | | | |
| Unid. Fish | 2 | 1 | 19 | 13 | | | | | 21 | 2 |
| Hermit crab | 7 | 2 | 3 | | | | 3 | | | |
| Toad crab? | >500 | 333 | 80 | 259 | 3 | | | 6 | | |
| Snow crab | | | | | | | | 1 | 7 | 151 |
| Lithodes maja | | 4 | 5 | 4 | 2 | 3 | 3 | 8 | 9 | 4 |
| Sea urchin | | | | | | | | | | |
| Jonah crab | 49 | 34 | 94 | 98 | 22 | 54 | 103 | 130 | 68 | 30 |
| Sea cucumber | 13 | 4 | 8 | 8 | 6 | 4 | 5 | 24 | 18 | 16 |
| Feather star | | | | | | | | | | |
| Basket star | | | | | | | | | | |
| *Henricia* sp. | >500 | | | | | | | >500 | 47 | >500 |
| *Solaster* sp. | 19 | 4 | 2 | 2 | 2 | 2 | 9 | 8 | | |
| *Crossaster* sp. | 8 | 1 | | | | | | | | |
| *Hippasteria* sp. | 19 | 10 | 20 | 12 | 19 | 23 | 53 | 26 | 33 | 6 |
| *Ceramaster* sp. | | | | | | | 13 | 1 | | |
| *Asterias* sp | 240 | >500 | >500 | >500 | >500 | >500 | >500 | 8 | 2 | 13 |
| *Cerianthus* sp* | 16 | 161 | 220 | 255 | 538 | 170 | 431 | 18 | 202 | 3 |
| Sea anemone | 23 | 6 | 3 | 1 | 1 | 3 | | | 1 | 9 |
| Octopus? (KP83.291) | | | | 1 | | | | | | |
| Gastropod | 1 | | | | | | | | | |
| *Stylocordyla borealis* | | 3 | | | | | 2 | 7 | | 1 |
| Porifera* | 3 | | 3 | | | | | 1 | | |
| Encrusting sponge | | | | | | | | | | |
| Stalked tunicate | | | | | | | | | | |
| Soft Coral* | | | | | | | | | | |
| Coralline organism | | | | | | | | | | |
| Shrimp | | 1 | | S | | S | S | | | |
| Polychaete | | | | | | | | | | |
| *Observed around pipeline | **76.202** | **78.538** | **80.941** | **83.552** | **86.019** | **88.662** | **90.865** | **93.349** | **95.808** | **97.890** |
| S = superabundant taxa | End KP | | | | | | | | | |

# APPENDIX E 1

Acadia Bird Research Interim Report 2012

# Assessment of bird-human interactions at offshore installations

## Interim Progress Report – January, 2012

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# 1. Executive Summary

Difficulties associated with direct observations from offshore platforms and the episodic nature of bird-platform interactions means that there is a very poor documentation of patterns of bird activities at offshore installations. Assessment of bird-platform interaction effects could be substantially improved by incorporating instrument-based approaches. This study will combine multiple, automated instrument-based monitoring techniques (e.g. radar, VHF tracking, satellite telemetry) to quantify patterns of individual and population level bird activities on and around offshore installations. This report summarizes progress to date on the Encana-Acadia project entitled "Assessment of bird-human interactions at offshore installations".

***Telemetry*** – Field studies were conducted in June on Sable Island and Country Island which resulted in 1) VHF tag deployments on 20 Herring Gulls and 15 Leach's Storm-petrels, 2) colour wing- and leg-banding of 21 Herring Gulls and 29 Great Black-backed Gulls, and 3) Geolocator tag deployments on 11 Herring Gulls. VHF receivers were deployed on breeding colonies (Sable and Country Island), offshore platform supply vessels (Ryan Leet, Panuke Sea, Atlantic Condor) and other vessels of opportunity (CCGS Hudson, sailing vessel Balaena) resulting in nearly 600 receiver tracking-days. Receivers on the islands documented patterns of attendance for both gulls and storm-petrels. Vessel-based receivers detected gulls near Sable and around platforms showing patterns of nocturnal attraction near platforms. There was a considerable amount of VHF interference from vessel-based receivers and detection algorithms are being refined to further examine storm-petrel detections in offshore areas. A total of 27 colour-wing tag re-sightings were reported between June and December, 14 of which (52%) were observed in the vicinity of the Deep Panuke platform. Five different individuals (24% of the total tagged population) were observed from supply vessels operating near the Deep Panuke platform between 21-July and 22-August, suggesting that a high proportion of Sable Island gulls attend platforms and supply vessels post-breeding.

***Bird-Radar Deployment*** – In July, a site visit to the Deep Panuke platform in Mulgrave, NS, was conducted to evaluate options for positioning of the radar and VHF antennas/receiver. During this visit it was discovered that a Radar Beacon (Racon) installed on the PFC may become a problem for the planned bird-radar deployment. Several options to limit the triggering of the Racon were explored, however, tests of the modified radar at Chebucto Head were unsuccessful and it was deemed that the bird-radar installation on the communications deck of the PFC would not be feasible. Alternate scenarios for bird detection sensors are being investigated in conjunction with Encana and SBM engineers. These include the use of signals from S-band surveillance radar and X-band wave radar, low-light cameras, and acoustic recording devices to monitor bird calls.

***Funding*** **-** Application for federal funding support through the Natural Sciences and Engineering Research Council (NSERC) Collaborative Research and Development (CRD) grant was submitted in August and a conditional acceptance was awarded in December. Additional funding for the project is being pursued through grant applications to provincial agencies and non-profit organizations which will be used to increase the sample size of tagged birds during the study.

## 2. Background

The effects of offshore petroleum activities on birds have received prominent attention in recent environmental assessments in Eastern Canada and North America. Aside from the obvious effects from major unpredictable disasters, such as oil spills (Kerr et al. 2010), day to day operations of offshore petroleum activities may also have impacts on wildlife (Fraser et al. 2006; Wiese et al. 2001). One potential concern is the attraction of birds to offshore platforms and vessels (Montevecchi 2006; Sage 1979; Tasker et al. 1986). Birds are attracted to offshore platforms, drilling rigs, and support vessels for roosting sites (Baird 1990; Russell 2005; Tasker et al. 1986), foraging opportunities (Burke et al. 2005; Ortego 1978; Tasker et al. 1986), and due to disorientation by and attraction to light sources (Hope Jones 1980; Montevecchi 2006; Sage 1979).

Although bird attraction to offshore platforms has long been recognized, the factors correlated with attraction events and the mechanisms underlying these patterns are poorly understood. Anecdotally, it is known that poor weather, such as fog, precipitation and low cloud cover, can exacerbate the effect of nocturnal attraction to lights (Hope Jones 1980, Montevecchi 2006). However, there has been no systematic evaluation of bird attraction in relation to specific weather variables. Our ability to test hypotheses about factors driving bird attraction has been limited by poor documentation of patterns of bird activities at offshore installations. Therefore, there is a need to develop new systems for monitoring bird activities around offshore installations. This study will develop and test an instrument-based approach, using radar and telemetry, which holds a strong promise of monitoring bird activities 24 hours a day and in all weather conditions. Effective and efficient avian monitoring tools are crucial for quantifying patterns of bird activities at offshore installations and assessing factors associated with these patterns.

## 3. Goals and objectives

The overall goal of this research program is to *develop knowledge that could help reduce bird-human conflict at offshore installations*. The research objectives are:

1) Quantify the species-specific temporal and spatial patterns of attraction or repulsion of birds around offshore platforms.
2) Identify the environmental and anthropogenic factors that influence the spatial and temporal variation in bird distribution, abundance and movements at offshore platforms.
3) Develop the basis for a cost-effective, automated bird monitoring system to facilitate impact assessment, assess the need for mitigation, and improve platform safety.

# 4. Field Studies Completed in 2011

Between June and August, 2011, field studies using telemetry and other tags were conducted from Sable Island and Country Island to evaluate the efficacy of this approach for planned work in 2012. Data obtained through this approach will directly address objectives 1 and 2 (above).

## *4.1 VHF Telemetry*

***Tag and receiver deployments***

On Sable Island, from 07-14 June, 20 Herring Gulls were captured and fitted with 1 gram VHF tags mounted to two central tail feathers. On Country Island, 15 Leach's Storm-petrels were captured and fitted with 0.29 gram VHF tags on 28 June, 2011. Based on battery capacity, gull and storm-petrel tags have an expected transmission life of 160 and 45 days, respectively.

Receivers were deployed on two seabird colonies (Sable Island and Country Island) and five vessels, totaling 596.5 receiver-tracking-days between 08-Jun and 04-Jan, 2012 (Table 1). The receiver data from Sable Island was downloaded on 12 August, 2011, but was left recording into the autumn – this data and receiver was recovered in January 2012 providing continuous VHF monitoring on Sable from June through to the end of the expected tag life for gulls (~20 November, 2011).

*Table 1 – Summary of VHF tracking effort in 2011. SOEP = Sable Offshore Energy Project, which includes vessels attending various platforms operated by ExxonMobil.*

| Platform | Location | Start | End | Days | Receiver type | Scanning | Antennas |
|---|---|---|---|---|---|---|---|
| **Islands** | | | | | | | |
| | Sable Island* | 8-Jun-11 | 4-Jan-12 | 207.2 | DL | 60sec/10min | omni |
| | Country Island | 28-Jun-11 | 12-Aug-11 | 44.9 | DL | continuous | directional |
| **Vessels** | | | | | | | |
| Ryan Leet | Deep Panuke platform | 24-Jul-11 | 16-Nov-11 | 114.8 | DL | continuous | omni |
| Atlantic Condor | Scotian Shelf | 14-Jun-11 | 9-Jul-11 | 25.0 | 600 | continuous | omni |
| Panuke Sea | SOEP platforms | 7-Jul-11 | 3-Nov-11 | 97.5 | 600 | continuous | omni |
| Balaena | Scotian Shelf (Gully MPA) | 11-Jul-11 | 02-Sep-11 | 53.0 | 600 | continuous | omni |
| CCGS Hudson | Scotian Shelf | 23-Sep-11 | 19-Oct-11 | 26.3 | 600 | continuous | omni |
| CCGS Hudson | Gulf of St. Lawrence | 19-Oct-11 | 16-Nov-11 | 27.9 | 600 | continuous | omni |
| **Totals** | **Islands** | 8-Jun-11 | 4-Jan-12 | 252.1 | | | |
| | **Vessels** | 14-Jun-11 | 16-Nov-11 | 344.4 | | | |
| | **TOTAL** | 8-Jun-11 | 4-Jan-12 | 596.5 | | | |

***Preliminary Results - Gulls***

Receivers on Sable Island documented the presence of gulls during the breeding and post-breeding period, until expected tag failure (~20 November, 2011). Four gulls were detected continuously from June through August with brief (~several hours to half day) periods of absence from the island. Unfortunately, for the other 16 individuals, it appears that most tags stopped transmitting by the end of June, and it seems likely that these individuals had either destroyed the antennas or removed the tags from their tail feathers. Both antenna strength and attachment methods will be improved for deployments in 2012. Activity patterns after August have not yet been analyzed as receiver data was just recently downloaded (Jan 4, 2012).

