Offshore Environmental Effects Monitoring for Deep Panuke

Program Annual Report 2012

McGregor number: *1113-EEMRDP*

Photograph courtesy of Encana Corporation

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Offshore Environmental Effects Monitoring for Deep Panuke

Program Annual Report 2012

McGregor number: *1113-EEMRDP*

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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. The objective of this ongoing study is to provide the follow up program addressing all production operations-related environmental effects monitoring (EEM) commitments made during the Deep Panuke regulatory process as outlined in the 2007 Comprehensive Study Report (CSR) and environmental effects predictions made during the 2002 and 2006 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 2012 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.

The 2012 field program includes fish habitat alteration analyses as well as marine wildlife observations including stranded-bird observations, Sable Island oiled bird observations and the Acadia research study, assessment of bird-human interactions at offshore installations. The remainder of the sampling program will continue following first gas which is expected sometime in 2013.

The results of the 2012 EEM program include the following:

Fish Habitat Alteration

- Epifauna colonization of WHPS at all well site locations observed had similar species density and assemblages as the survey in 2011. Species composition was homogenous across all wellhead sites;

- Differences in fish density, especially Atlantic cod, from 2011 to 2012 around the base of the riser caisson and WHPS is due to the seasonality of fish species and migration patterns;
- 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;
- There was an increased abundance of Tubularian hydroids at the base of the riser caisson. It also appears that the hydroid has managed to colonize parts of the vortex induced vibration (VIV) suppression strakes where Cuprotect coating has been applied.

Marine Wildlife Observations

- A single bird stranding occurred (Leach's storm petrel) with the bird being returned to its natural habitat unharmed;
- The Acadia bird research team developed an automated VHF receiver that was lab and field tested at multiple mainland, island and vessel locations during 2012.
- Ongoing monitoring of bird movements was conducted from May through the end of November, 2012 on Sable Island, Country Island and Bon Portage Island. Results are discussed in detail in the 2012 Acadia research study, assessment of bird-human interactions at offshore installations.
- Ongoing monitoring of oiling rates in beached birds on Sable Island was conducted over the course of 11 surveys carried out between January 1st, and December 21st, 2012. Results are discussed in detail in the Beached Seabird Survey, Sable Island, 2012.

No sampling was conducted in 2012 for the Produced Water Chemistry and Toxicity, Marine Water Quality Monitoring and Sediment Chemistry and Toxicity as start of production and resulting produced water discharges were postponed until 2013. These monitoring components will resume following commencement of production on the PFC. Fish Health (section 6.5 of the EEMP) and Air Quality Monitoring (section 6.7 of the EEMP) will also be included in the program after First Gas. The proposed Sable Island air emission monitoring plan is included in **Appendix E**.

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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) to provide environmental effects monitoring services and data analysis for the Deep Panuke Project. McGregor undertook data analysis and report production as per the Environmental Effects Monitoring Plan (EEMP) (Encana, 2011: DMEN-X00-RP-EH-90-0003).

The 2012 EEM project team consists of:

- McGregor GeoScience Ltd. (including subsea video data analysis)
- 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)
- Acadia University (bird monitoring research)
- Zoe Lucas (sable Island beached bird survey)

Table 1.1 provides an overview of the 2012 EEM program including relevant environmental effects monitoring (EEM) components and survey timing. No produced water, water quality or sediment sampling took place in 2012 since start of production and resulting produced water discharges were postponed until 2013. These monitoring components will resume following commencement of production on the PFC.

Table 1.1 Overview of 2012 EEM Program

EEM Component(s)	*2012 EEM Program*	*Survey Timing*
Fish Habitat Alteration	Inspection of ROV video data to determine development of benthic communities at the wellheads, wellhead protection structures and pipelines.	March and April, 2012 and September through November, 2012.
PFC Marine Wildlife Observations	Summarize PFC and vessels observations. Results include single stranded bird incident.	Continuous
Assessment of bird-human interactions at offshore installations	Study combined multiple, automated instrument-based monitoring techniques (VHF, satellite telemetry) to quantify patterns of individual and population level bird activities on and around offshore installations.	Ongoing, project extended through the end of 2013.
Oiled Bird Study conducted on Sable Island	Eleven surveys for beached seabirds were conducted on Sable Island. Species identification, corpse condition and extent of oiling were recorded for seabird specimens.	Between January 11 and December 31, 2012.

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.

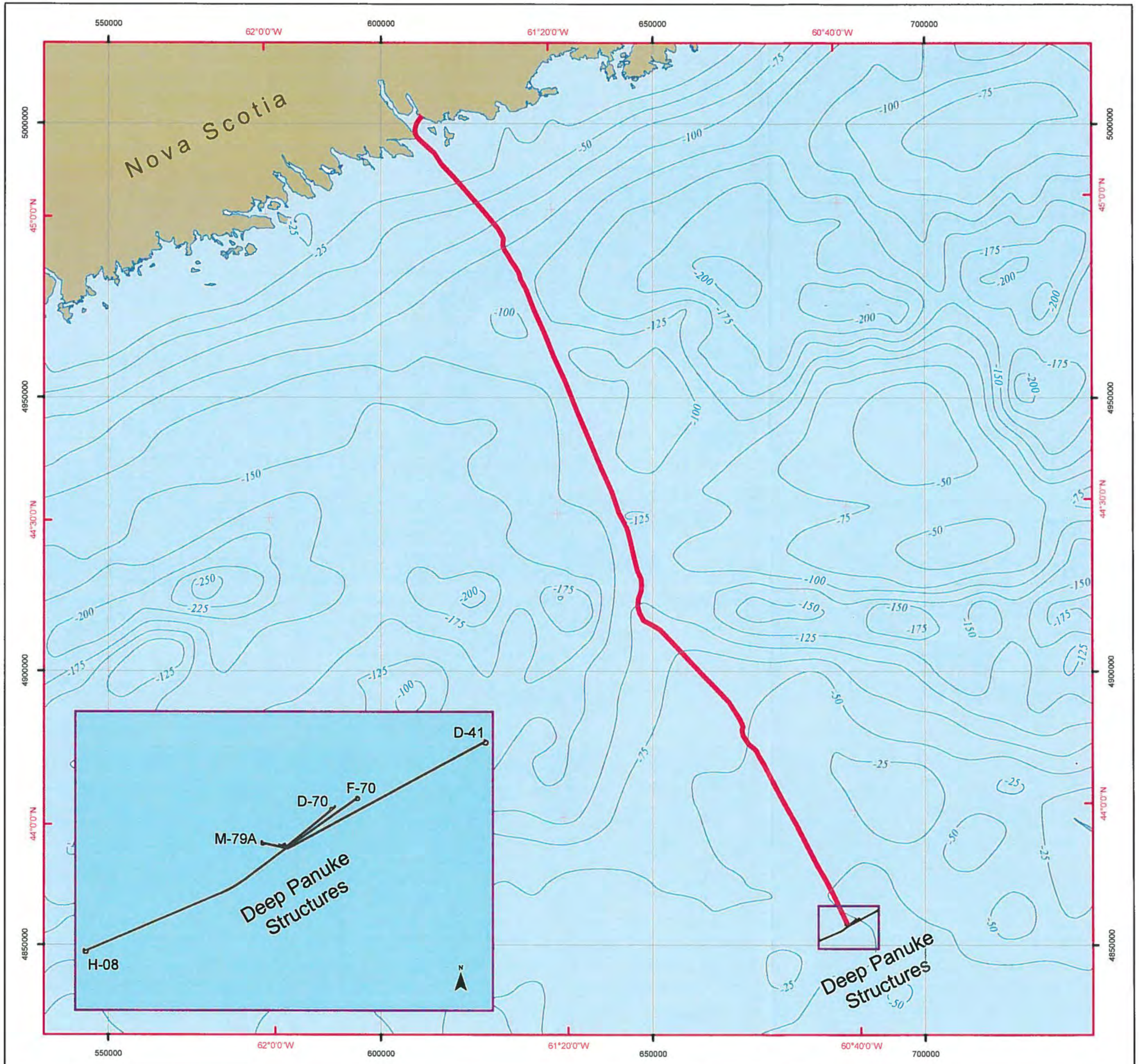
Deep Panuke is a sour gas reserve with raw gas containing approximately 0.18 mol % hydrogen sulphide (H_2S). The offshore processing system consists of separation, compression (inlet and export), gas sweetening, gas dehydration, gas dewpointing (via Joule-Thompson), condensate sweetening and stabilization, 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.

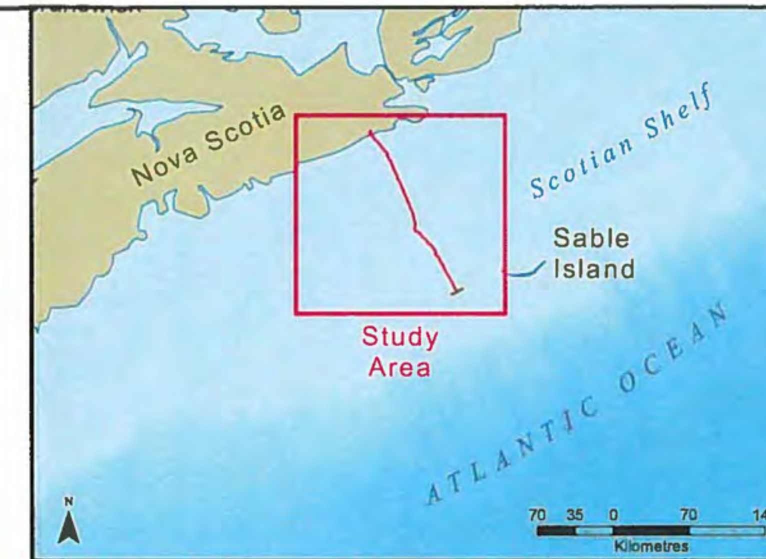
In November 2007, Encana entered into an agreement with Single Buoy Moorings Inc. (SBM) for the engineering, procurement, fabrication, installation and commissioning of the Deep Panuke PFC. In addition to the provision of the PFC, SBM will provide personnel to help ensure a smooth transition from the 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.

PFC hook-up and commissioning activities are still ongoing with First Gas expected in 2013.

1.2 2011 PROJECT OVERVIEW

The project location of the Deep Panuke EEMP is shown in **Figure 1**.





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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

EnCana

Project General Location

Deep Panuke Survey Area

Scotian Shelf

McGregor GeoScience Limited
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Bedford, Nova Scotia, Canada

Date Saved: 26/03/2012 9:43:55 AM

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 monitoring will start following commencement of production on the 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.

The field sampling program in 2011, reported in the 2011 Offshore Environmental Effects Monitoring for Deep Panuke Program Annual Report (DMMG-X00-RP-EH-90-0001.03U), concluded that metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines). This data set represents baseline levels measured prior to the PFC becoming operational.

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

No sampling took place in 2012 since start of production and resulting produced water discharges were postponed until 2013. The Water Quality Monitoring Program will resume following commencement of production on the PFC.

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 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 was a valuable monitoring parameter in the SOEP EEM program until this EEM component was discontinued after 2007.

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).

The field sampling program in 2011, reported in the 2011 Offshore Environmental Effects Monitoring for Deep Panuke Program Annual Report (DMMG-X00-RP-EH-90-0001.03U), concluded that metal, non-metal, hydrocarbon and nutrient concentrations were all found to fall below threshold levels as defined by the Canadian EQG (Environmental Quality Guidelines).

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

No sampling took place in 2012, since start of production and resulting produced water discharges were postponed until 2013. The Sediment Chemistry Monitoring Program will resume following commencement of production on the PFC.

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 in the SOEP EEM program.

The field sampling program in 2011, reported in the 2011 Offshore Environmental Effects Monitoring for Deep Panuke Program Annual Report (DMMG-X00-RP-EH-90-0001.03U), presented results from a laboratory-based sediment toxicity bioassays 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. Lab method "Tox 49" was used for the bioassay using *Eohaustorius estuarius* as the test species on sediments collected during the 2011 monitoring program. All sediments were found to be non-toxic.

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

No sampling and laboratory-based sediment toxicity bioassays tests took place in 2012 since start of production and resulting produced water discharges were postponed until 2013. The Sediment Toxicity Monitoring Program will resume following commencement of production on the PFC, expected in 2013.

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 pollock and cunners), and occasionally by crustaceans (e.g. Jonah crabs). Sea stars and sea anemones 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 pollock 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). 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. The 2011 EEM work confirmed that there was no cutting pile at the E-70 location or any of the other wellsites. 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 subsea production structures [EA predictions #1, 2, 3, 4, 5, 6, 7, 8, 9 & 10 in **Table 3.1**].

2.5.3 Objectives

- 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:

- 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 Subsea Structures

Subsea inspection videos of the wellhead areas (Spring and Fall 2012) and of the PFC area (March and October 2012) were provided on DVD recordable discs and viewed with video software. After initial viewing, inspection tasks, 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 schools of fish were highly mobile so estimates were multiplied by the number of sides of the structure. 2012 data was compared to the 2011 video data (spring and fall 2011 for the wellheads and fall 2011 for the PFC).

2.5.5.2 Cuprotect Coated Structures

Subsea inspection videos of structures coated with the Cuprotect antifouling products in the PFC riser/spools area (March and October 2012) 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) suppression strakes, disposal flowline and export pipeline in the PFC riser caisson area. After initial viewing, inspection tasks, 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 riser caisson. Each species encountered was identified and given approximate estimates for abundance. Data from 2012 was compared to the 2011 video data (fall survey only).

2.5.5.3 GEP and Flowlines

Videos of the export pipeline subsea inspection survey (July and August 2012) 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 of the 2012 survey data (same locations as surveyed in 2011) were analyzed and quantitative values were recorded for all fish and epifauna encountered. Small organisms, (i.e. shrimp) 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 and compared with data obtained from the 2011 survey.

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 Subsea Structures

- Abundances and species present were comparable to the 2011 survey of the WHPS at each location. Common species observed include the blue mussel (*Mytilus edulis*), the tubularian hydroid (*Tubularia* sp.), orange footed sea cucumber (*Cucumaria frondosa*), frilled anemone (*Metridium* sp.), common sea stars (*Asterias vulgaris*), and comb jellies (likely *Pleurobrachia* sp.);

- Zonation was observed occurring on each WHPS/tree in different locations. The bottom zone was colonized by tubularian hydroids (*Tubularia* sp.) and sea cucumbers (*Cucumaria frondosa*) in varying densities, and the top zone was colonized by blue mussels (*Mytilus edulis*) (**Tables 2.2 and 2.3; Figure 2.1a-e**). Colonization of blue mussels extended from 1.0 metres above the seafloor to the top of the structure at H-08 (**Figure 2.1a**), but at D-41, they extended from 7.5 metres above the seafloor to the top of the structure (**Figure 2.1d**). Total fouling of the WHPS was estimated to be between 75% to 90% for all structures. There was little difference of biofouling between the 2011 and 2012 survey, as evidenced by the same structure captured by the ROV between the two surveys (**Figure 2.2**);
- In the spring survey of the wellheads, comb jellies (likely *Pleurobrachia* sp.) were observed surrounding the structures in varying densities. The WHPS at H-08 and M-79A had the highest numbers (reaching approximately 200 individuals) and E-70, F-70 and D-41 were between 3 and 25 observed comb jellies. The reduced water clarity in the spring from floating debris/detritus may correspond to the increased abundances of the comb jellies;
- The fall survey in 2011 had large numbers of Atlantic cod (*Gadus morhua*) around the WHPS and concrete protection tunnels (**Table 2.3**). In the 2012 survey, Atlantic cod were not observed at any WHPS, however schools of Pollock (*Polachius virens*) were found in abundances up to approximately 100 individuals at H-08, M-79A, F-70, and the PFC. Pollock were infrequently observed around the structures at E-70 and D-41. Seasonal differences from 2011 to 2012 may account for the absence of the Atlantic cod, especially with the 2011 survey occurring in November and the 2012 survey occurring for the most part in September and October;
- Cunner, (*Tautoglabrus adspersus*), were occasionally observed around the WHPS in the 2011 survey, whereas they were commonly found in greater abundances in the 2012 survey. Structures at all sites experienced increased abundances of cunner, individual numbers reaching approximately 150 at M-79A. Where pollock and cunner were observed at the same site, pollock congregated at the base (Level 1) of the WHPS, whereas cunner were observed around the top (Level 2) of the WHPS;

- The few species of epifauna found around the Cuprotect coated surfaces were found in the concrete protection mats and sandbags;
- One occurrence of a sea star was observed on the Cuprotect-coated SPU insulation of the GEP line (**Figure 2.3, GEP line**);
- In contrast to the 2011 survey, Atlantic cods (*Gadus morhua*) were not observed in great numbers beneath the riser caisson or protection tunnels in either the spring or fall survey, (one possible occurrence of Atlantic cod was at the R-5 flowline in the fall survey). Pollock (*Pollachius virens*) and cunner (*Tautogolabrus adspersus*), and other unidentified fish were observed in decreased numbers (~370 total pollock at all WHPS in fall survey);
- Sculpin, (*Myoxocephalus* sp.), were the only other infrequently observed fish species;
- 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 (**Tables 2.4 and 2.5**).

Table 2.2 Spring 2012 Survey of GVI of WHPS, Subsea Tree and Protection Structures

Spring 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
H-08	WHPS	*Mytilus edulis* Ctenophora *Tubularia* *Asterias vulgaris* *Metridium sp.*	S ----- A C F	S A O F	~200	• Mussels (*Mytilus*) cover entire structure (fewer below 1.0m) • Visibility slightly reduced from ambient light
	Subsea Tree	*Tubularia* *Mytilus edulis* Ctenophora *Asterias vulgaris*	A O ----- -----	A A O	~100	• Approximately 80% fouling by *Mytilus* over the entire structure • Mussels (*Mytilus*) found on the tree guide funnel and occasionally on the subsea tree • Sea stars (*Asterias*) frequent on the base of the subsea tree, rare on the tree
	Concrete Protection Mats (Mar)	*Tubularia* *Cucumaria frondosa*		A S		• Visibility slightly reduced from ambient light • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Mats (Apr)	*Tubularia* *Cucumaria frondosa*		A S		• Visibility slightly reduced from ambient light • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (Mar)	*Cucumaria frondosa*		A		• Visibility slightly reduced from ambient light
	Concrete Protection Tunnel (Apr)	*Cucumaria frondosa*		A		• *Cucumaria* abundant in dense patches

Spring 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
M-79A	WHPS	*Cucumaria frondosa*	A	A		• Mussels (*Mytilus*) begin at 4.0 m on legs • High density of sea cucumbers colonizing the base of the structure
		Ctenophora	-----		15	
		Tubularia	A	A		
		Mytilus edulis	A	A		
		Myoxocephalus sp.	-----		5	
		Metridium sp.	O	C		
		Asterias vulgaris	C	F		
	Subsea Tree	*Tubularia*	S	A		• ~70% fouling by *Tubularia* over entire structure
		Cucumaria frondosa	S	O		
		Ctenophora	-----		~100	
	Concrete Protection Mats (Mar)	*Cucumaria frondosa*		S		• Posterior protection mat and flange cover entirely covered by *Cucumaria*
		Asterias vulgaris		C		
		Myoxocephalus sp.			1	
	Concrete Protection Mats (May)	*Cucumaria frondosa*		S		• Posterior protection mat and flange cover entirely covered by *Cucumaria*
		Asterias vulgaris		C		
	Concrete Protection Tunnel (Mar)	*Cucumaria frondosa*		S		• Poor visibility • Dense patches of *Cucumaria* covering the entire structure
		Ctenophora			~150	
	Concrete Protection Tunnel (May)	*Cucumaria frondosa*		S		• Poor visibility • Dense patches of *Cucumaria* covering the entire structure
		Ctenophora			~200	
E-70	WHPS	*Mytilus edulis*	A	A		• Mussels (*Mytilus*) begin at 5.0 m on legs and occasionally on inside of structure • Sea anemones (*Metridium*) recorded throughout entire structure, somewhat higher density at top of structure
		Asterias vulgaris	F	O		
		Metridium sp.	O	F		
		Ctenophora	-----		6	
		Cucumaria frondosa	-----	R		
		Tubularia	A	A		
	Subsea Tree	*Tubularia*	F	F		• ~30% fouling by *Tubularia* over the entire structure • Few patches of *Mytilus* and *Metridium* on top of the structure
		Ctenophora	-----		5	
		Metridium sp.	-----	O		
		Mytilus edulis	O	R		
		Asterias vulgaris	-----	R		
	Concrete Protection Mats (Mar)	*Asterias vulgaris*		F		• Shell material present in the protection mats
		Cucumaria frondosa		C		
	Concrete Protection Mats (Apr)	*Asterias vulgaris*		F		• Shell material present in the protection mats
		Cucumaria frondosa		C		
		Ctenophora			1	
F-70	WHPS	*Mytilus edulis*	A	A		• Mussels (*Mytilus*) begin at 3.0 m on legs and covering inside of structure
		Tubularia	A	A		
		Asterias vulgaris	F	F		
		Metridium sp.	O	C		
		Ctenophora	-----		25	
	Subsea Tree	*Tubularia*	A	C		• ~50% fouling by *Tubularia* over the entire structure • Few patches of *Mytilus* on the subsea tree
		Ctenophora	-----		16	
		Asterias vulgaris	C	R		
		Metridium sp.	R	R		
		Mytilus edilus	C	R		
	Concrete Protection Mats (Mar)	*Asterias vulgaris*		C		• 25% fouling by *Cucumaria* of the closing spool flange
		Myoxocephalus sp.			1	

Spring 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
F-70 (cont'd)		*Cucumaria frondosa*		C		
	Concrete Protection Mats (Apr)	*Asterias vulgaris* *Cucumaria frondosa* *Myoxocephalus sp.*		F A	 1	• Poor visibility • 25% fouling by *Cucumaria* of the closing spool flange • 80% fouling by *Cucumaria* of the flange installation cover
	Concrete Protection Tunnel (Mar)	*Cucumaria frondosa*		C		• Very dark video - poor visibility
	Concrete Protection Tunnel (Apr)					• Poor visibility - no coverage of tunnels
D-41	WHPS	*Tubularia* *Metridium* sp. *Asterias vulgaris* *Mytilus edulis* *Cucumaria frondosa* Ctenophora	A O A C F -----	A C C C C	 3	• Mussels (*Mytilus*) begin at ~7.5 m on legs
	Subsea Tree	*Tubularia* *Asterias vulgaris* *Metridium* sp. Ctenophora	F ----- A -----	S R A	 3 13	• 75% fouling over entire structure; heavily colonized on the top surface • High density of *Metridium* colonizing the tree guide funnel
	Concrete Protection Mats	*Asterias vulgaris* *Cucumaria frondosa*		R A		• Suspended sediment clouding video • 100% fouling of closing spool flange
	Concrete Protection Tunnel	*Cucumaria frondosa*		N/A		• Video error before protection tunnel survey

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

Table 2.3 Fall 2012 Survey of GVI of WHPS, Subsea Tree Protection Structures

Fall 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
H-08	WHPS	*Mytilus edulis*		S		• Cunner (*Tautogolabrus*) are congregating at Level 2 of structure, pollock (*Pollachius*) are around Level 1
		Tautogolabrus adspersus	19		~70	
		Metridium sp.		C		
		Myoxocephalus sp.			3	
		Asterias vulgaris		R		
		Tubularia		A		
		Pollachius virens	~4000 Cod		~100	
	Subsea Tree	*Pollachius virens*			~70	• Approximately 80% fouling by *Mytilus* over the entire structure • *Mytilus* covering entire top surface of Subsea tree
		Mytilus edulis		S		
		Tubularia		C		
		Asterias vulgaris		F		
		Metridium sp.		O		
		Tautogolabrus adspersus			~60	
	Concrete Protection Mats	*Asterias vulgaris*	C	C		• *Cucumaria* super abundant on posterior protection mats after protection tunnel
		Cancer sp.	R		4	
		Pollachius virens	-----		9	
		Myoxocephalus sp.	-----		6	
		Cucumaria frondosa	-----	S		
	Concrete Protection Tunnel	*Cucumaria frondosa*	-----	A		• *Cucumaria* abundant in dense patches
		Pollachius virens	-----		~50	
		Myoxocephalus sp.	-----		1	
		Cancer sp.	-----		8	
		Asterias vulgaris	-----	F		
		Tautogolabrus adspersus	1		2	
M-79A	WHPS	*Tautogolabrus adspersus*	3		~150	• Structure entirely covered by *Tubularia* at base, *Mytilus* begin at 4.0 m on legs
		Cucumaria frondosa		C		
		Tubularia		A		
		Mytilus edulis		A		
		Asterias vulgaris		C		
		Metridium sp.		C		
		Pollachius virens	>1000 Cod		~100	
		Myoxocephalus sp.			1	
	Subsea Tree	*Tautogolabrus adspersus*			~100	• 90% coverage of *Tubularia* over entire subsea tree
		Tubularia		S		
		Asterias vulgaris		R		
	Concrete Protection Mats	*Cucumaria frondosa*		S		• *Cucumaria* super abundant on posterior protection mats after protection tunnel
		Asterias vulgaris		C		
		Tautogolabrus adspersus			2	
		Unid. fish			20	
		Cancer sp.			1	
	Concrete Protection Tunnel	*Cucumaria frondosa*	S	S		• *Cucumaria* covers entire tunnel
		Tautogolabrus adspersus	—		3	

Fall 2012 Video Assessment

Wellhead Site	Structure	Fauna	2011 Abundance*	2012 Abundance*	2012 Numbers	2012 Description
E-70	WHPS	Unid. fish	~250 Cod		23	• Cod abundances lower in 2012 than 2011
		Tautogolabrus adspersus	1		45	
		Tubularia		A		
		Mytilus edulis		A		
		Asterias vulgaris		F		
		Metridium sp.		F		
	Subsea Tree	*Tautogolabrus adspersus*			16	• ~75% fouling by *Tubularia* over the entire structure
		Tubularia		A		
		Metridium sp.		F		
		Mytilus edulis		F		
		Asterias vulgaris		F		
		Pollachius virens			1	
	Concrete Protection Mats (Sept)	*Asterias vulgaris*		O		• Shell material in protection mats
		Unid. fish			3	
		Pollachius virens			1	
		Cucumaria frondosa		C		
	Concrete Protection Mats (Oct)	*Asterias vulgaris*		O		• Shell material in protection mats
		Unid. fish			3	
		Myoxocephalus sp.			1	
		Tautogolabrus adspersus			1	
		Cucumaria frondosa		C		
		Cancer sp.			1	
		Pagurus sp.			1	
F-70	WHPS	*Tautogolabrus adspersus*	26		~130	• Cunner (*Tautogolabrus*) are congregating at Level 2 of structure, Pollock (*Polachius*) are around Level 1
		Myoxocephalus sp.			2	
		Pollachius virens	~650 Cod		~100	
		Cancer sp.			3	
		Pagurus sp.			3	
		Mytilus edulis		A		
		Tubularia		A		
		Asterias vulgaris		F		
		Metridium sp.		C		
		Cucumaria frondosa		R		
	Subsea Tree	*Tubularia*		C		• ~60% fouling by *Tubularia* over the entire structure • Few patches of *Mytilus edulis* on the subsea tree • Pollock (*Pollachius*) congregate at base of subsea tree near seafloor • Cunner (*Tautogolabrus*) congregate at top of subsea tree
		Tautogolabrus adspersus			~50	
		Pollachius virens			~120	
		Mytilus edilum		O		
		Asterias vulgaris		F		
		Metridium sp.		O		
	Concrete Protection Mats	*Myoxocephalus sp.*			2	• 25% fouling by *Cucumaria* of the closing spool flange
		Asterias vulgaris		O		
		Cucumaria frondosa		F		
		Unid. fish			18	
		Pollachius virens			1	
	Concrete Protection Tunnel	*Cucumaria frondosa*		C		• Little coverage of tunnels

Fall 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
D-41	WHPS	*Tautogolabrus adspersus*	3		~100	• Cunner (*Tautogolabrus*) congregate at base and around funnels at top of legs • *Metridium*, *Asterias* and *Mytilus* heavily colonized on level 2
		Pollachius virens	~250 Cod		3	
		Tubularia		A		
		Metridium sp.		A		
		Asterias vulgaris		C		
		Mytilus edulis		C		
		Cucumaria frondosa		C		
	Subsea Tree					• Video not close enough for analysis
	Concrete Protection Mats	*Tautogolabrus adspersus*			~32	• Cunner (*Tautogolabrus*) congregate at concrete protection mats around wellhead
		Cancer sp.			1	
		Cucumaria frondosa		A		
	Concrete Protection Tunnel	*Cucumaria frondosa*	A	A		• *Cucumaria* abundant in dense patches
		Pollachius virens			49	
		Tautogolabrus adspersus			1	
		Unid. Fish			1	
		Cancer sp.	R		3	
		Asterias vulgaris		O		

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

Table 2.4 PFC Survey Spring 2012 (No Spring 2011 data collected for comparison)

Spring 2012 Video Assessment					
Wellhead Site	**Structure**	**Fauna**	**2012 Abundance***	**2012 Numbers**	**2012 Description**
PFC	Flange caps (R-3,4,8,9)	*Tubularia*	S		• Densely colonized by *Tubularia*
	Base of riser caisson	*Tubularia* Ctenophora Sculpin *Cucumaria frondosa*	A O	 67 8 	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections
	Concrete Protection Mats (M-79A)	*Cucumaria frondosa* *Asterias vulgaris* *Cancer sp.*	A O 	 1	• Shells present in protection mats • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (M-79A)	*Cucumaria frondosa* Sculpin	C 	 1	• *Cucumaria* common in dense patches
	Concrete Protection Mats (H-08)	*Cucumaria frondosa*	A		• Shells present in protection mats • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (H-08)	*Cucumaria frondosa* *Asterias vulgaris*	A R		• *Cucumaria* abundant in dense patches
	Concrete Protection Mats (D-41)	*Cucumaria frondosa* *Asterias vulgaris* *Myoxocephalus sp.*	A O 	 4	• Shells present in protection mats • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (D-41)	*Cucumaria frondosa* *Asterias vulgaris* *Myoxocephalus sp.*	A R 	 2	• *Cucumaria* abundant in dense patches
	Concrete Protection Mats (F-70)	*Cucumaria frondosa* *Asterias vulgaris* *Myoxocephalus sp.*	A R 	 1	• Shells present in protection mats • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (F-70)	*Cucumaria frondosa*	A		• *Cucumaria* abundant in dense patches
	Concrete Protection Mats (E-70)	*Cucumaria frondosa* *Asterias vulgaris* *Myoxocephalus sp.*	A R 	 1	• Shells present in protection mats • *Cucumaria* super abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (E-70)	*Cucumaria frondosa*	A		• *Cucumaria* abundant in dense patches
	Concrete Protection Tunnel (GEP)	*Cucumaria frondosa*	N/A		• Video not close enough for detailed analysis