Despite the low number of functioning tags on gulls, there were six confirmed tag detections from receivers deployed on vessels (Table 2). Four detections were recorded from the sailing vessel Balaena while it was anchored near Sable Island on each of three separate occasions (13 Jul, 30 Jul, 16 Aug). These detections ranged in duration from approximately 3 minutes to 3 hours and were most likely from gulls roosting or foraging on Sable Island. One individual (tag 36) was detected on two nights in September attending the offshore supply vessel, Panuke Sea. During these detections, which lasted all night (Figure 1), the supply vessel was on stand-by adjacent to the Thebaud platform, located approximately 9 km from Sable Island. This pattern of night-time attendance was likely associated with gulls foraging behind supply vessels which illuminate the water surface with deck lights (R. Ronconi pers. obs.). The detections summarized in Table 2 illustrate the type of data that will be recorded in 2012 for a variety of species to address objectives 1 and 2 (above) regarding the nature, timing, frequency and duration of bird interactions with offshore platforms and vessels.

*Table 2 – Confirmed detections of gull tags from receivers deployed on vessels. Signal strength is determined from the receiver on a scale of 1-255 which indicates the relative proximity of tags from the vessels. Relationship between signal strength and distance from platform will be calculated from deployments in 2012 based on VHF tags deployed simultaneously with satellite-GPS tags.*

| Date | Platforms | Location | TagID | Signal Strength | Duration |
|---|---|---|---|---|---|
| 13-Jul-11 | Balaena | 1.1 km from Sable | 26 | 30-70 | 3.5 min |
| 30-Jul-11 | Balaena | 200m from Sable | 26 | 30-255 | ~3 hrs |
| 30-Jul-11 | Balaena | 200m from Sable | 22 | ~80 | 35 min |
| 16-Aug-11 | Balaena | 150m from Sable | 36 | 40-90 | <5min |
| 07/08-Sept-2011 | Panuke Sea | Thebaud platform | 36 | 30-255 | all night |
| 10/11-Sept-2011 | Panuke Sea | Thebaud platform | 36 | 30-255 | all night |

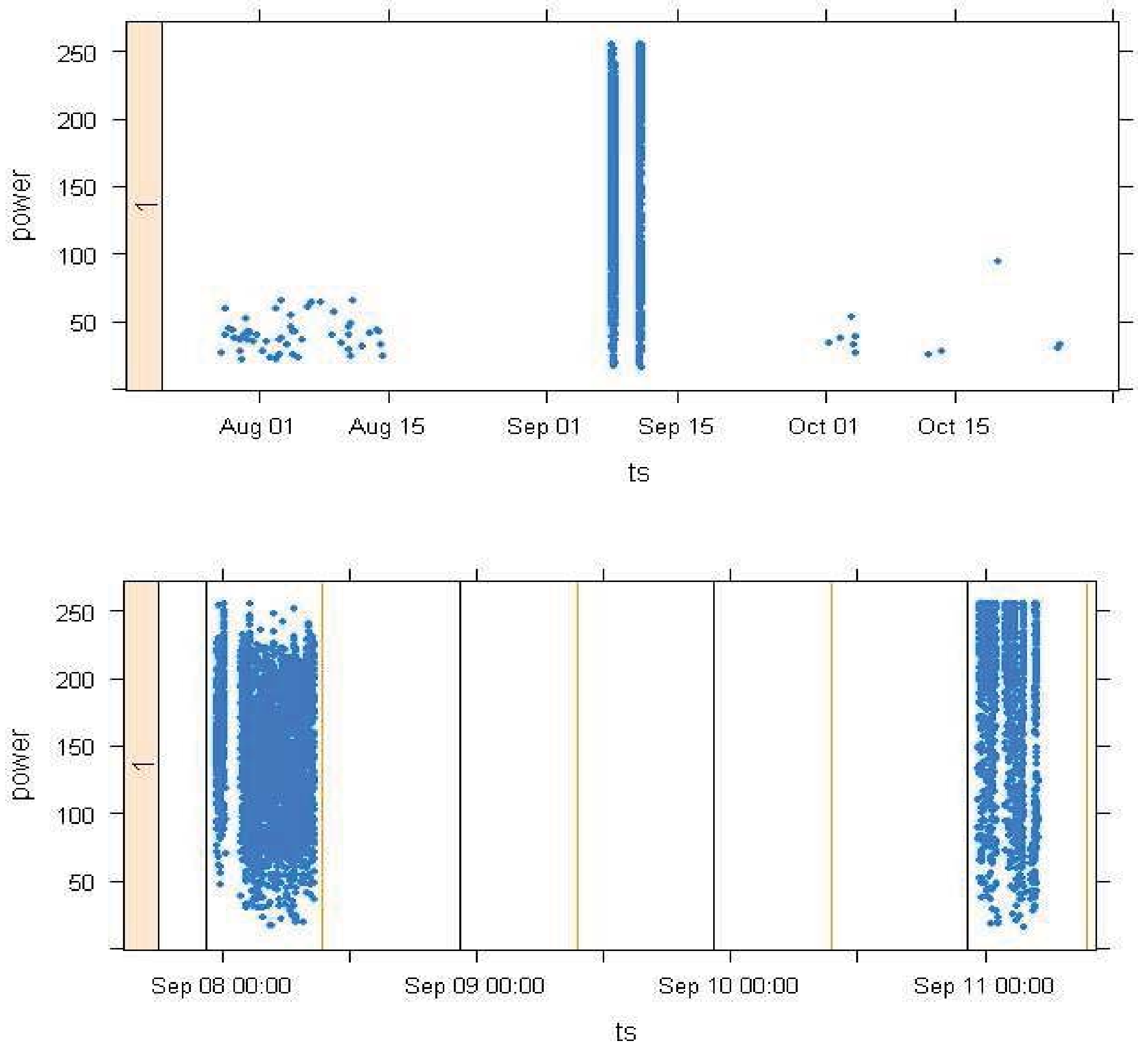


*Figure 1 – Detections of Herring Gull tag #36 recorded from a receiver deployed on the Panuke Sea. Each dot represents a single detection from an individual tag which was programmed to transmit every 5 seconds. ts = time stamp (i.e. date/time), power = relative signal strength of the VHF tag on a scale of 1-255. In the upper panel, detections in August and October are false positives, i.e. "noise", but the strong and continuous detections on two days in September represent sustained contact with bird 36 on two nights. Lower panel zooms in on the September detections showing continuous detections starting after sunset (black bars) and ending before sunrise (yellow bars). Time is in UTC (3 hrs ahead of local time – Atlantic Daylight Savings Time ADT).*

***Preliminary Results – Storm-petrels***

Receivers on Country Island documented patterns of colony attendance for nesting Leach's Strom-petrels between 28 June (tag deployment) and 12 August (receiver recovery and expected tag battery failure). All deployments were successful showing regular patterns of attendance during incubation and early chick rearing. Figure 2 illustrates an example of colony attendance inferred from VHF signals detected by the receiver. Nests were checked again on 12 August (when receivers were retrieved) documenting empty nests with no eggs or chicks in 10/15 (66%) of the burrows. VHF data can be used to infer nest failure dates (see Figure 2) when adults stopped attending burrows. These relatively high and unexpected failure rates in 2011 were likely due to an unusually high abundance of voles on the island this year – we found evidence of vole predation on egg remains in one burrow. Next steps with colony attendance data include classification of incubation patterns for each bird and interpretation of arrival and departure direction from variability in signal strength recorded by each of the two directional antennas.

A preliminary analysis of storm-petrel detections from offshore receivers found no obvious signals. Due to the erratic nature of storm-petrels behaviour at sea, we did not expect strong and sustained contact between storm-petrels and offshore supply vessels (as observed for gulls; Fig. 1). The large amount of "noise" recorded from receivers on vessels may be obscuring infrequent and short duration storm-petrel detections. Next step is to refine the VHF detection algorithm to increase our ability to distinguish true storm-petrel detections from "noise" recorded by receivers on offshore vessels.