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

Table 2.5 PFC Survey Fall 2012

Fall 2012 Video Assessment						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**2012 Description**
PFC	Flange caps (R-3,4,8,9)	*Tubularia*		S		• *Tubularia* colonizing Flange caps
	Base of riser caisson	*Tubularia* *Cucumaria frondosa* *Asterias vulgaris* *Pollachius virens*		A O O	 85	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections
	Concrete Protection Mats (M-79A)	*Cucumaria frondosa* *Asterias vulgaris* *Myoxocephalus sp.* Unid. Fish *Cancer sp.*		C O	 2 6 2	• Shells present in protection mats • *Cucumaria* abundant on posterior protection mats after protection tunnel • Crabs (*Cancer*) observed on protection mats for control umbilical
	Concrete Protection Tunnel (M-79A)	*Cucumaria frondosa* Unid. Fish	C 243 Cod	C	 2	• *Cucumaria* common in dense patches
	Concrete Protection Mats (H-08)	*Cucumaria frondosa* *Asterias vulgaris* *Cancer sp.* Unid. Fish		C F	 3 4	• Shells present in protection mats • Cucumbers abundant on posterior protection mats after protection tunnel • Crabs observed on protection mats for control umbilical
	Concrete Protection Tunnel (H-08)	*Cucumaria frondosa* *Asterias vulgaris* Unid. Fish	C ---- 336 Cod	C R	 1	• *Cucumaria* common in dense patches
	Concrete Protection Mats (D-41)	*Cucumaria frondosa* *Asterias vulgaris* Unid. Fish *Cancer sp.*		C O	 3 1	• Shells present in protection mats • *Cucumaria* abundant on posterior protection mats after protection tunnel • Crabs (*Cancer*) observed on protection mats for control umbilical
	Concrete Protection Tunnel (D-41)	*Cucumaria frondosa*	C 368 Cod	C		• *Cucumaria* common in dense patches
	Concrete Protection Mats (F-70)	*Cucumaria frondosa* Unid. Fish		C	 12	• *Cucumaria* abundant on posterior protection mats after protection tunnel
	Concrete Protection Tunnel (F-70)	*Cucumaria frondosa* Unid. Fish	A 562 Cod	C	 2	• *Cucumaria* common in dense patches
	Concrete Protection Mats (E-70)	*Cucumaria frondosa*		C		• *Cucumaria* common on posterior protection mats after protection tunnel • *Cucumaria* abundant on control umbilical mats • Shells present in protection mats
	Concrete Protection Tunnel (E-70)	*Cucumaria frondosa* Unid. Fish	C 158 Cod	C	 1	• *Cucumaria* common in dense patches
	Concrete Protection Tunnel (GEP)	*Cucumaria frondosa* *Asterias vulgaris* Unid. fish	S	S R	 2	• *Cucumaria* covers entire tunnel

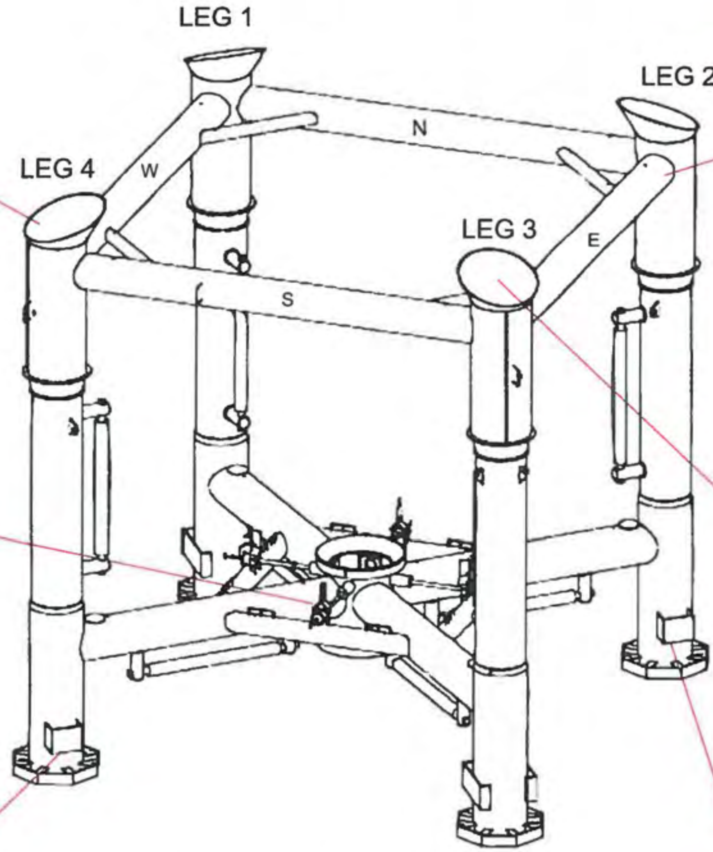
* Abundance values are based on the SACFOR scale (S = superabundant; A = abundant; C = common; F = frequent; O = occasional; R = rare)

Station H-08

Blue mussels and sea anemones colonizing top of Leg 4

Dense blue mussels on the inside of the WHPS

Base of Leg 4 with blue mussel and sea cucumber



Wellhead Protection Structure

East horizontal brace densely colonized by mussels

Blue mussels colonizing top of Leg 3

Sea cucumbers and blue mussels on base of Leg 2

McGregor GeoScience Limited

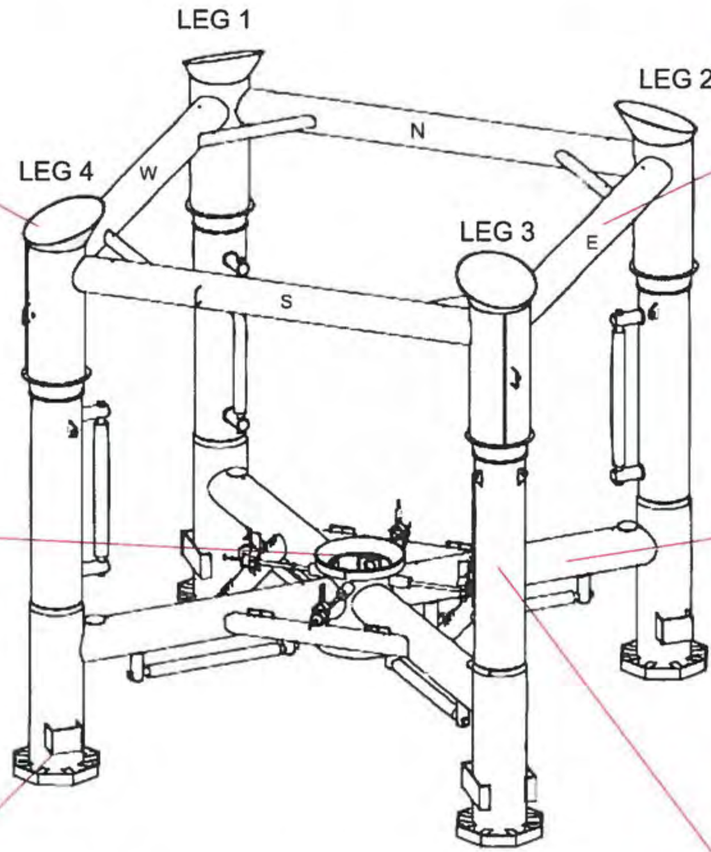
Figure 2.1a …head Protection Structures and Associated Fauna at H-08

Station M-79A

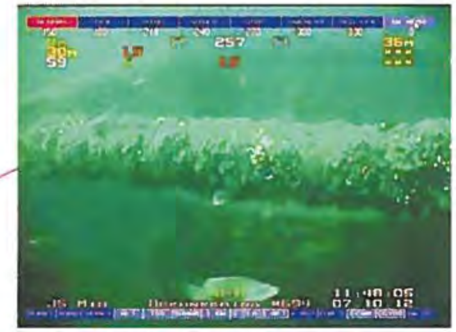
Blue mussels, hydroids and sea stars colonize the top of Leg 4

High density of sea cucumbers and hydroids at base of Subsea Tree

Sea cucumbers and sea anemones at base of Leg 4



Wellhead Protection Structure



East horizontal bracket with blue mussels and hydroids

Horizontal bracket HB01-2 with hydroids, cunner and pollock surrounding

Blue mussels and hydroids colonizing Leg 3 and anode

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Figure 2.1b Wellhead Protection Structures and Associated Fauna at M-79A

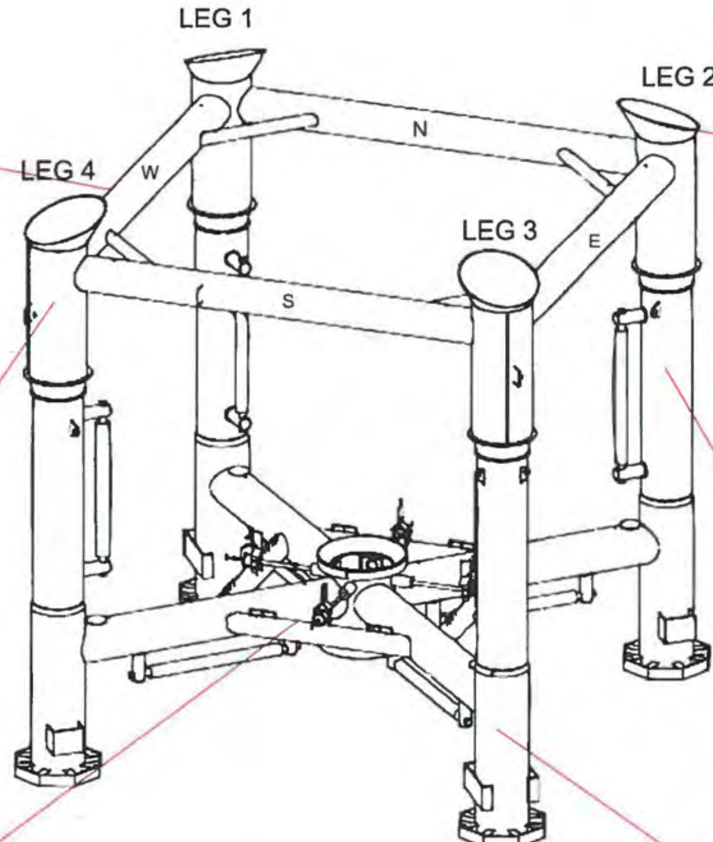
Figure 2.1b

Station F-70

West horizontal bracket densely colonized by blue mussels

Top of Leg 4 with large patches of blue mussels and sea anemones

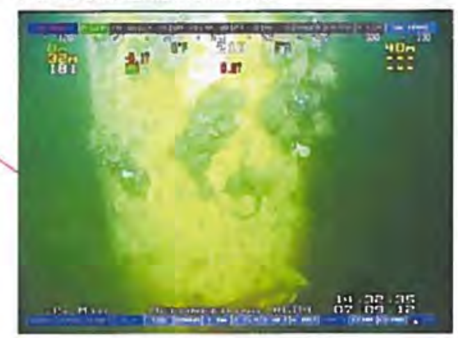
Blue mussels on base of Leg 4 with sea stars and sea cucumbers



Wellhead Protection Structure

Blue mussels, hydroids, and sea anemones at top of Leg 2

Blue mussels and hydroids colonizing Leg 2 with occasional sea anemones



Base of Leg 3 with little marine growth

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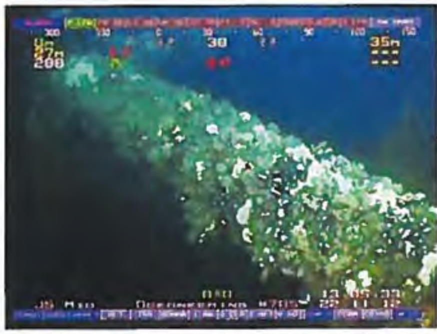
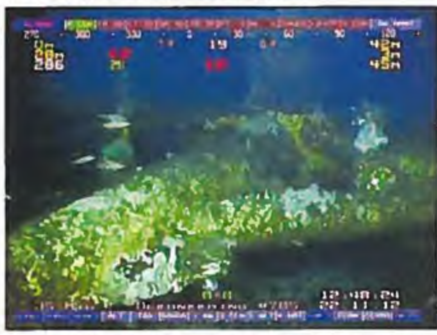
Figure 2.1c ead Protection Structures and Associated Fauna at F-70

Figure 2.1c

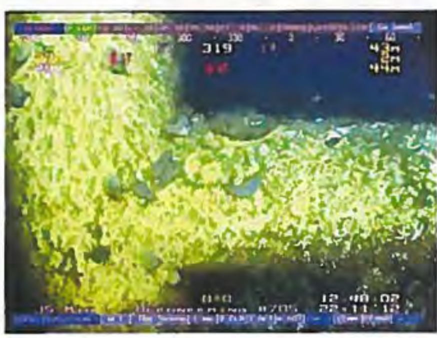
Station D-41



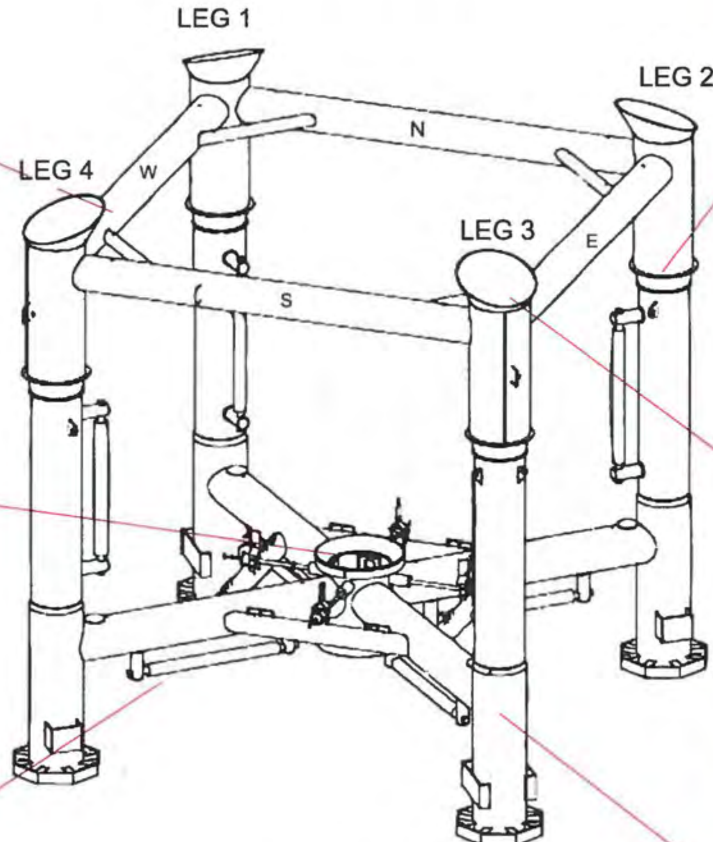
West horizontal brace with dense patches of blue mussel, hydroids and sea anemones