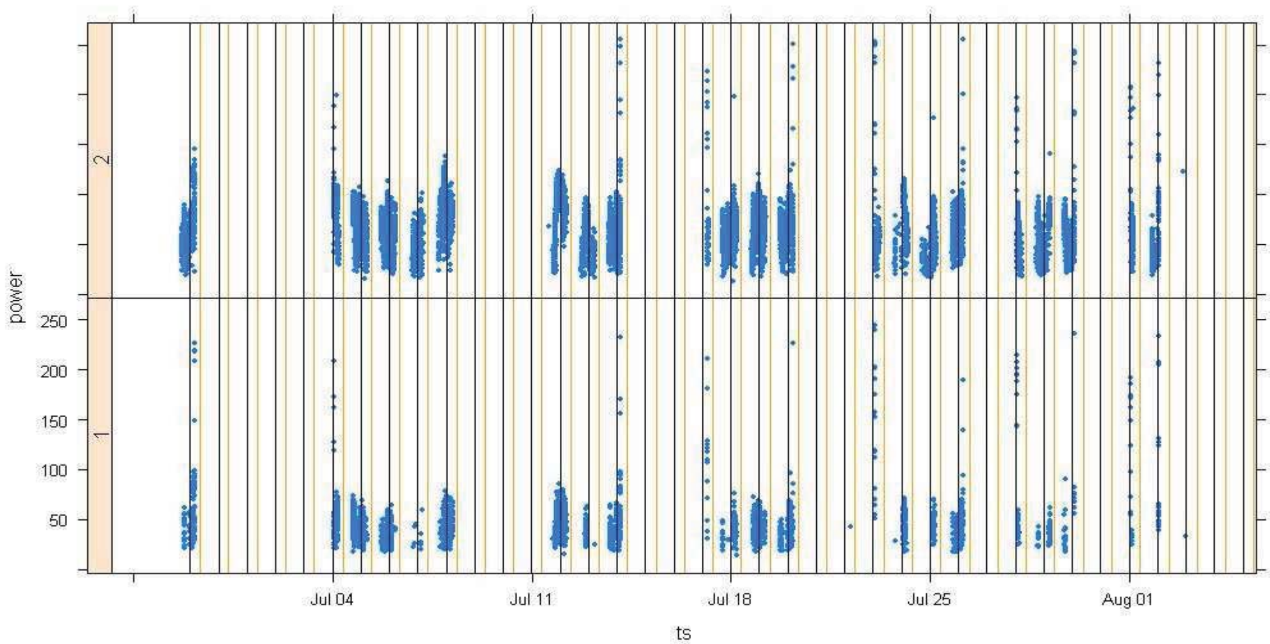


*Figure 2 – Detections of Leach's Storm-petrel tag #44 recorded from a receiver deployed on Country Island with two directional antennas (upper and lower panel). Each dot represents a single detection from an individual tag which was programmed to transmit every 10 seconds for 12 hrs daily. ts = time stamp (i.e. date/time), power = relative signal strength of the VHF tag on a scale of 1-255. Vertical bars indicate sunset (black) and sunrise (yellow). Incubation pattern may be inferred as follows: tagged on June 28 and departed colony the same night, 6 incubation shifts (4-8 July, 10-12 July, 17-20 July, 23-26 July, 28-30 July), and likely abandonment after 2 August.*

## 4.2 Colour Banding

A total of 50 birds were marked with colour bands that contained a unique 3-letter code. This included 29 Great Black-backed Gull chicks that were marked with green leg bands, and 21 Herring Gulls that were marked with both pink leg bands and wing tags (Figure 3). Supply vessels attending Encana and ExxonMobil platforms were notified about these deployments and asked to submit sightings reports and photos of any tagged birds observed offshore. Additional outreach regarding the colour-banding program was conducted through the following:

- Blog created www.sableislandgulls.wordpress.com
- Blog linked to other bird tagging websites
- Notice sent to bird watching email listserves for all eastern provinces and states (approximately 20 in total)
- Handout developed (French and English) and distributed to:
  - Offshore supply vessels
  - CNSOPB Fisheries Advisory Committee
  - Canadian Wildlife Service seabird observer program
  - Canadian Coast Guard Vessels (15 in total)
  - NOAA fisheries observer programs in the eastern USA
  - College of the Atlantic (Maine)
  - Bird Studies Canada piping plover program
  - Northwest Atlantic Seabird Conservation Cooperative (e-mailed to >100 seabird researchers and managers)
- Stories in newsletters:
  - Encana newsletter
  - Bird Studies Canada newsletter
  - Cayuga Bird Club Newsletter (NY state area)
- Posting on facebook pages and blogs:
  - Gulf of Maine Bird Watch
  - Grand Manan Whale and Seabird Research Station

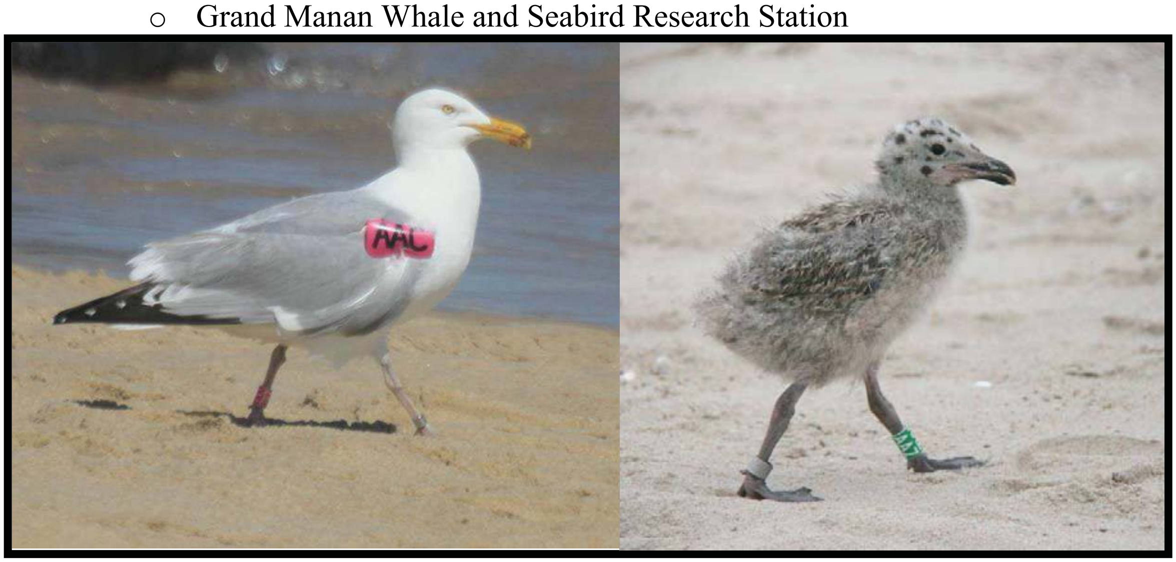


*Figure 3 – Colour wing- and leg-bands deployed on Herring Gull adults (left) and Great Black-backed Gull chicks (right).*

Only one Great Black-backed Gull chick was re-sighted which occurred on 18-August on Appledore Island, Maine, documenting an 870 km dispersal distance. Despite only 21 adult Herring Gulls being banded and tagged, we received a total of 27 re-sightings between 01 July and 24 October (Table 3). Individual identification codes were confirmed on 59% (16/27) of these. Sightings of 8 different individuals (38% of tagged birds) were confirmed by 3-letter codes, and most individuals were spotted on multiple occasions (Table 3). More than half of the sightings and 5 of the confirmed individuals (24% of the total tagged population) were observed from supply vessels operating near the Deep Panuke platform between 21-July and 22-August. Eight of these sightings (30%) were from two individuals (AAP and AAJ) suggesting that some individuals may show stronger associations with vessels and platforms than others. Four sightings from SOEP supply vessels and one sighting from a fishing vessel 10 miles from Sable confirm that Sable Island Herring Gulls also attended other offshore platforms and vessels.

This limited sample size of tagged birds but subsequent high re-sighting rates suggest three patterns in relation to the timing of gull movements from Sable Island. First, birds begin attending offshore supply vessels and platforms after chick rearing is complete (21-Jul to 22-Aug). Second, migration to the mainland occurs between late August and early October. Finally, at least some individuals remain offshore to forage near supply vessels and platforms (2 sightings of wing-tagged gulls near Venture and Thebaud platforms on October $10^{th}$ and $24^{th}$).

*Table 3 – Summary of 27 re-sightings of wing-tagged Herring Gulls, 01 July to 24 October, 2011. % of sightings = percentage of all confirmed tag re-sighting reports (total of 27).*

| Location | No. sightings | % of sightings | Confirmed individuals (no. of sightings) | Dates |
|---|---|---|---|---|
| Sable Island | 3 | 11.1 | none identified | 01-Jul to 08-Aug |
| Offshore | | | | |
| Supply vessels* - Deep Panuke | 14 | 51.9 | AAP(3), AAJ(5), AAZ(1), AAU(1), AAY(1) | 21-Jul to 22-Aug |
| Supply vessels** - SOEP | 4 | 14.8 | none identified | 10-21Aug, 10-24 Oct |
| Fishing vessel - 10 miles from Sable | 1 | 3.7 | AAV(1) | 26-Jul |
| Mainland | | | | |
| New London, PEI | 3 | 11.1 | AAR(2) | 27-Aug to 09-Sep |
| Glace Bay, NS (Cape Breton) | 2 | 7.4 | AAF(2) | 03-Oct to 07-Oct |
| **Totals** | 27 | 100.0 | 8 | 01-Jul to 24-Oct |

*Ryan Leet and Rolling Stone; **Panuke Sea

## 4.3 Other tags

During gull captures on Sable Island in June, 11 individuals were also fitted with 2g geolocation tags mounted to metal leg bands. These tags record sunrise and sunset times which are used to calculate coarse-scale positions (± 150 km) of gulls twice daily, year-round. These are archival tags which will be recovered in 2012 to obtain the data.

# 5. Bird-Radar Deployment

One of the primary objectives of this project is the development of radar as a tool to monitor bird activity around the Deep Panuke platform. In July, a site visit to the Deep Panuke platform in Mulgrave, NS, was conducted to evaluate options for positioning of the radar and VHF antennas/receiver. During this visit it was discovered that a Radar Beacon (RACON) installed on the PFC may become a problem for the planned bird-radar deployment. When triggered, RACONs send out morse-code patterned pulses in response to incoming marine radar signals. This can cause two kinds of interference: 1) obstruction of targets on bird radar due to a large number of RACON response pulses, and 2) potential safety hazards due to our triggering the RACON too often, leading to its not being able to respond adequately to ships. Since this discovery we have worked on identifying solutions to this problem and alternative approaches to sensors for detecting birds at the PFC.

## *5.1 RACON interference and Chebucto Head polarization test*

Several options to mitigate the RACON triggering were explored including rotation of the polarization of the bird radar from horizontal to vertical. Most X-band RACONs whose details we're aware of have horizontally polarized antennas, matching that of most X-band ship radars. For a typical bird radar, this rotation requires re-orienting the rectangular waveguide feed so that the long edge (in cross-section) is vertical, rather horizontal. We don't know how much bird radar cross-sections will differ between the two polarization modes, but it shouldn't significantly affect our ability to detect birds since a vertically operated t-bar antenna is (briefly and repeatedly) vertically polarized when it is aligned up-and-down, and we haven't heard of or noticed any corresponding "disappearance" of birds from the radar at those times.

Vertical polarization tests were conducted in the lab, at Acadia University, and in the field, where the bird radar was positioned near a Canadian Coast Guard RACON at Chebucto Head lighthouse (Figure 4). For full details of results on radar testing refer to website: http://radr-project.org/In_house_stuff/RACON_interference_with_bird_radar . Chebucto Head test of the modified radar confirmed that radar still triggered the RACON causing significant interference in the ability of the radar to detect birds. At a meeting on December 12, 2011, It was agreed collectively that the radar could not be an option for this project because of the risk of triggering the PFC RACON. Trying to modify the RACON to prevent it from responding to the radar was deemed not feasible for this project because of operational, cost, schedule and safety considerations. Therefore, we are investigating options to utilize existing S-band and X-band radars on the PFC as well as other detection sensors.

*Figure 4 – Set up of bird radar polarization test at Chebucto Head lighthouse, 26 October 2011. Access to lighthouse area was granted by Canadian Coast Guard to conduct this test.*

## 5.2 Use of PFC radars

Due to the RACON interference problem, we will not be placing our own radar on the PFC. Instead, we will try tapping the existing S-band surveillance and possibly X-band wave radars. These options are being investigated in conjunction with Encana and SBM engineers. The PFC's S-band radars are two Furuno 13.4 kW S-Band scanners with ~2m open-array antennas. The radar processors are two Furuno FAR 2137BB RPU's, networked via NAVNET into a single remote display, which multiplexes the two radars into a single sweep (one large sector from each radar; each radar has sector blanking on the portion of its sweep pointing inboard). The RPUs and the display are in the control room on the main deck of the PFC and there should be enough space in the control room for a separate computer to connect to the two RPUs. The X-band wave radar black-box is also in the control room; we'd need to investigate with the subcontractor whether and how to interface with that one. Next step is to determine whether the 2137BB has a remote display port that we can tap to digitize the signal ourselves; if so, decide whether this makes more sense than grabbing pre-digitized data via NAVNET, and whether to use Rutter cards or go with USRPs.

### *5.3 Use of other sensors*

As indicated in the CRD proposal, other sensors, in addition to bird-radar and telemetry, may provide additional valuable information on the patterns of bird interactions with offshore platforms. These include thermal and other low-light cameras, and acoustics monitoring of bird calls (Gauthreaux and Livingston 2006; Hüppop et al. 2006). On the Deep Panuke platform, one area of interest is the monitoring of bird activities around the flare stack and the flare itself. The intense heat generated from the flare will preclude the use of thermal cameras; therefore we will explore the use of low-light cameras which will take advantage of ambient light generated from the flare and platform lights. Acoustic monitoring of bird calls has already been used successfully from an offshore production platform in the Gulf of Mexico (Farnsworth and Russell 2007), thus, this option will also be implemented to provide supplementary information on bird species identification which can be distinguished from bird calls. The next step in the implementation of these additional sensors is the approval of equipment types and placement on the platform (e.g. approved housing for electronic equipment, availability of power supply). We are working with Encana engineers to sort out the details of this equipment usage.

# 6. Funding

The following table summarizes funding secured and applications pending which will support this overall project.

| Source/Grant | Purpose | Amount | Status |
|---|---|---|---|
| Encana R&D | Bird-platform interactions (radar and telemetry studies) | [redacted] | awarded |
| NSERC-CRD | Bird-platform interactions (radar and telemetry studies) | [redacted] | awarded |
| Canadian Wildlife Federation | Telemetry studies including terns and Ipswich sparrows | [redacted] | awarded |
| NS Habitat Conserv. Fund | Additional satellite tags for gulls | [redacted] | pending |
| Encana R&D | Bird-platform interactions (Blackpoll warbler migrations) | [redacted] | pending |
| **Total** | | $394,300 | |

# 7. Training and Certifications

Summary of offshore training and certifications completed by Rob Ronconi

| Training and other certifications | Requirement | Obtained | Expiry |
|---|---|---|---|
| Basic Survival Training (BST) | Mandatory - helicopter travel offshore | 21-Oct-11 | 21-Oct-14 |
| Emergency Breathing Apparatus (HUEBA) | Mandatory - helicopter travel offshore | 21-Oct-11 | 21-Oct-14 |
| Helicopter Underwater Evacuation Training (HUET) | Mandatory - helicopter travel offshore | 21-Oct-11 | 21-Oct-14 |
| Marine Emergency Duties (MED A1) | Mandatory - vessel travel offshore | 20-Sep-07 | no expiry |
| First Aid + CPR (Wilderness First Aid) | Recommended | 5-Dec-11 | 4-Dec-14 |
| WHMIS | Mandatory - helicopter travel offshore | 19-Sep-11 | no expiry |
| Hydrogen Sulfide Alive (H2SA) | Mandatory - helicopter travel offshore | 28-Jul-11 | 27-Jul-14 |
| Valid medical certificate (age 18-40; every 3 yrs) | Mandatory - helicopter travel offshore | 25-Jul-11 | 24-Jul-14 |
| ATV training | Mandatory - ATV use on Sable Island | 28-May-11 | no expiry |
| Encana Regulatory Awareness | Mandatory - Encana policies | 25-Oct-11 | no expiry |

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# APPENDIX E 2

OGOP Encana 2011 PRC Tow, Rock Placement Program, and Umbilicals Program Report

# OGOP Oil and Gas Observer Program Canada

| | |
|---|---|
| To: | Marielle Thillet, Environmental Lead, Deep Panuke Project, Encana Corporation |
| From: | John Salsbury, Manager, OGOP |
| Date: | August 11, 2011 |
| Re: | Deep Panuke Production Field Centre Tow Program – Final Report by John Salsbury |

The Deep Panuke Production Field Centre (PFC) Tow Program in 2011 consisted of towing the PFC from the Mulgrave area to its final location in the Deep Panuke field. The OGOP Observer program started with deployment to Mulgrave on July 21, 2011 and concluded with demobilization on July 26, 2011. The PFC Tow took place from 11:30 on July 22nd to 20:00 on July 24th at which time the PFC was on location.

OGOP deployed Fisheries Liaison Officer Lindsay Williams for this program. There was one trip rotation. Due to space limitations aboard the PFC and other considerations, observer deployment was aboard the Fairmount Expedition, one of several tugs and supply/standby vessels escorting the PFC to the field.

… Continued on page 2 …

The OGOP fisheries observer reported being treated professionally and with respect during this work.

There were no fishing boats observed during this program. There were a few seabird sightings, including Great Black-backed Gull and Herring Gull. Additional information on wildlife observations (including coordinates) have been recorded on separate marine mammal records of sightings and bird observation reports transmitted to Encana.

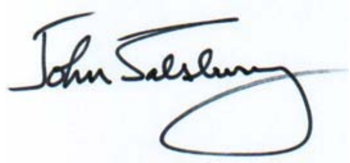
A total of eight marine mammal sighting reports were filed by the observer during this program. These are shown in the following table.

| Date | Obs # | Details |
|---|---|---|
| July 23 | 1 | Two adult humpback whales swimming slowly East |
| July 23 | 2 | Four adult common bottlenose dolphins jumping while moving East |
| July 24 | 1 | One adult fin whale swimming fast to East |
| July 24 | 2 | Two adult humpback whales swimming slowly East |
| July 25 | 1 | Three adult minke whales feeding |
| July 25 | 2 | One adult minke whale feeding |
| July 25 | 3 | Four adult and one juvenile pilot whales swimming slowly West |
| July 25 | 4 | Ten adult and two juvenile common dolphins feeding |

The PFC is on location at approximately Latitude 43’ 48 N and Longitude 60’ 41 W.

We appreciate the opportunity to have been of service to Encana on this Production Field Centre Tow program component of the Deep Panuke project.

August 11, 2011



John Salsbury

1801 – 45 Alderney Drive, Dartmouth, Nova Scotia, Canada B2Y 2N6
Tel: (902) 463-7790 Fax: (902) 469-8294 Email: ogop@ns.aliantzinc.ca

# OGOP Oil and Gas Observer Program Canada

| | |
|---|---|
| To: | Marielle Thillet, Environmental Lead, Deep Panuke Project, Encana Corporation |
| From: | John Salsbury, Manager, OGOP |
| Date: | August 11, 2011 |
| Re: | Deep Panuke Rock Placement Program – Final Report by John Salsbury |

The Deep Panuke 2011 Rock Placement Program consisted of placing rock on certain portions of the infield flowlines, the Production Field Centre (PFC) footings, and the main gas export pipeline from the PFC to the mainland. The OGOP Observer program started with deployment to Mulgrave on July 18, 2011 and concluded with demobilization on August 6, 2011.

OGOP deployed Fisheries Liaison Officer Charles Swim for this program. There was one trip rotation with several runs from the field to shore to pick up additional supplies of rock. Observer deployment was aboard the M/V Rollingstone (pictured above). The OGOP fisheries observer reported being treated professionally and with respect during this work.

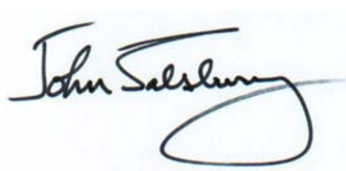
… Continued on page 2 …

There was contact with one fishing boat during this program. The fishing vessel did not respond to attempts to contact it and the Rollingstone operations ceased until the fishing vessel departed the area. There were a large number of seabird sightings, including Great Black-backed Gull, Greater Shearwater, Herring Gull, Northern Fulmar, Northern Gannet, and Sooty Shearwater. Sightings included birds tagged by researchers sponsored by Encana (see photo below). Additional information on wildlife observations (including coordinates) have been recorded on separate marine mammal records of sightings and bird observation reports transmitted to Encana.. A total of twelve marine mammal sighting reports were filed by the observer during this program. These are shown in the following table.