Inside of WHPS with large patches of sea anemones



Little marine growth on base of Leg 4 and HB01-4



Wellhead Protection Structure

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

High density of sea anemones at top of Leg 3

Little marine growth on base of Leg 3

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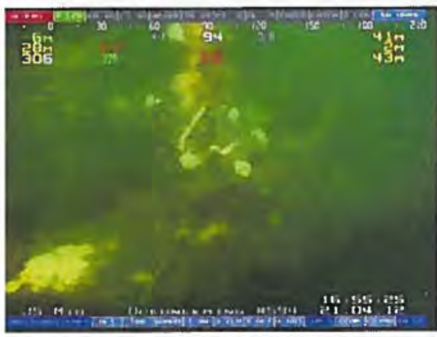
Figure 2.1d Wellhead Protection Structures and Associated Fauna at D-41

Figure 2.1d

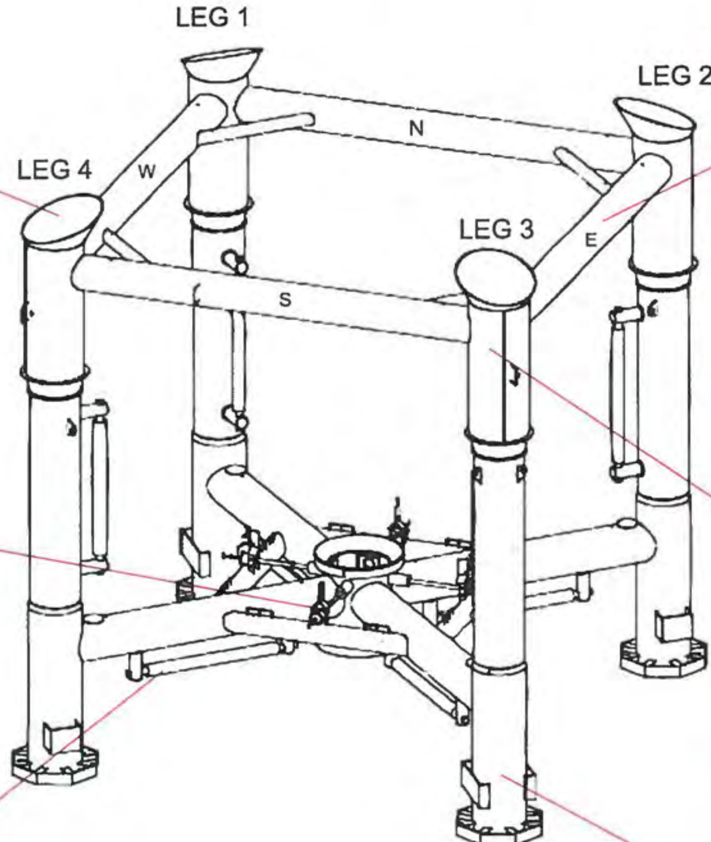
Station E-70

Patches of blue mussels on top of Leg 4



Sea anemones and mussels on supporting pins

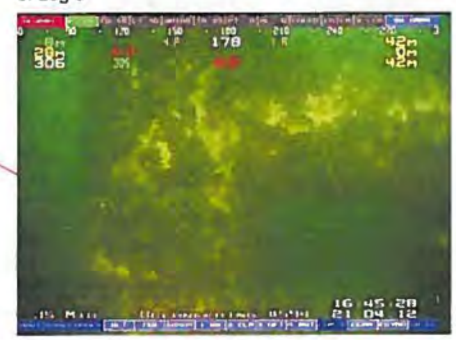
Hydroids densely colonizing anode AN04



Wellhead Protection Structure

Abundant mussel growth and hydroids on East horizontal bracket

Colonies of blue mussels and sea anemones at top of Leg 3



Marine growth on base of Leg 3

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Figure 2.1e head Protection Structures and Associated Fauna at E-70

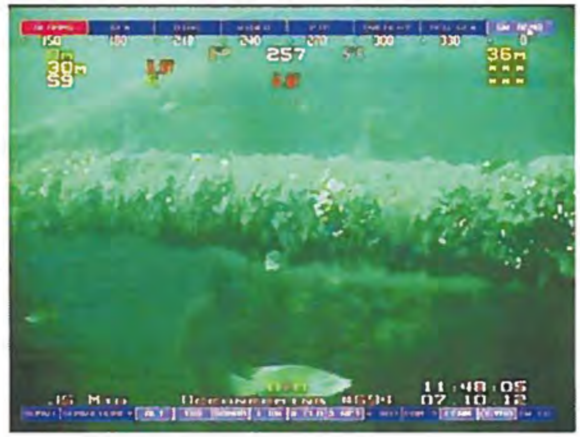
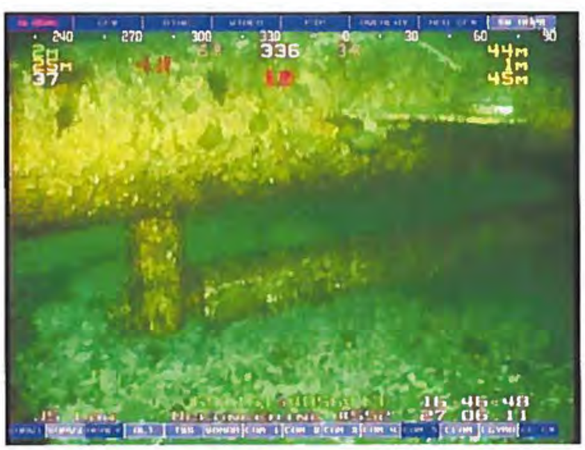
2011 Survey	2012 Survey
 Moderate marine growth on East horizontal bracket at WHPS M-79A in 2011 survey	 Significant growth of marine fauna on East horizontal bracket at WHPS M-79A in 2012 (Figure 2.1b, top right)
 Blue mussel growth starting at 4 metres above the seafloor on Leg 2 at WHPS F-70 in 2011 survey	 Similar growth on Leg 2 in 2012 survey (Figure 2.1c, middle right)
 Little marine growth at base of Leg 4 and HB01-4 at WHPS D-41 in 2011 survey	 Similar sparse marine growth at D-41 in 2012 (Figure 2.1d, bottom left)

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Figure 2.2 Comparison of 2011 and 2012 Surveys at WHPS Figure 2.2

2.5.7.2 Cuprotect Coated Structures

- *Tubularia* sp. growth increased greatly since the 2011 survey, where it was only observed occasionally on the GEP and M-79A non-coated Inconel 625 straps (**Figures 2.3 and 2.4**). In the 2012 survey, *Tubularia* sp. was commonly observed colonizing the straps and flanges (non Cuprotect surfaces) at all flowlines. In several instances, it appears that *Tubularia* sp. had colonized the junctures between strake sections, which are Cuprotect surfaces (**See Figure 2.3, VIV suppression strakes of D-41 Flowline**). It is possible that the internal surfaces of the VIV suppression strakes are not covered in Cuprotect and the hydroid is using the gaps as a foothold. This does not appear to be a deterioration or ineffectiveness of the Cuprotect coating;
- Algal growth was found colonizing future flange caps. The flange caps were not treated with Cuprotect coating, as shown in the inspection drawings (**Tables 2.6 and 2.8**, **Figure 2.3, future flange caps**);
- One occurrence of a sea star was observed on the Cuprotect-coated SPU insulation of the GEP line, (**Figure 2.3 GEP line**);
- 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 2.6 Cuprotect surfaces Spring 2012 (No Spring 2011 data collected for comparison)

Cuprotect Coated Structures Spring 2012					
Wellhead Site	**Structure**	**Fauna**	**2012 Abundance***	**2012 Numbers**	**Description**
PFC	GEP	*Tubularia* Ctenophora *Myoxocephalus sp.*	F	 28 3	• *Tubularia* only colonizing straps and flange (non cuprotect surfaces) • Sculpin only present around GEP
	R-2 Flowline	*Tubularia* Ctenophora *Myoxocephalus sp.*	C	 13 3	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections
	R-5 Flowline	*Tubularia* Ctenophora *Myoxocephalus sp.* *Cucumaria frondosa*	C O	 10 2	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections • *Cucumaria frondosa*, Sculpin, Ctenophora only present around flowline
	R-6 Flowline	*Tubularia* Ctenophora	C	 7	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections

Cuprotect Coated Structures Spring 2012					
Wellhead Site	**Structure**	**Fauna**	**2012 Abundance***	**2012 Numbers**	**Description**
PFC cont'd	R-7 Flowline	*Tubularia* Ctenophora *Cucumaria frondosa*	C A	 9	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections • *Cucumaria frondosa* present around, but not on flowline
	R-10 Flowline	*Tubularia*	C		• *Tubularia* only colonizing flowline past flange (non Cuprotect surface)

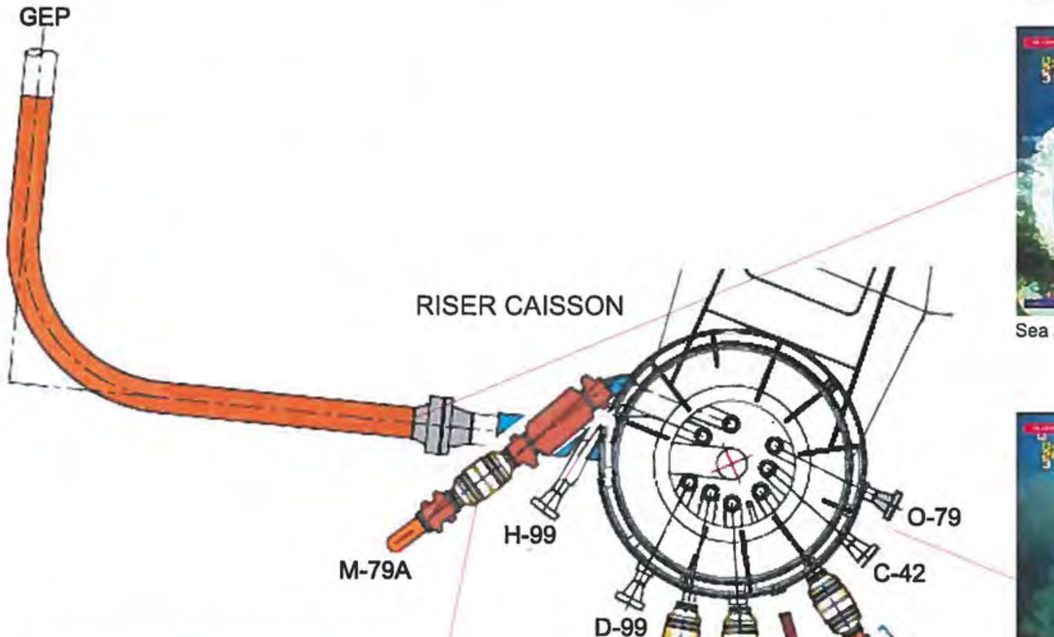
* Abundance values are based on the SACFOR scale (S = superabundant; A = abundant; C = common; F = frequent; O = occasional; R = rare)

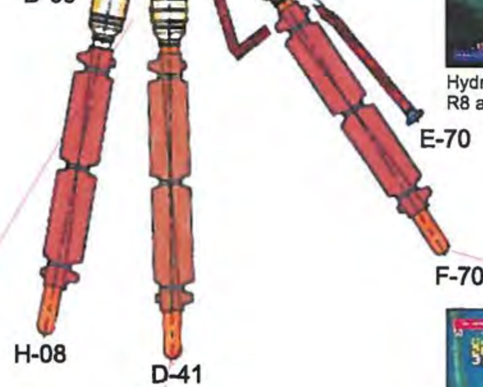
Table 2.7 Cuprotect surfaces Fall 2012

Cuprotect Coated Structures Fall 2012						
Wellhead Site	**Structure**	**Fauna**	**2011 Abundance***	**2012 Abundance***	**2012 Numbers**	**Description**
PFC	GEP	*Tubularia* Unid. Fish *Asterias vulgaris* Unid. Fish	O 73 Cod	F R	 13 6	• *Tubularia* only colonizing straps and flange (non Cuprotect surfaces) • An *Asterias vulgaris* observed on the cuprotect surface of the GEP line
	R-2 Flowline	*Tubularia* Unid. Fish		C	 1	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections
	R-5 Flowline	*Tubularia* Unid. Fish *Gadus morhua* *Cucumaria frondosa*		C R	 1 1	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections • *Cucumaria* only present by anode (non Cuprotect surface)
	R-6 Flowline R-6 Flowline	*Tubularia*		C		• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections
	R-7 Flowline	*Tubularia* Unid. Fish *Cucumaria frondosa*		C R	 12	• *Tubularia* colonizing straps and flange (non Cuprotect surfaces) • *Tubularia* also appears to colonize in junctures between strake sections • *Cucumaria* only present by anode (non Cuprotect surface)
	R-10 Flowline	*Tubularia* Unid. Fish		C	 7	• *Tubularia* only colonizing flowline past flange (non Cuprotect surface)
	Future Flange caps (R-3,4,8,9)	*Tubularia*	A	A		• *Tubularia* covering entire flange caps (non Cuprotect surfaces)

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

PFC Subsea Riser Caisson






Sea star on Cuprotect coating of GEP line


Hydroid colonization of future flange caps of R8 and R9


Extensive hydroid coverage of stainless steel straps on insulation cover for M-79A (R2)


Insulation cover of flowline H-08 with extensive marine growth on the straps


Extensive marine growth on straps of suppression strakes at the flowline for F-70 (R7)


Possible fouling of Tubularia hydroid on Cuprotect coating of suppression strakes at D-41 (R6)

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Figure 2.3 Photos of Cuprotect Coated Structures

2011 Survey	2012 Survey
 Tubularian hydroids sparsely colonizing straps of insulation cover of flowline M-79A in 2011 survey	 Significantly greater colonization of Tubularian hydroids on straps of insulation cover M-79A flowline in 2012
 Absence of Tubularian hydroids on VIV suppression strakes of D-41 in 2011 survey	 Colonization of Tubularian hydroids on VIV suppression strakes of D-41 in 2012 survey - Note the area colonized in 2012 does not have any straps in the general area in 2011
 Moderate coverage of future flange cap R-8 by hydroids in 2011	 Increase of coverage of future flange caps R-8 and R-9 by hydroids in 2012 survey

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Figure 2.4 Comparison of Cuprotect Coated Structures between 2011 and 2012 Surveys Figure 2.4