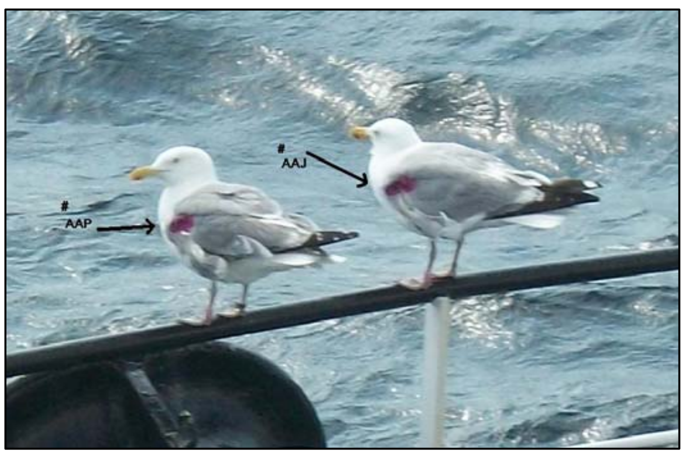
| Date | Obs # | Details |
|---|---|---|
| July 24 | 1 | Six adult and two juvenile pilot whales swimming fast |
| July 25 | 1 | Three adult and one juvenile pilot whale swimming fast |
| July 25 | 2 | One adult minke whale swimming fast |
| July 26 | 1 | One adult minke whale swimming fast |
| July 27 | 1 | One adult minke whale swimming fast |
| July 29 | 1 | One adult minke whale swimming fast |
| July 30 | 1 | One probable adult minke whale swimming fast |
| July 30 | 2 | One probable adult minke whale feeding |
| July 31 | 1 | One adult minke whale acting curious around vessel |
| July 31 | 2 | One adult minke whale swimming fast |
| Aug 2 | 1 | Nine adult and six juvenile common dolphins bow riding and swimming fast |
| Aug 2 | 2 | Four adult and two juvenile pilot whales swimming slowly and resting |

We appreciate the opportunity to have been of service to Encana on this Rock Placement program component of the Deep Panuke project.

August 11, 2011



John Salsbury



# OGOP Oil and Gas Observer Program Canada

| | |
|---|---|
| To: | Marielle Thillet, Environmental Lead, Deep Panuke Project, Encana Corporation |
| From: | John Salsbury, Manager, OGOP |
| Date: | August 11, 2011 |
| Re: | Deep Panuke Umbilicals Program – Final Report by John Salsbury |

The Deep Panuke 2011 Umbilicals Program consisted of pipelaying and trenching of five infield umbilicals between wells and the Production Field Centre (PFC). The OGOP Observer program started with deployment to Mulgrave on July 8, 2011 and concluded with demobilization on July 22, 2011.


OGOP deployed Fisheries Liaison Officer Eugene Sears for this program. There was one trip rotation. Observer deployment was aboard the M/V Acergy Falcon (pictured above in 2010).

The OGOP fisheries observer reported being treated professionally and with respect during this work. He specifically mentioned the presence of a culture of safety aboard the vessel.

… Continued on page 2 …

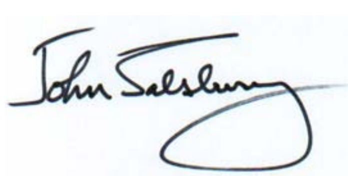
There were no fishing boats observed during this program. There were a large number of seabird sightings including Black-legged Kittiwake, Great Black-backed Gull, Greater Shearwater and Herring Gull. Additional information on wildlife observations (including coordinates) have been recorded on separate marine mammal records of sightings and bird observation reports transmitted to Encana..

A total of nine marine mammal sighting reports were filed by the observer during this program. These are shown in the following table.

| Date | Obs # | Details |
|---|---|---|
| July 11 | 1 | Possibly three fin whales swimming and possibly feeding |
| July 12 | 1 | Six fin whales swimming fast |
| July 12 | 2 | Possibly eight fin whales feeding |
| July 14 | 1 | Two fin whales, possibly minke whales, feeding |
| July 14 | 2 | Possibly two fin whales probably feeding |
| July 15 | 1 | One harbour porpoise swimming around vessel |
| July 15 | 2 | One minke whale swimming |
| July 16 | 1 | Two fin whales swimming and diving |
| July 16 | 2 | One minke whale swimming and blowing |

We appreciate the opportunity to have been of service to Encana on this umbilicals program component of the Deep Panuke project.

August 11, 2011



John Salsbury

# APPENDIX E 3

Blue Shark Photograph


**Blue shark sighted from the Deep Panuke PFC on August 31, 2011.**

# APPENDIX E 4

2011 Seabird Salvage Permit Report

**Report of "Live" Migratory Seabirds Salvaged**
**Under The Authority of a Federal Migratory Bird Permit**

In compliance with the provisions of the Migratory Birds Convention Act and Regulations, I am submitting a complete report of the number of specimens of each species of live migratory bird recovered from

_January 1, 2011_ to _December 31, 2011_ under the authority of Permit # __LS 2568___.

NAME Marielle Thillet (Environmental Lead) _______ TELEPHONE # ____(902) 492-5422___
(PLEASE PRINT)

ORGANIZATION _____EnCana Corporation_______________ FAX # ____(902) 425-2766____

ADDRESS _______1701 Hollis Street, Halifax, NS ________ POSTAL CODE ____ B3J 3M8___

E-mail ______ marielle.thillet@encana.com ______

SIGNATURE ____________________________________________ DATE ____January 16, 2012____

Return to: Permit Section, Atlantic Region
Canadian Wildlife Service
PO Box 6227
Sackville NB E4L 1G6

Phone: 506-364-5033; Fax: 506-364-5062
e-mail: andrew.macfarlane@ec.gc.ca

**Renew Permit: Yes? __X__ No? _____**

***(a) Subsea Asset Inspection Survey [May 2011]***

**Vessel Name:** Atlantic Condor

**Position:** Between PFC and well locations (H-08, M-79A, F-70, D-41 and E-70) and export pipeline route (see attached map)

**General activity of vessel:** ROV survey of subsea equipment

**Search effort for live birds:** Conducted by vessel staff during activities

***(b) Umbilical Installation Program [Jul 2011]***

**Vessel Name:** M/V Acergy Falcon (survey/pipelay vessel)

**Position:** Between PFC and well locations (H-08, M-79A, F-70, D-41 and E-70) (see attached map)

**General activity of vessel:** Laying and trenching of the umbilicals on the seabed

**Search effort for live birds:** Conducted by vessel staff during activities

***(c) Rock Placement Program [Jul-Aug 2011]***

**Vessel Name:** Tideway Rollingstone (rock placement vessel)

**Position:** On sections of the flowlines, sections of the export pipeline and at PFC (see attached map)

**General activity of vessel:** Rock placement on the seabed

**Search effort for live birds:** Conducted by vessel staff during activities

***(d) PFC Installation and Deep Panuke Field Hook-Up and Commissioning [Jul 2011-ongoing]***

**Vessel Name:**

- PFC tow and installation: PFC, Boa Barge, construction vessel Skandi Skolten, four tug boats and two supply vessels (first two weeks of the program)
- PFC hook-up and commissioning: two supply vessels – Ryan Leet and Condor (started after PFC installation; ongoing)
- Diving program (subsea equipment installation, hook-up and commissioning): diving vessel Acergy Discovery (Jul-Nov 2011)

**Position:** PFC area (see attached map)

**General activity of vessel:** as per above

**Search effort for live birds:** Conducted by vessel staff during activities

**Only one stranded bird was found during the 2011 Deep Panuke offshore programs. The bird was a Purple Gallinule stranded on the MV Atlantic Condor. It was safely released in a marsh habitat near Bedford.**