2.5.7.3 GEP and Flowlines

- In all videos analyzed, marine life continues to be abundant and diverse around the GEP in relation to the surrounding ocean floor (**see Appendix A, Fish Habitat Alteration Video Assessments; Figures 2.5 to 2.9**);
- Redfish (*Sebastes* sp.) were found in comparable, yet slightly elevated total numbers compared to the 2011 survey (10,600 in 2011; 10,914 in 2012) throughout the stretch of exposed pipeline. These fish were commonly found along the rockier sections of the route, as well as wherever the pipeline created a hollow pocket in the seafloor (**Figure 2.8**);
- Numbers of Atlantic cod (*Gadus morhua*) show an increase of over 140% in total individuals observed in 2012 compared to numbers observed in 2011 (502 in 2012 compared to 207 in 2011). This may be due to the migrational nature of the Atlantic cod population on the Scotian Shelf, as the video was recorded in June of 2011 and July/August of 2012. As observed in the seasonality of fish abundance in the wellhead protection structure videos (**See Tables 2.2, 2.3, 2.4 and 2.5**), spring and early summer appear to have fewer occurrences of fish species than in late summer and fall;
- Total numbers of Flounder (Pleuronectidae) decreased by 520% (62 total individuals in 2011 compared to 10 total individuals in 2012). These are a very cryptic group of fish and quality of video may be a factor affecting the differences in the annual surveys;
- There were two species of fish recorded in the 2012 survey which were not observed in 2011 survey (Atlantic torpedo, *Torpedo nobiliana* and American butterfish, *Peprilus triacanthus*);
- Snow crab (*Chionoecetes opilio*) were observed in 25 of 36 videos analyzed, totalling 941 individuals sighted. The total numbers of snow crab decreased by approximately 20% from 2011, with 1185 observed snow crabs appearing in 35 of 36 videos. However, due to the highly mobile nature of these crabs, variations in their presence and absence from the vicinity of the pipeline should be expected. Jonah crab (*Cancer borealis*) were more abundant in 2012, with 1367 total individuals observed compared to 838 total individuals in 2011. Other crustaceans found with near equal total abundances from 2011 to 2012 include Northern Stone crab (*Lithodes maja*), Hermit crab (*Pagurus* sp.) and shrimp;

- Evidence from the video shows again many examples of all species of crustaceans sitting on top and on the sides of the pipeline where the pipe sat fully out of the sediment (**Figure 2.9**). The presence of these species on the pipeline provides strong evidence that the pipeline is not acting as a physical barrier to crustacean movement;
- Commonly observed sea stars (*Asterias* sp and *Henricia* sp) were shown to increase in total numbers by almost 150% in 2012. The small size of many of the sea stars inhabiting the pipeline makes it difficult to obtain exact numbers and estimates were calculated in 2011 due to the quality of video, making comparison between the annual surveys difficult to interpret;
- Comparison of faunal diversity by major groups between the 2011 and 2012 surveys are shown in **Figure 2.6**. The graphs indicate a near equal or elevated abundance of organisms for each group across the 8 transects selected. Noted exceptions are the number of fish species in KP 83.552, which show a decrease of 260% in total abundance from 2011 to 2012. This is due to a large school of pollock (*Pollachius virens*) present only in 2011. These differences are expected with highly mobile species. Echinoderms at KP 64.474 show an increase of 350% abundance, largely due to the sea stars *Asterias* sp and *Henricia* sp. As explained in the previous point, presence of small sea stars makes it difficult to interpret the differences;
- Flowlines from the PFC to the wellheads which were partially exposed in 2011 appeared to have been covered by a rock dump between the surveys (**Figure 2.7, H-08 and D-41 Flowline**). Sea cucumbers (*Cucumaria frondosa*) were commonly observed on the rocks compared to the sparse fauna observed on the featureless seafloor where the pipeline remained buried;
- The GEP was partially exposed from KP 1 to 23, and KP 98 to 168 where sea cucumbers (*Cucumaria frondosa*) were observed in large densities and numbers (**Figure 2.7, Exposed GEP**);
- No fauna was observed on buried sections of the GEP and flowlines. Only discernable features were disarticulated bivalve shells (**Figure 2.7, E-70 Flowline**).

2.5.8 Summary and Conclusions

2.5.8.1 Subsea Structures

- Epifauna colonization of WHPS/subsea trees at all well site locations observed varied little from the 2011 survey. Species composition was homogenous across all wellhead sites;
- There was a noted absence of Atlantic cod found in the November 2012 survey and an apparent replacement with a smaller population of Pollock. Seasonal differences from 2011 to 2012 may account for the absence of the Atlantic cod;
- Wellheads and protective structures appear to continue to act 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.

2.5.8.2 Cuprotect Coated Structures

- Apparent colonization by *Tubularia* sp. in the junctures between VIV suppression strakes at the base of the riser caisson may indicate that some internal surfaces not covered in Cuprotect are being used as a foothold for the densely colonizing hydroid. Other surfaces which were colonized by marine life were the non-coated Inconel 625 steel straps which hold insulation covers in place;
- Epifauna were observed around the base of the riser caisson structures such as the future flange caps, sandbags and concrete protection mats, all of which are not treated with Cuprotect coating;

2.5.8.3 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, monkfish, American butterfish and redfish (**Figure 2.8**);
- The only commercial crustaceans observed in the analyzed video were snow crabs and Jonah crabs (snow crab being the most abundant);

- Other commercial invertebrate observed include the orange-footed sea cucumber;
- The GEP does not act as a barrier to crustacean movement, as suggested by the evidence of several crab species sitting on top of the pipeline when it is fully unburied (**Figure 2.9**).

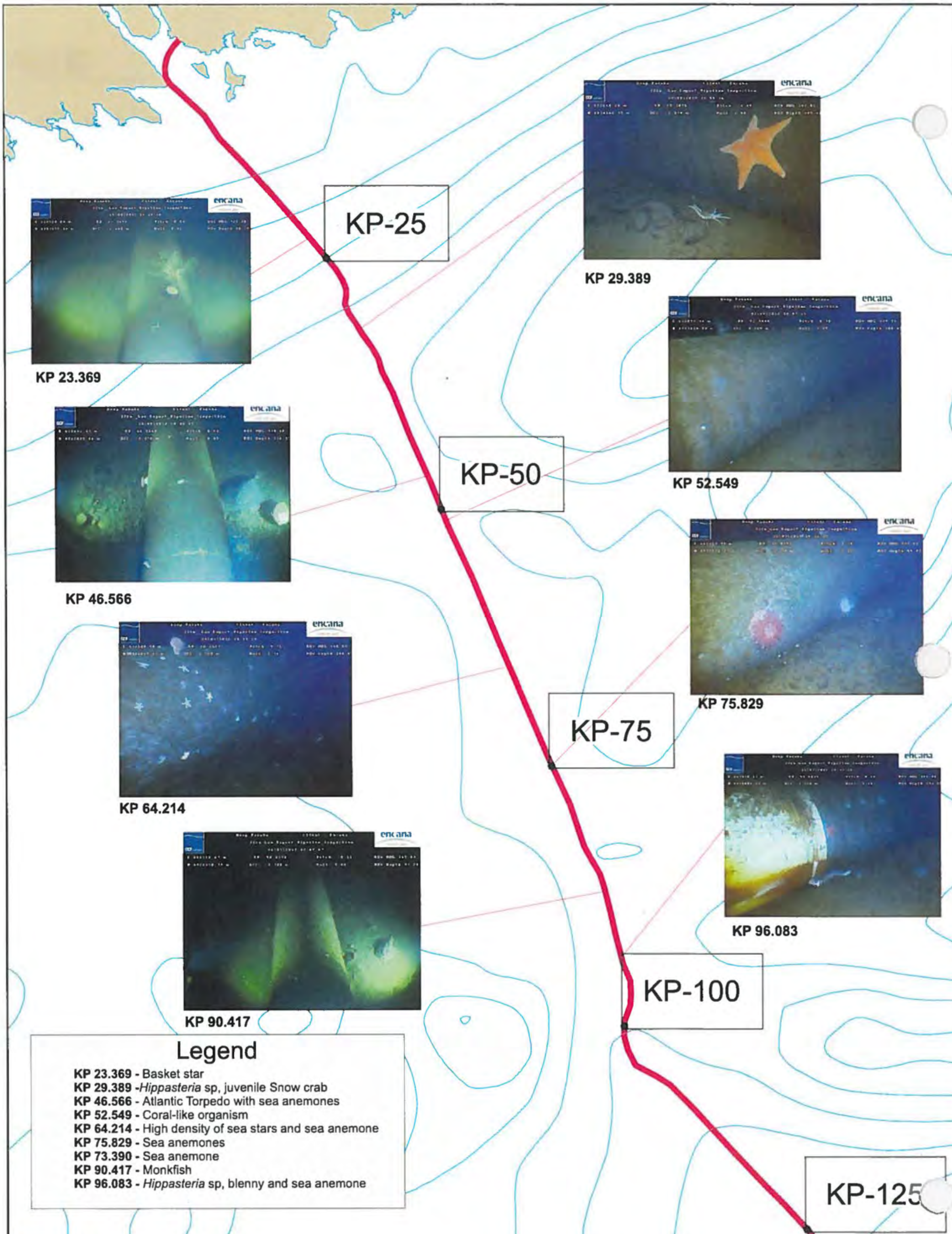

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Figure 2.5 Representative Stills from ROV Footage Along GEP Figure 2.5

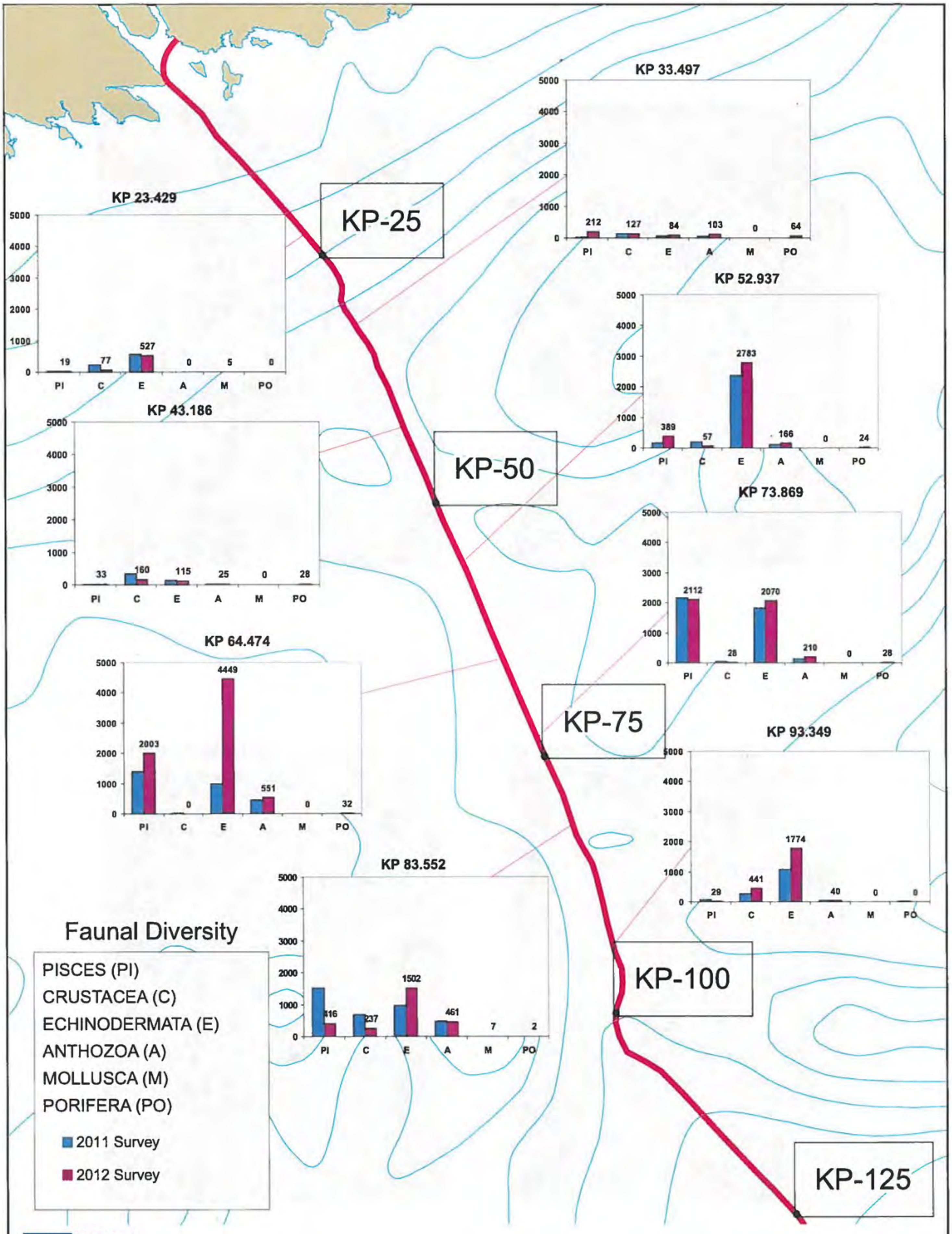

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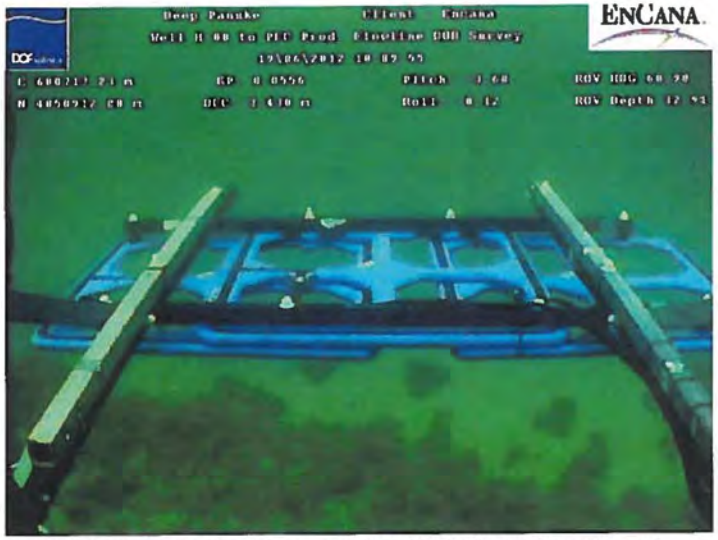
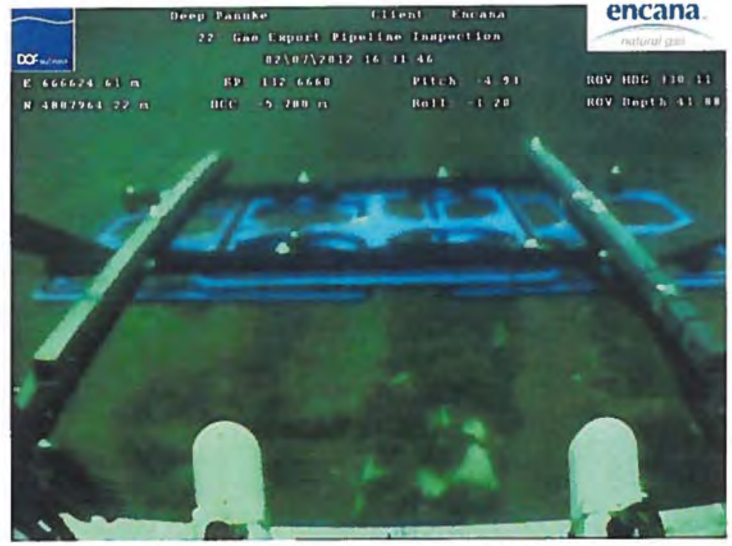
Figure 2.6 Standardized Faunal Composition of Exposed GEP at 10 km Intervals from 2011 and 2012 Surveys Figure 2.6