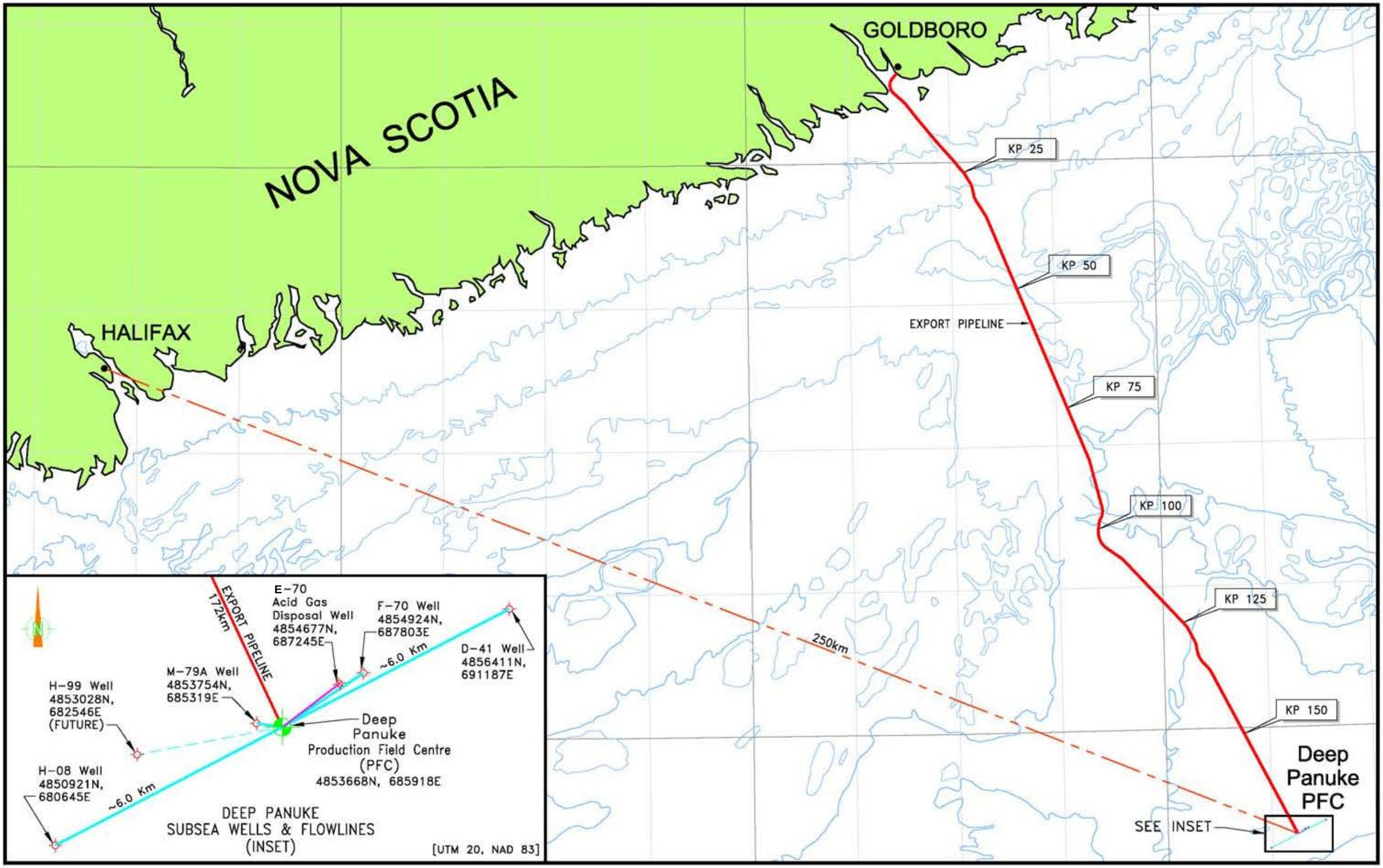
*Live Bird Events (MV Atlantic Condor)*

| Date | Species | Condition | Action Taken | Fate of Bird |
|---|---|---|---|---|
| 30-Jul-11 | Purple Gallinule | Good condition | Bird was found in the morning of July 30, 2011 on the Atlantic Condor. Encana contacted CWS (A. Boyne) who recommended bringing the bird back to shore and releasing it in a marsh habitat. The crew of the Condor caught the bird and built a cage to house it in for safe transport to shore. The bird was showing no sign of distress. Vessel staff then released the bird at a small pond 3 km up Rocky Lake Drive from Bedford on the right side of the road (there were ducks and Canada geese in the pond as well as in the larger body of water across the road) – see photos below. The bird was released at 1500hrs July 30 and observed until 1520hrs. Bird was drinking water and picking around in the grass; see photos below. Went back to check at 1730hrs; it was torrential downpour at the time and bird was hunkered down in the tall grass not far from point of release. Checked the area again on July 31 at 0800hrs and 1400hrs; the bird could not be seen. | The NS Rare Bird Alert website later reported sightings of a Purple Gallinule along the South Shore of Nova Scotia in early to mid-August. |


Purple Gallinule stranded on the MV Atlantic Condor

Purple Gallinule release location near Bedford, NS

Purple Gallinule released in marsh habitat



NOVA SCOTIA
GOLDBORO
HALIFAX
KP 25
KP 50
EXPORT PIPELINE
KP 75
KP 100
KP 125
KP 150
250km
Deep Panuke PFC
SEE INSET
EXPORT PIPELINE
172km
E-70
Acid Gas Disposal Well
4854677N, 687245E
F-70 Well
4854924N, 687803E
~6.0 Km
D-41 Well
4856411N, 691187E
H-99 Well
4853028N, 682546E
(FUTURE)
M-79A Well
4853754N, 685319E
Deep Panuke Production Field Centre (PFC)
4853668N, 685918E
H-08 Well
4850921N, 680645E
~6.0 Km
DEEP PANUKE SUBSEA WELLS & FLOWLINES (INSET)
[UTM 20, NAD 83]

## Instructions:

**Position of vessel**: latitude and longitude or a general description (e.g. SE Grand Banks) if the vessel is moving.

**Activity of vessel**: brief description. Examples: drilling, seismic, stand-by, production.

**Search effort for birds**: describe how birds were found. Examples: opportunistically by all staff, daily/nightly (or other interval) rounds by # of observers.

## Table:

**Complete one line for every bird handled.** This is required so that the fate of all birds handled can be tracked.

**Date:** date when bird was first found.

**Species:** use AOU codes if possible, see Appendix below. Otherwise, write species name in full. Do not use generic terms (e.g. turr, songbird, gull).

**Condition** (when found): briefly describe the condition of the bird. Examples: oiled, wet or dry; active, dazed, lethargic, or dead.

**Action taken**: describe what was done. Examples: held and released that night, released immediately, sent onshore for rehabilitation, dead and sent to CWS office.

**Fate of bird**: describe what happened to the bird. This may require some follow-up. Examples: released alive on site, died and disposed of on site, died onshore, released alive onshore.

**Renew permit**: if you are renewing the permit and there are changes to the nominees, please send the information in an e-mail to: andrew.macfarlane@ec.gc.ca

**Appendix**. AOU Codes for common bird species observed on the Grand Banks, includes a list of rarely seen species and our own codes for unknown species.

| Common Name | AOU Code | Latin Name |
|---|---|---|
| **COMMONLY SEEN BIRDS** | | |
| Atlantic Puffin | ATPU | *Fratercula arctica* |
| Black-headed Gull | BHGU | *Larus ribindus* |
| Black-legged Kittiwake | BLKI | *Rissa tridactyla* |
| Common Murre | COMU | *Uria aalge* |
| Cory’s Shearwater | COSH | *Calonectus diomedea* |
| Dovekie | DOVE | *Alle alle* |
| Great Black-backed Gull | GBBG | *Larus marinus* |
| Glaucous Gull | GLGU | *Larus hyperboreus* |
| Greater Shearwater | GRSH | *Puffinus gravis* |
| Great Skua | GRSK | *Stercorarius skua* |
| Herring Gull | HERG | *Larus argentatus* |
| Iceland Gull | ICGU | *Larus glaucoides* |
| Lesser Black-backed Gull | LBBG | *Larus fuscus* |
| Leach’s Storm-petrel | LHSP | *Oceanodroma leucorhoa* |
| Long-tailed Jaeger | LTJA | *Stercorarius longicaudis* |
| Manx Shearwater | MXSH | *Puffinus puffinus* |
| Northern Fulmar | NOFU | *Fulmarus glacialis* |
| Northern Gannet | NOGA | *Morus bassanus* |
| Parasitic Jaeger | PAJA | *Stercorarius parasiticus* |
| Pomarine Jaeger | POJA | *Stercorarius pommarinus* |
| Ring-billed Gull | RBGU | *Larus delawarensis* |
| Sooty Shearwater | SOSH | *Puffinus griseus* |
| Thick-billed Murre | TBMU | *Uria lomvia* |
| **UNKNOWN BIRD CODES** | | |
| Unknown | UNKN | |
| Unknown Alcid | ALCI | |
| Unknown Gull | UNGU | |
| Unknown Jaeger | UNJUA | |
| Unknown Kittiwake | UNKI | |
| Unknown Murre | UNMU | |
| Unknown Shearwater | UNSH | |
| Unknown Storm Petrel | UNSP | |
| Unknown Tern | UNTE | |
| **RARELY SEEN BIRDS AND POTENTIAL BIRDS** | | |
| Black-browed Albatross | BBAL | *Diomedea melanophris* |
| Common Eider | COEI | *Somateria mollissima* |
| Common Tern | COTE | *Sterna hirundo* |
| Ivory Gull | IVGU | *Pagophila eburnea* |
| Long-tailed Duck | LTDU | *Clngula hyemalis* |
| Ruddy Turnstone | RUTU | *Arenaria interpres* |
| Sabine’s Gull | SAGU | *Xema sabini* |
| Wilson’s Storm Petrel | WISP | *Oceanites oceanicus* |

# APPENDIX E 5

Sable Offshore Energy Program 2011 Summary Report

**OFFSHORE ENVIRONMENTAL EFFECTS MONITORING PROGRAM**
**SABLE OFFSHORE ENERGY PROGRAM**
**2011 SUMMARY REPORT**

**COMPONENT:** beached seabird surveys on Sable Island

**REPORTING ORGANIZATION:** Zoe Lucas, Sable Island

## 1. Background:

Since 1993, regular surveys for beached birds have been conducted on Sable Island to monitor trends in numbers and rates of oiling in beached seabirds, and to collect specimens of contamination for gas chromatographic analysis to generically identify oil types.

Results of analysis of oil samples collected during 1996-2005 are reported in [1], and results of beached bird surveys conducted during 1993-2009 are reported in [2].

## 2. Goal:

By monitoring numbers and oiling rates in beached seabirds on Sable Island, industry and regulators can identify and correct potential sources of oil contamination arising from industry operations.

## 3. Objectives:

- To monitor trends in oiling rate in beached seabird corpses.
- To generically identify oil types found on seabird feathers and in pelagic tar.

## 4. 2011 Sampling:

Contractor: Zoe Lucas, Sable Island.

- Between January 1 and December 31, 2011, ten surveys for beached seabirds were conducted on Sable Island. No surveys were conducted for April and December.

- All surveys were carried out by Zoe Lucas.

- Species identification, corpse condition and extent of oiling were recorded for seabird specimens. When possible, the time since death was estimated based on freshness of tissues and degree of scavenging.

- The oiling rate is the fraction of oiled birds of the total number of birds coded for oil (i.e. with >60% of body intact) during 2011.

- Samples of oiled feathers (representing contamination on various seabird species) were collected.

- Oil samples were packaged in aluminum foil, labeled, kept frozen for periods ranging from one week to several months, and delivered to the laboratory for gas chromatographic analysis (Maxxam Analytics). Interpretation of GC/FID results were conducted by MacGregor & Associates (Halifax) Ltd.

- Oil specimens were solid samples (oiled seabird feathers) and were dissolved directly in dichloromethane. This extract, filtered to remove solids, was injected on a glass capillary column (SPB-1) in an HP 5890 Gas Chromatograph with Flame Ionization Detector (GC/FID). Outputs from the GC were retrieved on HPChem station, and chromatograms were produced and assessed manually. Concurrently standard oils such as Bunker C, Scotian shelf crude and condensate, marine diesel, and hydrocarbon n-alkane marker standards (C6-C16 and C18-C32) were run under the same conditions. This permitted identification of the n-alkane peaks in the chromatograms. N-alkane peaks were not quantified: only relative concentration calculations based on peak height were undertaken

- Oil samples found on bird corpses on Sable Island were identified as representing separate discharge events on the basis of date, bird corpse condition, and oil characteristics.

| **Survey Period** | **January –December 2011** |
|---|---|
| **Platform** | beach, Sable Island |
| **Type of Sample** | oil on seabird feathers |
| **Test Sample Locations** | n/a |
| **Reference Sample Locations** | n/a |
| **Number of Samples** | 6 oil samples |
| **Sample Preparation** | frozen |
| **Equipment** | collection by hand into metal foil containers |

## 5. Analyses

### 5.a. Data Analyses

For oiling rate and number of clean birds/km (see Figures 1 - 7), annual trends were first analyzed with generalized linear models (with Poisson links for densities and binomial links for oiling rate), but yielded excessive overdispersion even after corrections. Thus instead data were transformed (log transformation for densities, arcsine transformation for oiling rate) and analyzed by least squares regression.