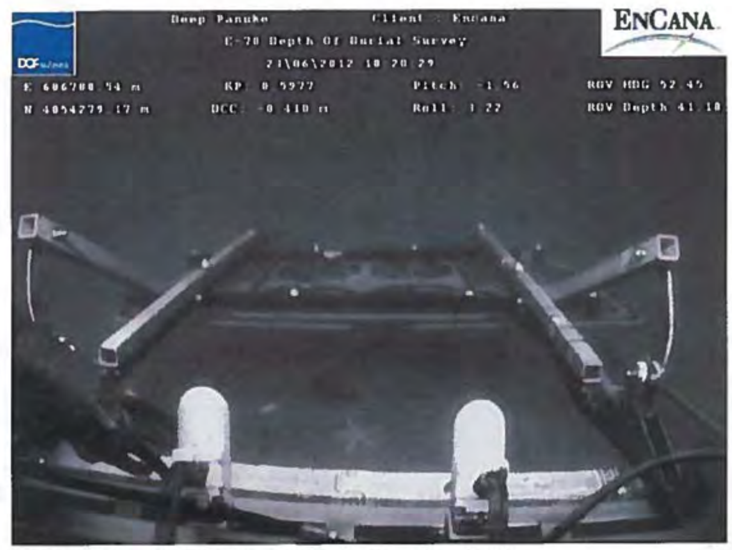


End of rock dump and buried flowline to wellhead H-08 with sandy seafloor and large patches of the sea cucumber *Cucumaria frondosa*



Exposed GEP pipeline with 90% fouling of the sea cucumber *Cucumaria frondosa*

Rock dump covering flowline to wellhead D-41



Sandy seafloor with few fauna over flowline to wellhead E-70

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Figure 2.7 [illegible]d and Exposed GEP and Wellhead Flowlines with Associated Fauna

Figure 2.7

Atlantic Torpedo (*Torpedo nobiliana*) observed at KP 46.566 and at a depth of 116 m

American Butterfish (*Peprilus triacanthus*) at KP 88.486

High abundance of Redfish (*Sebastes* sp) at KP 64.379

Monkfish (or Goosefish, *Lophius americanus*) resting on the seafloor at right at KP 90.417

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Figure 2.8 Fish Diversity Along GEP Pipeline

Figure 2.8

Jonah Crab (*Cancer borealis*) and Snow Crab (*Chionoecetes opilio*) at KP 97.567

Northern Stone Crab (*Lithodes maja*) at KP 95.479

Hermit Crab (*Pagurus* sp) at KP 80.585

Snow Crabs (*Chionoecetes opilio*) at KP 29.444

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Figure 2.9 Examples of Crustacean Movement Over GEP Pipeline

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 also been seen feeding close to platform operations. 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 result from 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 2012 **Appendix B**). Seabirds 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 processing of radar data, which are being used to quantify patterns of individual and population level bird activities on and around the PFC.

Delays in hookup and commissioning of the Deep Panuke platform resulted in an opportunity to expand the scope of the seabird observation program, taxonomically, spatially and temporally. The initial project was expanded to include three additional seabird species and two additional passerine species of birds. An additional study site in Cape Breton was added to the study and the study was extended by an additional year.

In 2012, bird researchers developed an automated VHF receiver that was lab and field tested at multiple mainland, island and vessel locations. Improvements to the receiver addressed the problem of the limited data storage capacity of the receivers. These newly developed receivers allow for more control over tag recording and detection which will likely enable the significant noise issues encountered in 2011 to be reduced.

Ongoing monitoring of bird movements was conducted from May through the end of November, 2012 on Sable, Country and Bon Portage Islands. For a complete description of this project, please refer to Assessment of bird-human interactions at offshore installations (**Appendix B**).

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. This component of the wildlife observation program was not carried out in 2012 but is expected to continue in 2013 following commencement of production on the platform.

Seabird mortality due to chronic oiling in proximity to the PFC was also monitored during 2012. Beached bird surveys carried out on Sable Island from January 1993 to present 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

- Record any stranded (live or dead) birds found on the Deep Panuke PFC;
- Carry out regular surveys of beached seabirds on Sable Island;
- Conduct seasonal visual observations of marine mammals and sea turtles in the vicinity of the Deep Panuke PFC (Season observations will continue following commencement of production); and
- Integrated bird management research study (led by Acadia University):
  - Develop and adapt soft and hardware interfaces with existing RADAR systems to monitor real-time round-the-clock bird activity; and
  - Use radio-transmitter, solar-powered satellite tags and bird banding to study movement patterns of birds during the breeding season, focusing specifically on timing of and factors affecting visits to offshore platforms.

- Scope of study expanded from 2011 to include 3 additional seabird species and 2 passerine species, and an addition study site in Cape Breton.

2.6.5 Analysis

- Patterns of individual and population level bird activities on and around offshore installations were quantified using combined multiple, automated instrument-based monitoring techniques (VHF tracking, and satellite telemetry) (Assessment of bird-human interactions at offshore installations **Appendix B**).
- Oil types observed on feathers from beached seabirds collected on Sable Island were monitored (**Appendix C**);

2.6.6 Parameters Analyzed

Table 2.8 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 Visual monitoring of seabirds, marine mammals and sea turtles around PFC	As required (systematic daily deck sweeps to be conducted for stranded birds) In conjunction with daily deck sweeps for stranded birds	Yearly bird salvage report submitted to CWS Direct observations	Species; condition; action taken; fate of bird Species, counts and behavioural observations (e.g. any congregation of wildlife will be reported)
Sable Island	Beach bird surveys	Approx. 11 surveys/year	Based on CWS protocol	Oiling rate (standardized approach)
Sable Island and PFC area (Acadia research study)	Bird monitoring with radio and satellite transmitters	Expected two-year program (2011 to 2013)	Analysis of radar, transmitters and camera and acoustic data	Specific research/analysis parameters to be developed
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 Seabird Observations

Acadia Bird Monitoring Research Study

Field studies were conducted from the beginning of May through the end of November 2012 on Sable Island, Country Island and Bon Portage Island. This resulted in:

1. VHF tag deployments on 224 birds including Herring Gulls (HERG), Great Black-backed Gulls (GBBG), Common Terns, Arctic Terns, Leach's Storm-petrels, Ipswich Sparrows, and Blackpoll Warblers;
2. Satellite-GPS tag deployments on 6 HERG;
3. Geolocator tag deployments on 37 Leach's Storm-petrels; and
4. Colour wing- and leg-banding of 27 HERG and 54 GBBG. VHF receivers were run at three breeding colonies, six coastal sites, and four offshore platform supply vessels, resulting in ~1000 receiver tracking-days, including >300 days from supply vessels.

VHF tags and colour wing-bands show that gulls depart from colonies on Sable Island between mid July and mid August; this departure period corresponds with observations of gull-platform interactions offshore. Satellite tags revealed gull-platform interactions for 2 of 6 HERG. These individuals spent 6 and 12% of their time within 200 m of offshore platforms prior to departing the Sable Island area in late October. During breeding, terns on Sable Island made regular foraging trips of 3 to 6 hours. Most individuals had departed the colony by mid August (bird-platform interactions are still being assessed). Stable isotope analysis revealed dietary differences between the two tern species suggesting the species forage in distinct areas or specialize on different prey types.

Foraging trips by Storm-petrels from Bon Portage Island (BP) and Country Island (CI) lasted 3-5 days; GLS data indicated that they may travel as much as 1000 km offshore during these trips. The foraging areas of CI Storm-petrels overlap with the platform area, though this is based on a small number of tag deployments and foraging trips. Colony-based tracking data also suggest the BP birds depart south on foraging trips, this limiting potential platform interactions, whereas CI petrels depart on easterly trajectories which may bring them in proximity to platforms in the Sable area.

Ipswich Sparrows tagged in August undertook migratory departures from Sable Island between September and November; juveniles departed earlier than adults. About half (61%) of sparrows detected on the mainland were first detected at the northerly stations (Taylor's Head and CI) which suggests a north-westerly migration path for these individuals. If Ipswich Sparrows are taking a direct route between Sable Island and northern portions of Nova Scotia's Eastern Shore which would limit over-water travel distance and their potential overlap with the Deep Panuke platform.

A small sample of Blackpoll Warblers tagged in Cape Breton showed evidence of south-westerly movements along the coast of Nova Scotia (3 out of 4 birds). Thirty-four of 53 warblers tagged on BP were recorded departing from the island. Twenty-eight (82%) of these had northerly or easterly components to their departure directions and six (18%) had southerly components. This result suggests that only a small proportion of birds are initiating long-distance, trans-oceanic migrations from BP. Of the 28 individuals departing north and east from BP, 19 were re-detected at coastal mainland sites which suggest considerable landscape-scale movements of this species within Nova Scotia prior to migration, and may indicate that individuals undertake their trans-oceanic flights from points further east.

In March 2012, a scope of work document was completed which outlines the plans for equipment installations on the Deep Panuke platform, including VHF receivers, use of platform radars, and use of a low-light camera. Encana plans to have the VHF receiver/antennas installed prior to spring field studies (April 2013) and access to the radar data by July 2013 prior to autumn migration. Cameras will be tested by the researchers during their 2013 visits to the PFC. .

For details of the results, refer to the Assessment of bird-human interactions at offshore installations, Interim Report, Year 2, December 2012 (**Appendix B**).

Seabird Stranding Summary

- A stranded bird, a Leach's Storm Petrel, was found on the PFC on Nov. 23, 2012.

- The bird was caught, placed in a box until it was later released from the PFC.
- No other stranded birds were reported.

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

Sable Island Beached Bird Survey

Eleven surveys for beached seabirds were conducted on Sable Island between January 1st and December 21st, 2012. Species identification, corpse condition and extent of oiling were recorded for seabird specimens. Where possible, the time since death was estimated based on freshness of tissues and degree of scavenging.

During 2012, the corpses of 606 beached seabird corpses were collected in Sable Island. Fulmars and shearwaters accounted for 57.6% of total corpses recovered and alcids comprised 26.2%. The overall oiling rate for all species combined was 7.8%. The highest oiling rate for a seabird group, 40.4%, was observed in alcids. This oiling rate is markedly higher than the rate of 9.7% observed in 2011.

Of the 17 samples collected from the feathers of birds from the beach, 8 contained fuels oils in the mid-range distillate (marine diesel) range. None of the samples contained light distillate fuels or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms offshore Sable Island.

2.6.8 Summary and Conclusions

- The Acadia Bird Study resulted in VHF tag deployments on 224 birds including Herring Gulls (HERG), Great Black-backed Gulls (GBBG), Common Terns, Arctic Terns, Leach's Storm-petrels, Ipswich Sparrows, and Blackpoll Warblers. Satellite-GPS tags were deployed on 6 HERG and geolocator tags were deployed on 37 Leach's Storm-petrels. Twenty seven HERG and 54 GBBG were tagged with colour wing- and leg-banding. VHF receivers were run at three breeding colonies, six coastal sites, and four offshore platform supply vessels, resulting in ~1000 receiver tracking-days, including >300 days from supply vessels.

- A single bird stranding occurred with the bird being released from the PFC unharmed;
- Eleven surveys for beached seabirds were conducted on Sable Island between January 1st and December 21st, 2012. The corpses of 606 beached seabird corpses were collected. Fulmars and shearwaters accounted for 57.6% of total corpses recovered and alcids comprised 26.2%. The overall oiling rate for all species combined was 7.8%. None of the beached seabird samples contained light distillate fuels or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms offshore Sable Island.

3 ENVIRONMENTAL ASSESSMENT (EA) PREDICTIONS

Table 3.1 EEM Related Environment Assessment (EA) Predictions and 2012 Results

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2012 Plan	2012 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 8.3.4 8.4.4 8.5.4	- Marine Water Quality - Marine Benthos - Marine Fish - Marine Mammals and Sea Turtles	- Produced Water Chemistry and Toxicity - Marine Water Quality - Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water discharge to commence in 2012.	N/A - Produced water discharge to commence in 2013.
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 - Fish Habitat Alteration	Discontinue E-70 cuttings pile monitoring. Continue fish habitat analysis near subsea production structures into 2012 with annual ROV footage of wellsite structures and pipeline.	Benthic communities were well developed and continue to thrive at each of the wellheads, with a dense and diverse epifaunal fouling community on the wellhead protection structures. Some fish aggregations were also observed, suggesting no negative impacts, and possible "reef" affects attracting mobile organisms into the vicinity of the subsea structures.
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 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	8.4.4.2 8.3.4.2	- Marine Fish - Marine Benthos	- Produced Water Chemistry and Toxicity - Marine Water Quality Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water discharge to commence in 2012.	N/A - Produced water discharge to commence in 2013.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2012 Plan	2012 Results
	2.5°C temperature anomaly in unlikely to exceed tolerance thresholds of benthic species present.					
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 8.4.4.2	- Marine Benthos - Marine Fish	- Produced Water Chemistry and Toxicity - Marine Water Quality - Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water discharge to commence in 2012.	N/A - Produced water discharge to commence in 2013.
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 - Chemistry and Toxicity - Marine Water Quality Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water discharge to commence in 2012.	N/A - Produced water discharge to commence in 2013.
6	Experimental data pertinent to the toxicity of H2S on fish suggest that the concentrations of H2S that fish will likely be 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	8.4.4.2	- Marine Fish	- Produced Water - Chemistry and - Toxicity - Marine Water Quality Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water discharge to commence in 2012.	N/A - Produced water discharge to commence in 2013.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2012 Plan	2012 Results
	effects.					
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 - Fish Habitat Alteration - Fish Health Assessment	Sediment sampling to continue in 2012. Discontinue E-70 cuttings pile monitoring.	N/A - Sediment sampling to continue in 2013.
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 8.4.4	- Marine Benthos - Marine Fish	- Sediment Chemistry - and Toxicity - Fish Habitat Alteration	Discontinue E-70 cuttings pile monitoring.	N/A – EA prediction has been confirmed.
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) zone around PFC facilities.	8.2.4 8.3.4 8.4.4 8.5.4	- Marine Benthos - Marine Fish - 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 continues to cause 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 wellhead structure, and increased colonization was observed at most sites. Dense epifaunal colonization continued to be observed on many of the subsea structures. Cuprotect coated surfaces appeared to have colonization of marine life in junctures between the structures where Cuprotect may not have been used. Presence of 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.
10	It is highly unlikely that the proposed subsea pipeline, where unburied, would	8.3.4 8.4.4	- Marine Benthos - Marine Fish	- Fish Habitat Alteration	ROV video data to be inspected in order to determine and interpret the development of benthic	The subsea pipeline does not constitute a physical barrier to crustacean movement as

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2012 Plan	2012 Results
	constitute a significant concern as a physical barrier to crustacean movement.				communities along the pipeline.	evidenced by multiple species of crabs on top and on the sides of the exposed structure. EA prediction has been confirmed.
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 8.4.4 8.5.4	- Marine Water - Quality - Marine Fish - Marine Mammals and Turtles	- Marine Water Quality - Monitoring - Marine Wildlife Observations	Marine Mammal and Sea Turtle observations to continue in 2012.	- No attraction of wildlife has been observed at the PFC through indirect observations. Direct observations from platforms to commence in 2013.
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 (2002 CSR)	- Marine Related - Birds	- Marine Wildlife Observations	Summarize observations and findings from Acadia Study, Assessment of bird-human interactions at offshore installations. Vessel and platform observations to continue in 2013.	- The bird monitoring program, Assessment of Bird-Human Interactions at Offshore Installations continued. - Improvements to bird monitoring technologies (VHF receivers) were made 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 8.6.4	- Marine Water - Quality - Marine Related - Birds	- Marine Water Quality - Monitoring - Marine Wildlife Observations	Summarize observations and findings from Sable Island Beach Surveys.	N/A - Produced water discharge to commence in 2013.
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 quality data to be monitored as per proposed Sable Island air emissions monitoring plan (see **Appendix E**). Expected to start in 2013.	Air quality data to be monitored as per proposed Sable Island air emissions monitoring plan (see **Appendix E**). Expected to start in 2013.
15	Air quality modeling for accidental events indicates exposure levels to receptors on Sable Island remain not significant.	8.1.4	- Air Quality - Sable Island	- Air Quality Monitoring	Air quality data to be monitored as per proposed Sable Island air emissions monitoring plan (see **Appendix E**). Expected to start in 2013.	Air quality data to be monitored as per proposed Sable Island air emissions monitoring plan (see **Appendix E**). Expected to start in 2013.