## 5.b. Oil Sample Analyses

Analysis of six oil samples collected from the from feathers of beached seabird corpses in January, February and March 2011.

**Parameters Analyzed**

| Parameters | Analysis Method |
|---|---|
| HCR, MHCP, URM, URM/MHCP ratio | gas chromatograph (GC/FID) |

**Analysis QA/QC**

Maxxam Analytics is a CAEL facility (Canadian Associates of Environmental Laboratories).

## 6. Results

Results are presented in Tables 1, 2 and 3, and Figures 1 – 7 (see section 9).

## 7. Summary

- During 2011, the corpses of 413 beached fulmars, shearwaters, gannets, Larus gulls, and alcids were collected on Sable Island. Fulmars and shearwaters accounted for 67.6% of total seabird corpses recovered, and alcids comprised 22.5% (Table 1).

- Seasonal occurrence of complete corpses (Codes 0 – 3 combined) varied by bird group and species. Most Northern Fulmars and Northern Gannets occurred in summer (86.2% and 90.9%, respectively), and all shearwaters occurred in summer. Larus gull corpses were found throughout the year, with 54.5% in winter, and all alcid corpses occurred in winter (Table 1).

- The highest oiling rate for a seabird group, 13.0%, was observed in alcids (i.e., 3 of 23 complete corpses, Table 1). The oiled alcid species were Razorbill (1 of 1 complete corpse) and Atlantic Puffin (2 of 3 complete corpses).

- Although the 2011 oiling rate for alcids (all species combined) is higher than that observed in 2010 (13.0% compared with 5.3%), it is consistent with the relatively low levels of oiling (i.e., <15%) recorded during the previous four years.

- Six samples of oil were collected in 2011, and likely represented four separate discharge events (Tables 2 & 3).

- None of the six samples contained light or mid-range distillate fuels, or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms off Sable Island.

## 8. References

[1] Lucas, Z. and C. MacGregor. 2006. *Characterization and source of oil contamination on the beaches and seabird corpses, Sable Island, Nova Scotia, 1996-2005*. Marine Pollution Bulletin 52: 778-789.

[2] Lucas, Z., A. Horn and B. Freedman. *Beached bird surveys on Sable Island, Nova Scotia, 1993 to 2009, show a decline in the incidence of oiling.* Manuscript submitted to the Proceedings of the Nova Scotian Institute of Science, January 2012, and in review.

## 9. Tables & Figures

**Table 1.**
Beached seabird corpses collected on Sable Island during 2011. Totals & linear densities for clean complete corpses (Code 0) for winter (November-April) and summer (May-October), and oiling rate based on complete corpses (i.e., with >60% of body intact, Codes 0 - 3).

| Bird species & groups | Total [1] corpses | Code 0 Winter | Code 0 Summer | Code 0 number/km Winter | Code 0 number/km Summer | Oiling rate % |
|---|---|---|---|---|---|---|
| Northern Fulmar | 70 | 8 | 50 | 0.024 | 0.094 | 0 |
| Shearwater | 209 | 0 | 149 | 0 | 0.279 | 0.7 |
| Northern Gannet | 13 | 1 | 10 | 0.003 | 0.019 | 0 |
| Larus Gulls | 28 | 12 | 10 | 0.037 | 0.019 | 0 |
| Alcids [2] | 93 | 23 | 0 | 0.061 | 0 | 13.0 [3] |
| Common & Thick-billed Murres | 10 | 5 | 0 | 0.015 | 0 | 0 |
| Dovekies | 48 | 14 | 0 | 0.043 | 0 | 0 |

[1] Codes 0 - 4 combined.
[2] All alcid species combined.
[3] Oiled species were Razorbill (1) and Atlantic Puffin (2).

**Table 2.**
Generic identification of 6 oil samples collected from bird corpses during 2011.

| Month | Number of Samples | Matrix | Generic Identification of Oil |
|---|---|---|---|
| January | 1 | feathers, alcid | crude oil, moderate weathering |
| January | 1 | feathers, alcid * | lube oil with heavy fuel oil |
| January | 1 | feathers, alcid | lube oil with heavy fuel oil |
| February | 1 | feathers, alcid | lube oil with heavy fuel oil |
| March | 1 | feathers, alcid * | HFO & lube oil |
| March | 1 | feathers, alcid * | crude with some lube oil |

* Oil samples taken from incomplete corpses (Code 4).

**Table 3.**
Discharge events identified by generic oil source of samples collected on Sable Island during 2000-2011.

| Year | Crude oil | Fuel oil | Bilge | Total |
|---|---|---|---|---|
| 2000 | 6 | 1 | 1 | 8 |
| 2001 | 12 | 2 | 2 | 16 |
| 2002 | 5 | 3 | 2 | 10 |
| 2003 | 6 | 2 | | 8 |
| 2004 | 6 | | | 6 |
| 2005 | 9 | | | 9 |
| 2006 | 5 | 1 | | 6 |
| 2007 | 2 | 1 | | 3 |
| 2008 | 3 | 1 | 4 | 8 |
| 2009 | 2 | 3 | | 5 |
| 2010 | 2 | | 2 [1] | 4 |
| 2011 | 1 | | 3 [2] | 4 |
| Total | 59 | 14 | 14 | 87 |

[1] One specimen possibly bilge or fuel oil.
[2] Bilge or slop tanks.

**Figure 1**. Northern Fulmar
Oiling rate, $F_{1,17}$=42.58, P<.0001*; Clean corpses/km, $F_{1,17}$=3.66, P=0.07

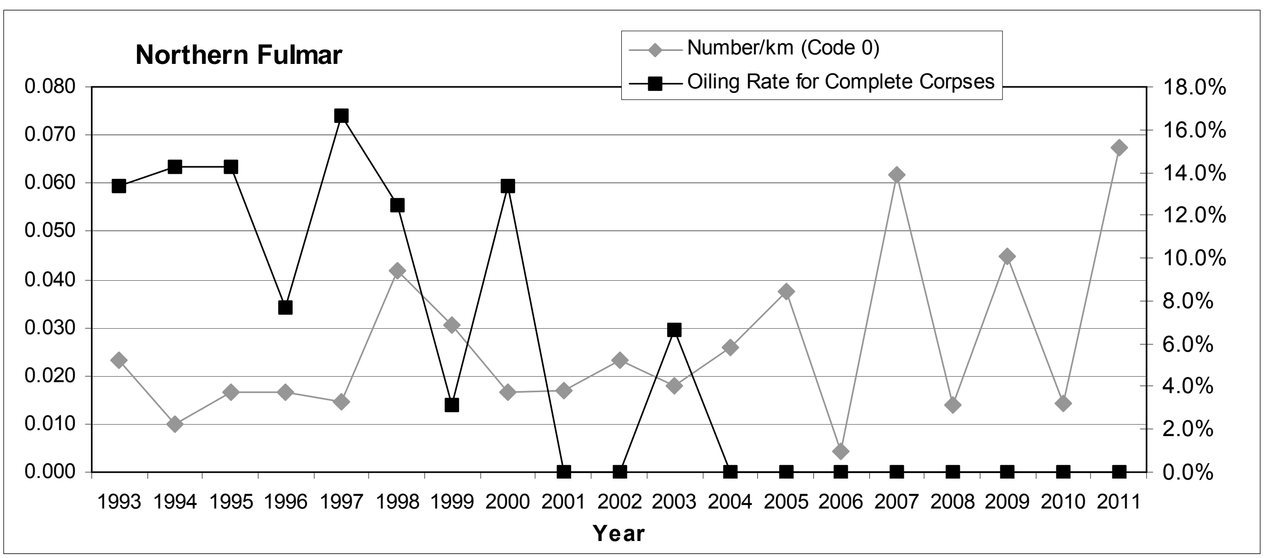


**Figure 2**. Shearwaters
Oiling rate, $F_{1,17}$=4.61, P=0.0465*; Clean corpses/km, $F_{1,17}$=0.00, P=0.96

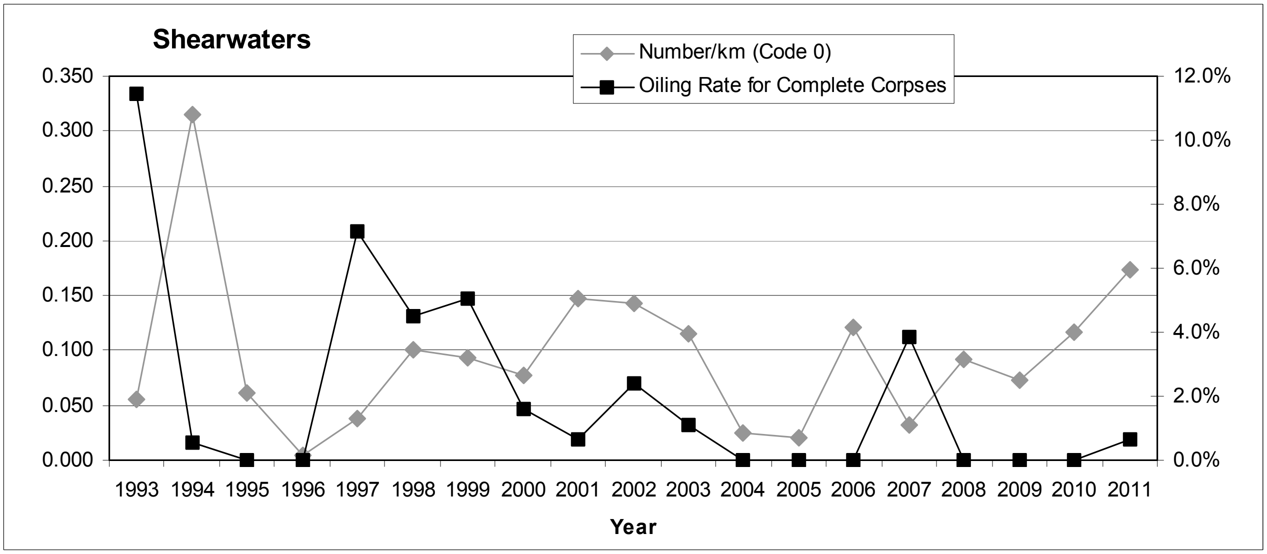



**Figure 3**. Northern Gannet
Oiling rate, $F_{1,17}$=4.01, P=0.06; Clean corpses/km, $F_{1,17}$=0.04, P=0.85

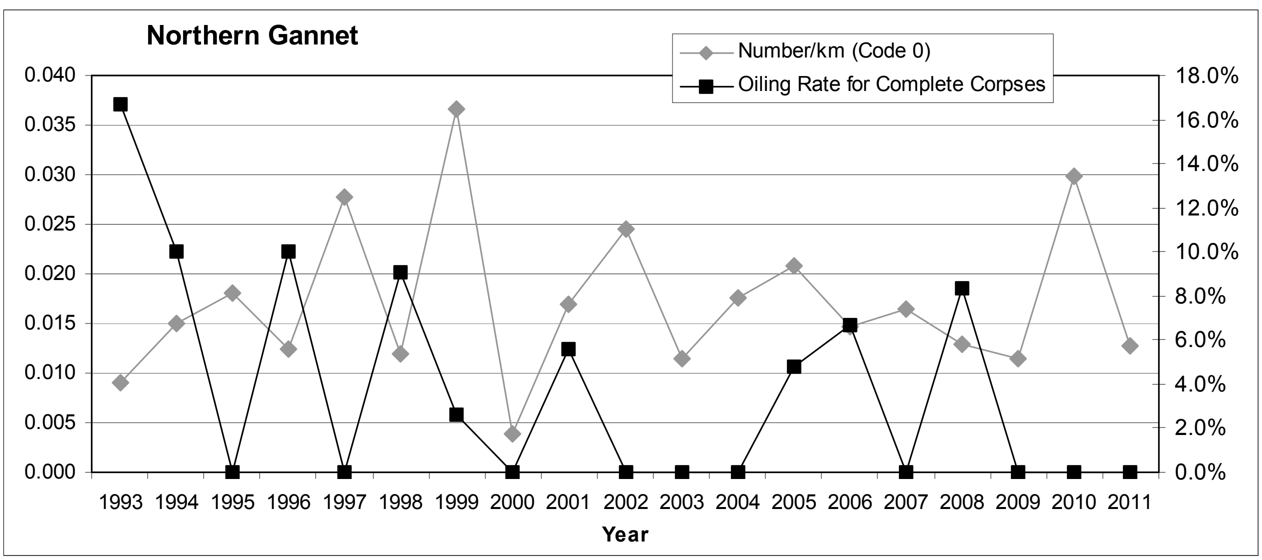


**Figure 4**. Larus Gulls
Oiling rate, $F_{1,17}$=5.69, P=0.0289*; Clean corpses/km, $F_{1,17}$=0.26, P=0.62

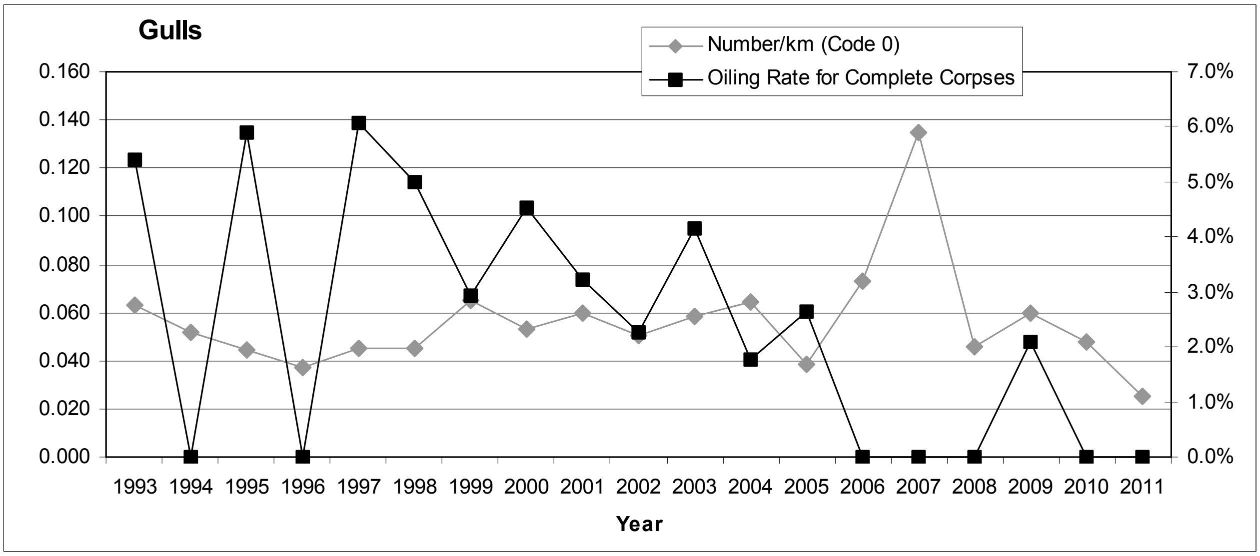



**Figure 5**. Alcids (all species combined)
Oiling rate, $F_{1,17}$=35.18, P<.0001*; Clean corpses/km, $F_{1,17}$=0.02, P=0.89

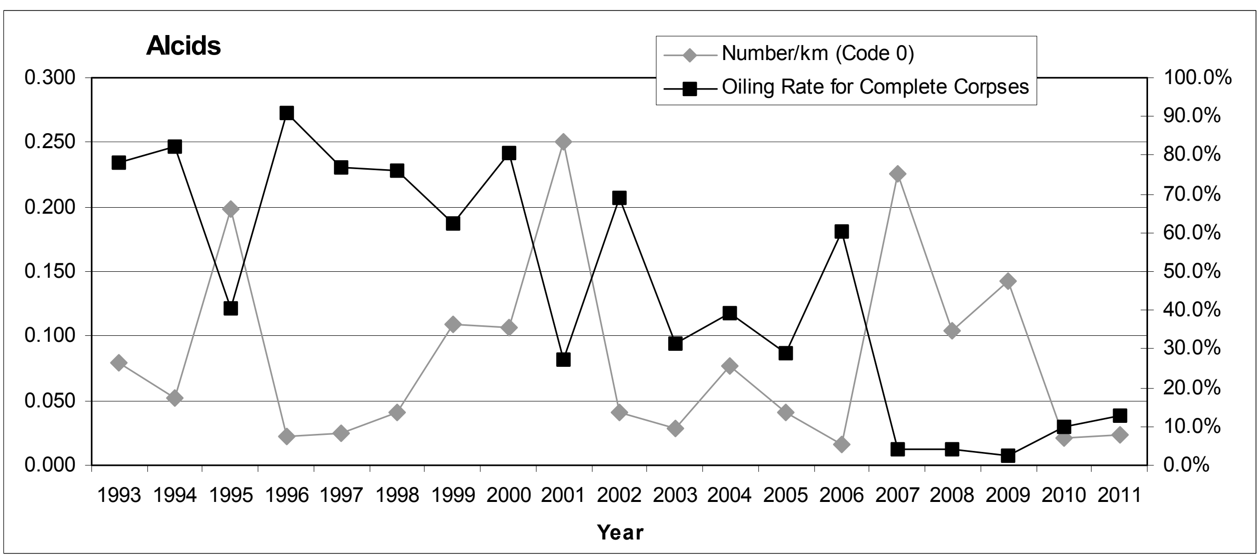


**Figure 6**. Common & Thick-billed Murres
Oiling rate, $F_{1,17}$=13.58, P=0.0018*; Clean corpses/km, $F_{1,17}$=0.02, P=0.89

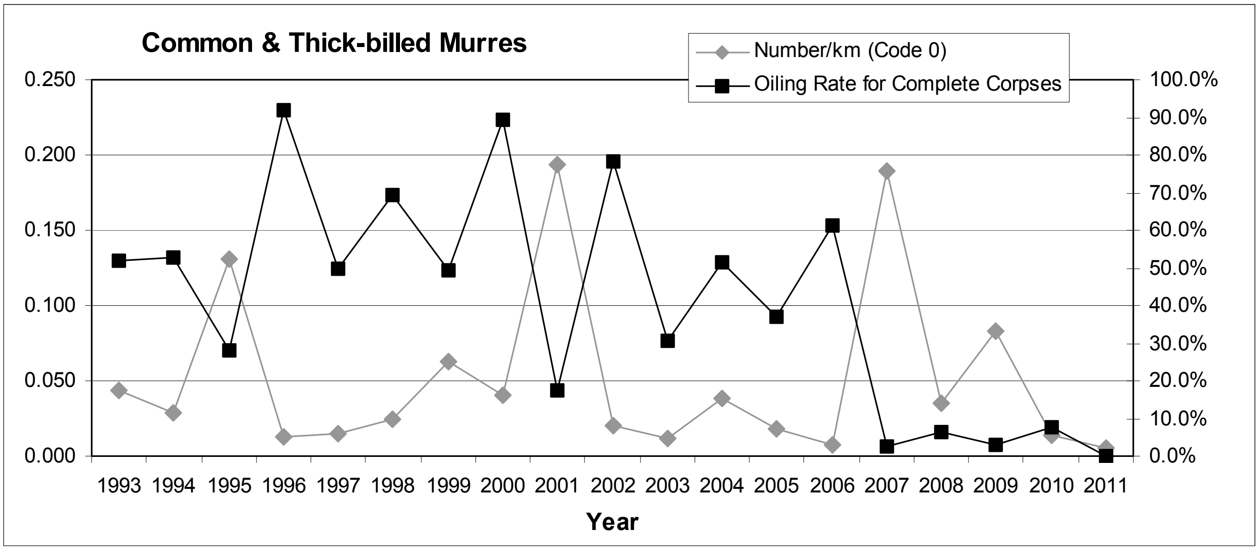



**Figure 7**. Dovekie
Oiling rate, $F_{1,17}$=42.87, P<.0001*; Clean corpses/km, $F_{1,17}$=0.04, P=0.85