4 RECOMMENDED EEM PROGRAM FOR 2013

Table 4.1 Summary of Deep Panuke 2012 Offshore EEMP Sampling Activities, Analysis, and 2013 Recommendations

EEMP Component	2012 Sampling			2012 Analysis		2013 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
Produced Water Chemistry and Toxicity **No 2012 data**	PFC (prior to mixing with seawater system discharge) **No Sampling Conducted in 2012**	Niskin Bottle **No Sampling Conducted in 2012**	Twice annually after First Gas **No Sampling Conducted in 2012**	Water quality composition **No Analysis Conducted in 2012**	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters **No Analysis Conducted in 2012**	Start produced water sampling in 2013 (depending on start of produced water discharges); to be collected and analyzed twice a year.
			Annually after First Gas **No Sampling Conducted in 2012**	LC49 bioassay acute toxicity analysis **No Analysis Conducted in 2012**		Start LC49 bioassay in 2013 after First Gas.
Marine Water Quality Monitoring **No 2012 data**	Triplicate seawater samples at 5 near-field downstream sites and 2 upstream sites along tide direction **No Sampling Conducted in 2012**	Niskin Bottle **No Sampling Conducted in 2012**	In 2011 (prior to First Gas), then annually for the three following years **No Sampling Conducted in 2012**	Water quality composition **No Analysis Conducted in 2012**	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters **No Analysis Conducted in 2012**	Conduct next water sampling program in 2013 after First Gas.
Sediment Chemistry and Toxicity **No 2012 data**	9 near-field benthic sampling locations and 2 far-field reference sites **No Sampling Conducted in 2012**	Grab Sample **No Sampling Conducted in 2012**	In 2011 (prior to First Gas and post 2010 drilling and completion activities), then annually for the following three years **No Sampling Conducted in 2012**	Chemical composition **No Analysis Conducted in 2012**	Sediment grain size and TOC; suite of metals and hydrocarbons measured in 2008 Benthic Baseline Study; TPH, PAHs and APs; and sulphides. **No Analysis Conducted in 2012**	Conduct next sampling program (10 near-field benthic sample locations) in 2013 after First Gas.
				LC49 bioassay acute toxicity analysis **No Analysis**	Suitable marine amphipod species such as *Rhepoxynius abronius* or *Eohaustorius estuaries*	Conduct LC49 bioassay in 2013 after First Gas.

EEMP Component	2012 Sampling			2012 Analysis		2013 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
				Conducted in 2012	**No Analysis Conducted in 2012**	
Fish Habitat	Subsea production structures	ROV video- camera survey	Annually (using planned activities, e.g. routine inspection and storm scour surveys)	Videotape analysis	Subsea production structures: evaluate the extent of marine colonization	Continue fish habitat analysis near subsea production structures into 2013 with annual ROV footage of wellsites, PFC and pipeline.
Fish Health Assessment	Mussels: PFC SW leg Fish: immediate vicinity of PFC and suitable far-field reference sites	Mussels: scraping Fish: angling	Mussels: annually after First Gas Fish: every 3 years after First Gas	Mussels: body burden 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 2013. (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 into 2013
Visual monitoring, no direct platform observations 2012		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	Beached bird surveys	Approx. 11 surveys/year	Based on CWS protocol	Oiling rate (standardized approach)	Continue into 2013

EEMP Component	2012 Sampling			2012 Analysis		2013 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
	Sable Island Country Island Portage Island	Bird monitoring with radar technology; radio and satellite transmitters; camera	Expected three-year program (2011 to 2014)	Analysis of radar, transmitters, camera	Specific research/analysis parameters outlined in NSERC proposal	Continue into 2013
Air Quality Monitoring **No 2012 data**	Sable Island Air Quality Monitoring Station **No Sampling Conducted in 2012** PFC **No Sampling Conducted in 2012**	Air quality monitoring instrumentation **No Sampling Conducted in 2012** Visual observations of flare plume **No Sampling Conducted in 2012**	Continuous **No Sampling Conducted in 2012** Twice daily **No Sampling Conducted in 2012**	Compare flare plume anomalies with Sable Island air quality and meteorological records **No Analysis Conducted in 2012**	Fine and ultra-fine particulates; Volatile Organic Carbons (VOCs), Sulphur dioxide (SO_2); Hydrogen sulphide (H_2S); Nitrogen oxides (NOx); Ozone (O_3); flare smoke shades **No Analysis Conducted in 2012**	Air quality monitoring to start in 2013 after First Gas as per proposed Sable Island air emissions monitoring plan (see **Appendix** E) PFC plume observations to start once flaring has started.

References

Baseline Benthic Study for the Deep Panuke Subsea Pipeline and Production Facility, 2006

Baseline Benthic Study for the Deep Panuke Subsea Pipeline and Production Facility, 2008.

Deep Panuke Production Environment Protection and Compliance Monitoring Plan (EPCMP), Encana: DMEN-X00-RP-EH-90-0002.

Environmental Effects Monitoring Plan (EEMP), Encana, 2011: DMEN-X00-RP-EH-90-0003.

APPENDICES

APPENDIX A

Fish Habitat Alteration Video Assessments 2012

Fauna	Start KP 97.890	95.808	93.349	90.865	88.662	86.019	83.552	80.941	78.538	76.202	73.869	71.478	68.952
Sculpin		1	1										
Flounder							1						
Redfish	10	37	11	318	263	631	194	593	483	395	1153	1016	464
Pollock				10			4						
Atlantic Cod		4				5	9	16	5	7	48	35	50
Haddock	1	1		2									
Skate													
Eelpout		1	1		1	1							
Hagfish				4	1	1	7	4			7	8	3
Blenny	1		2	3	1		4	2	1	1			
Hake		2		2	1		2	4					
Herring	16												
Torpedo ray													
Monkfish				1									
American Butterfish					1								
Unid. Fish	1			3	3	1	2						
Hermit crab			2	3	4		7	13					
Toad crab?							7	64				78	8
Snow crab	107	10	152	2	14			1					
Northern Stone Crab	11	7	4	7	1	1	3	3	1	3		1	2
Sea urchin												4	
Jonah crab	64	116	73	158	240	143	110	108	47	58	16	10	6
Sea cucumber	23	14	22		2	1	5	7	4	3	1	6	12
Feather star												1	1
Basket star													
Solaster			18	19	5	4	3	2	11	17	6	5	7
Crossaster										5		1	2
Hippasteria sp	45	53	36	28	27	19	5	16	16	29	3		3
Ceramaster				6				1					
Asterias/Henricia	810	140	854	135	545	1017	792	190	571	646	1174	833	1563
*Cerianthus sp**	1	215		319	289	303	246	491	323	252	38		
Sea anemone	20	4	21	3	2	1	1	5	13	44	82	352	423
Squid							4						
Gastropod													
Sponge*	5			5			1	4	4	9	16	15	10
Encrusting sponge													
Tunicate													
Soft Coral*													
Corraline organism													
Hydrozoa													
Shrimp	S	S	S	S	S	S	S						
*Observed around pipeline	97.378	95.361	92.825	90.347	88.109	85.448	83.016	80.354	78.183	75.587	73.297	70.947	68.353
	End KP												
	S = superabundant taxa, O = occasional taxa, R = rare taxa												

	Start KP												
Fauna	**66.852**	**64.474**	**62.170**	**59.795**	**57.295**	**55.190**	**52.937**	**51.175**	**49.013**	**46.864**	**45.175**	**43.186**	**41.140**
Sculpin										1			
Flounder												4	1
Redfish	673	1138	377	856	683	419	156	62	571	147	39	5	18
Pollock													3
Atlantic Cod	24	47	33	49	40	36	21	3	16	23		1	1
Haddock													
Skate												1	1
Eelpout													
Hagfish	2	1	1		1	3	1						
Blenny												2	7
Hake	1												
Herring													
Torpedo ray										1			
Monkfish													
American Butterfish													
Unid. Fish											2		
Hermit crab									1	4		3	4
Toad crab?	12		19	11		1	8	3					
Snow crab	2			4			2	38	6	32	67	43	121
Northern Stone Crab	1										2		
Sea urchin	1	40	89	203	4	114	915	1430	55	638	605		
Jonah crab	2		5	2	2	9	16	14	11	17	8	18	25
Sea cucumber	3	3	11	9	2	4	18	15	12	8	16	2	67
Feather star	1			2					2	1			
Basket star											4	1	1
Solaster	4	8	15	17	5	10	7	9	6	7	40	24	15
Crossaster			4	1	6	6	1	3	1	33	32	9	13
Hippasteria sp	5	15		4	8	15	2			4	21	7	11
Ceramaster					1								
Asterias/Henricia	1603	2568	1505	1856	2800	1885	329	82	219	126	25	3	6
*Cerianthus sp**													
Sea anemone	143	326	301	199	82	70	76	88	65	243	35	10	21
Squid													
Gastropod					1			1	1	3			
Sponge*	7	19	6	17	9	8	11	28	S	27		11	2
Encrusting sponge									S				
Tunicate													
Soft Coral*									2				
Corraline organism													
Hydrozoa					R		O	O	R				
Shrimp											S	S	S
*Observed around pipeline	**66.430**	**63.882**	**61.669**	**59.236**	**56.772**	**54.717**	**52.480**	**50.746**	**48.567**	**46.370**	**44.807**	**42.787**	**40.627**
	End KP												
	S = superabundant taxa, O = occasional taxa, R = rare taxa												

	Start KP									
Fauna	**39.101**	**37.354**	**35.450**	**33.497**	**31.517**	**29.869**	**27.893**	**26.317**	**24.573**	**23.429**
Sculpin			3	1		7				
Flounder	1	1	1			1				
Redfish	1	3		8	96	45	22	23	3	1
Pollock	60	1		100		100				
Atlantic Cod			1		9	7	4	5		3
Haddock										
Skate										
Eelpout										
Hagfish										
Blenny		6	5			1				
Hake										
Herring										
Torpedo ray										
Monkfish										
American Butterfish										
Unid. Fish		1								
Hermit crab			4	2	2	2		2		
Toad crab?										
Snow crab	56	9	10	46	21	75	14	43	50	16
Northern Stone Crab										
Sea urchin					2	27	1219	1844	170	40
Jonah crab	28	19	10	17	3	8	2		2	
Sea cucumber	29	11		3	2		1	2	4	1
Feather star								1		
Basket star					1	4		2	30	56
Solaster	5	5	1	2	1	3	2	1	2	3
Crossaster							1	3	8	9
Hippasteria sp	15	10	1	6		3	1			
Ceramaster										
Asterias/Henricia	33	21	12	32	17	31	45	24	1	
*Cerianthus sp**										
Sea anemone	21	14	79	40	29	59	7	3	47	
Squid										
Gastropod							2		2	1
Sponge*		17	16	33	11	8			2	
Encrusting sponge										
Tunicate						1				
Soft Coral*		2	9	13	1	13	1			
Corraline organism							2			
Hydrozoa										O
Shrimp	S					S				
*Observed around pipeline	**38.646**	**36.864**	**35.072**	**32.984**	**31.134**	**29.211**	**27.495**	**25.873**	**24.235**	**23.222**
	End KP									
	S = superabundant taxa, O = occasional taxa, R = rare taxa									

APPENDIX B

Assessment of bird-human interactions at offshore installations (DRAFT)

Acadia University

Assessment of bird-human interactions at offshore installations

Interim Report, Year 2 – December 2012

Prepared for

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Permits

Wildlife capture and handling procedures were approved by Acadia Animal Care Committee (certificate numbers: 15-11, 15-11R#1, 15-11R#1A#1, 06-09) and permit for scientific sampling was issued by Environment Canada (permits SC2761, SC2718, SC2741). Bird banding, tagging, and colour marking was authorized under by the Bird Banding Office (permits 10480-S, 10851, 10273-AH, 10695, 10273). Parks Canada Research and Collection Permit (SI-2012-0001) to work on Sable Island and deploy a VHF receiver station in Kejimkujik NP Seaside Adjunct. Permit to work in Sable Island Migratory Bird Sanctuary (MBS/SI-2011-1, MBS/SI-2012-1).

1. Executive Summary

Difficulties associated with direct observations from offshore platforms and the episodic nature of bird-platform interactions means that there is a poor documentation of patterns of bird activities at offshore installations. Assessment of bird-platform interaction effects could be improved by incorporating instrument-based approaches. This study aims to 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 field and lab work conducted during the period from May 2011 to December 2012.

Receiver Development – To improve our ability to detect birds in offshore and noisy working environments, and to address problems of data storage capacity on commercially available VHF receivers, we developed our own automated VHF receiver built with commercial off-the-shelf components. These receivers are inexpensive, can monitor multiple antennas simultaneously and can be used to improve our ability to detect VHF tags in noisy environments. They were lab and field tested at multiple mainland, island and vessel locations during 2012.

Bird movements – Field studies were conducted from the beginning of May through the end of November 2012 on Sable, Country, and Bon Portage Islands. This resulted in 1) VHF tag deployments on 224 birds including Herring Gulls (HERG), Great Black-backed Gulls (GBBG), Common Terns, Arctic Terns, Leach's Storm-petrels, Ipswich Sparrows, and Blackpoll Warblers; 2) satellite-GPS tag deployments on 6 HERG; 3) Geolocator tag deployments on 37 Leach's Storm-petrels; and 4) colour wing- and leg-banding of 27 HERG and 54 GBBG. VHF receivers were run at three breeding colonies, six coastal sites, and four offshore platform supply vessels, resulting in ~1000 receiver tracking-days, including >300 days from supply vessels.

VHF tags and colour wing-bands show that gulls depart from colonies on Sable Island between mid July and mid August; this departure period corresponds with our observations of gull-platform interactions offshore. Satellite tags revealed gull-platform interactions for 2 of 6 HERG. These individuals spent 6 and 12% of their time within 200 m of offshore platforms prior to departing the Sable Island area in late October. During breeding, terns on Sable Island made regular foraging trips of 3 to 6 h. Most individuals had departed the colony by mid August (bird-platform interactions are still being assessed). Stable isotope analysis revealed dietary differences between the two tern species suggesting the species forage in distinct areas or specialize on different prey types.

Foraging trips by Storm-petrels from Bon Portage (BP) and Country Island (CI) lasted 3-5 days; GLS data indicated that they may travel as much as 1000 km offshore during these trips. The foraging areas of CI Storm-petrels overlap with the platform area, though this is based on a small number of tag deployments and foraging trips. Colony-based tracking data also suggest the BP birds depart south on foraging trips, this limiting potential platform interactions, whereas CI petrels depart on easterly trajectories which may bring them in proximity to platforms in the Sable area.

Ipswich Sparrows tagged in August undertook migratory departures from Sable Island between September and November; juveniles departed earlier than adults. About half (61%) of sparrows

detected on the mainland were first detected at the northerly stations (Taylor's Head and CI) which suggests a north-westerly migration path for these individuals. If Ipswich are taking a direct route between Sable and northern portions of Nova Scotia's eastern shore, this route would limit over-water travel distance and their potential overlap with the Deep Panuke platform.

A small sample of Blackpoll Warblers tagged in Cape Breton showed evidence of south-westerly movements along the coast of Nova Scotia (3 out of 4 birds). Thirty-four of 53 warblers tagged on BP were recorded departing from the island. Twenty-eight (82%) of these had northerly or easterly components to their departure directions and six (18%) had southerly components. This result suggests that only a small proportion of birds are initiating long-distance, trans-oceanic migrations from BP. Of the 28 individuals departing north and east from BP, 19 were re-detected at coastal mainland sites which suggests considerable landscape-scale movements of this species within Nova Scotia prior to migration, and may indicate that individuals undertake their trans-oceanic flights from points further east.

Platform Sensors Deployment – In March 2012, a scope of work document was completed which outlines the plans for equipment installations on the Deep Panuke platform, including VHF receivers, use of platform radars, a low-light camera and acoustic sensors. Due to delays related to the PFC and at the request of Encana, the scope of work has not yet been forwarded to SBM. Our revised goal is to have a VHF receiver/antennas installed prior to spring field studies (May 2013) and other sensors installed and tested in July/August 2013 prior to autumn migration.

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 possible effects from major oil spills (Kerr et al. 2010), day to day operations of offshore petroleum activities can also have impacts on wildlife (Fraser et al. 2006; Wiese et al. 2001). One concern is the attraction of birds to offshore platforms and vessels (Montevecchi 2006; Sage 1979; Tasker et al. 1986). Birds are attracted to these sites for roosting (Baird 1990; Russell 2005; Tasker et al. 1986), foraging (Burke et al. 2005; Ortego 1978; Tasker et al. 1986), and as a result of disorientation and attraction caused by light sources (Hope Jones 1980; Montevecchi 2006; Sage 1979). Many songbird species are susceptible to light attraction at platforms, with direct effects through mortality associated with gas flares or collisions with infrastructure (Sage 1979) or indirect effects, when individuals circle platforms for long periods and deplete their fat reserves (Hope Jones 1980; Russell 2005; Wallis 1981).

The factors correlated with attraction and the mechanisms underlying these patterns are poorly understood. Anecdotally, it is known that weather (fog, precipitation and low cloud cover) can exacerbate the effect of nocturnal attraction to lights (Hope Jones 1980; Montevecchi 2006) but we are not aware of any systematic evaluation of bird attraction in relation to specific weather variables. Our ability to test hypotheses about factors driving bird attraction has also 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. The current study is focused on developing and testing an instrument-based approach to monitoring bird interactions with platforms using a variety of sensors. These sensors may enable the monitoring of bird activities 24 hours a day and in all or most weather conditions. Effective and efficient avian monitoring tools will enable the quantification of patterns of bird activities at offshore installations and allow for the assessment of factors associated with these patterns.

In 2011 we initiated studies using VHF tracking to monitor the movements of Herring Gulls and Leach's Storm-petrels from several colonies (Sable Island, Country Island, and Bon Portage Island) and quantified their interactions with offshore platforms including Encana's Deep Panuke project. We were able to document patterns of individual attendance at colonies, and, using receivers on platform standby vessels, to document patterns of bird-platform interactions. We also encountered a significant amount of "noise" when deploying VHF receivers on vessels, resulting in high rates of false-positive detections (see the first annual report for details; Ronconi & Taylor 2012).

In 2012, delays in hookup and commissioning of Encana's new Deep Panuke platform resulted in an opportunity to expand the scope of this study taxonomically, spatially, and temporally. Encana provided additional financial support for 2012 and 2013, which, coupled with funds acquired from other organizations, has allowed us to expand the initial project to include additional (passerine) species of birds and to conduct a third year of field studies. In 2012, the project was continued and expanded in two significant ways. First, to improve our ability to accurately detect birds offshore, and address problems of data storage capacity of the receivers, we developed a new receivers based on commercially available 'off the shelf' components. These receivers allow us much more control over tag recording and detection, which we anticipate will enable us to deal with the significant VHF noise issues encountered in 2011. Second, with additional support from Encana and other granting agencies, we expanded the scope of our study to include 3 additional seabird species and 2 passerine species, and an additional study site in Cape Breton. This report summarizes preliminary results of VHF tracking for all species along with other tracking approaches (geolocation and satellite telemetry) used in 2012.

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 Methods

Between May and November, 2012, field studies were conducted on Sable Island, Country Island, Bon Portage Island, and south-eastern Cape Breton Island (Figure 4.1-1) with the aim of tracking the movements of birds at breeding colonies, in the vicinity of offshore platforms and along migration routes. Data obtained through this approach will be used to address objectives 1 and 2 (above). This section provides details on the study site and species (section 4.1), development of new VHF receivers (4.2), deployment of receivers (4.3), and deployment of telemetry devices (4.4) and colour bands on birds (4.5).

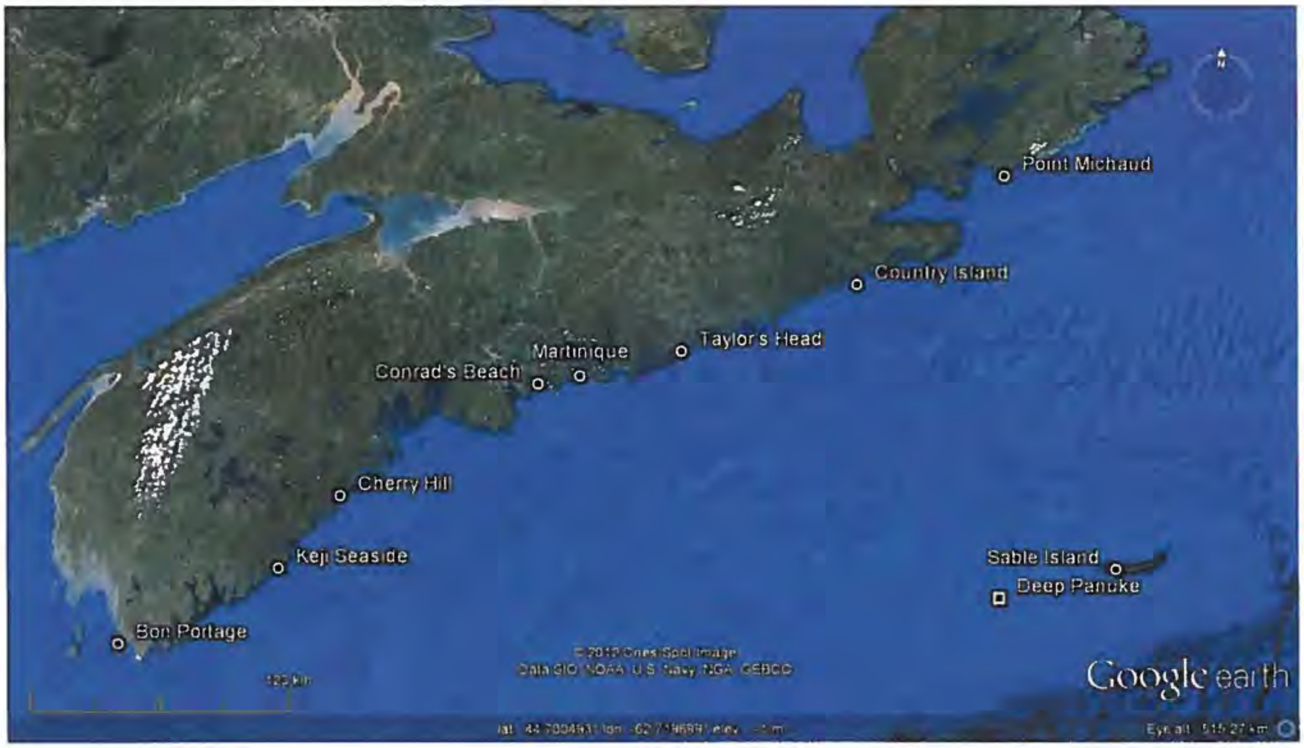

Figure 4.1-1 – Location study field sites in Nova Scotia relative to the Deep Panuke platform. Bon Portage Island, Country Island and Sable Island are seabird colonies where field studies were conducted. Some Blackpoll Warblers were also tagged at Point Michaud in Cape Breton. Other locations on the mainland represent sites of receiver station deployments.

4.1 Study sites and species

In Atlantic Canada, offshore oil and gas extraction is currently limited to two areas: the Grand Banks of Newfoundland (3 platforms, 1 proposed), and Sable Island Bank on the Scotian Shelf including the Sable Offshore Energy Project (SOEP, 5 platforms) and the Deep Panuke project (1 platform positioned offshore in July 2011 and currently in the process of hook-up and commissioning). Situated approximately 300 km from mainland Nova Scotia, the Scotian Shelf platforms extract natural gas from wells near Sable Island and along the edge of the continental shelf (Figure 4.1-2, Table 4.1-1). With an estimated field life of 25 yrs, SOEP platforms developed by ExxonMobil began extractions in 1999 (3 platforms), 2003 (1), and 2004 (1); Encana's Deep Panuke platform is slated to begin production in 2013. Some of these platforms have continuous human presence while others are automated with infrequent helicopter landings for maintenance. Platforms are situated between ~5 and 50 km from Sable Island and ~10 and 50 km from the Scotian shelf edge. Both locations provide breeding and foraging habitat for resident and migratory birds (Huettmann and Diamond 2000; McLaren 1981). The diversity in platform age, level of human activity, and distribution relative to the surrounding landscape provides a unique framework in which to test hypotheses related to bird-platform interactions.

Figure 4.1-2 – Location of offshore natural gas platforms surrounding Sable Island (43.93°N, 59.90°W, approximate centre). Sable Island is approximately 40 km in length, and 1.2 km wide at the centre. Receiver stations were deployed at West Light and East Light on Sable Island.

Table 4.1-1 – Natural gas platforms operating on the Sable Island Bank area of the Scotian Shelf. Latitude and Longitude are in decimal degrees (datum = NAD84, data obtained from www.cnsopb.ns.ca/pdfs/platform_locations.pdf). Year is date of production commencement (Exxon platforms) and date platform was installed offshore (Encana, production scheduled to commence in 2013). POB = Personnel On Board at all times. Distances are approximate.

Platform	Operator	Latitude	Longitude	Year	POB	Distance (km) to Sable Island	to shelf edge
Thebaud	Exxon	43.89188	-60.19989	1999	yes	9	48
Venture	Exxon	44.03328	-59.58175	1999	no	7	44
North Triumph	Exxon	43.69958	-59.85454	1999	no	25	18
Alma	Exxon	43.59483	-60.68200	2003	no	60	27
South Venture	Exxon	43.99820	-59.62730	2004	no	6	42
Deep Panuke	Encana	43.81270	-60.68837	2011	yes	47	50

The birds in this area comprise summer nesting species, year-round resident birds, and seasonal migrants (McLaren 1981). Nesting seabirds species on Sable include Herring Gull (*Larus argentatus*), Great Black-backed Gull (*L. marinus*), Leach's Storm-petrel (*Oceanodroma leucorhoa*), and three species of terns (Common Tern; *Sterna hirundo;* Arctic Tern; *S. paradisaea* and Roseate Tern; *S. dougallii)*. Sable Island is far offshore, and so well away from migration routes of most songbird species, but vagrant individuals are regularly observed (McLaren 1981). Two songbird species are most vulnerable to potential interactions with platforms: Ipswich Sparrow (*Passerculus sandwichensis princeps*) which breeds only on Sable Island, and Blackpoll Warbler (*Dendroica striata*) which undertakes cross-oceanic migrations that may take it in proximity to the platforms in the fall.

Gulls – Herring Gulls were tracked in 2011, and both Herring and Great Black-backed Gulls were tracked in 2012. Gulls are commonly attracted to platforms and supply vessels for foraging/roosting (Baird 1990; Tasker et al. 1986) and also pose the greatest threat to helicopter operations at unmanned SOEP platforms (M. Tuttle, ExxonMobil, pers. comm.). Gulls are also predators of terns nesting on Sable Island and elsewhere (Lock 1973; Whittam and Leonard 1999). Coloured wing-tags deployed on Herring Gulls in 2011 revealed high rates of birds attending offshore supply vessels: 52% of re-sighting events and 24% of tagged individuals were observed from supply vessels operating at the Deep Panuke platform. VHF telemetry revealed fine-scale behavioural information about these attraction events whereby vessel-based receivers recorded prolonged attraction of gulls between sunset and sunrise, likely related to nocturnal foraging opportunities associated with vessel and platform lights. These results supported the work plan for 2012: continued use of VHF and colour marking with Herring Gulls, additional deployments of VHF and colour marks on Great Black-backed Gulls, and satellite tag deployments on Herring Gulls. During May and June, gulls were captured on Sable Island using a combination of a hand-pulled leg noose set around the rim of nests, remotely activated bow nets (Modern Falconry, 1.2 m Fast Action Bownet) set around nests, or leg-loop noose carpets set around seal carcasses on the beach. Most Herring Gulls were captured with the first two methods and most Great Black-backed Gulls were captured with the latter.

Terns - Large colonies of Common and Arctic Terns nest on Sable Island, and Sable is one of only seven nesting sites in Canada for the endangered Roseate Tern (COSEWIC 2009b). Sable is considered 'critical habitat' for Roseate Terns and their recovery strategy includes protecting large, healthy colonies of Common and Arctic Terns (Environment Canada 2010), because all three species nest together. Identified threats, relevant to the Sable Island area, include human disturbance and industrial development including associated increases in large vessel traffic (COSEWIC 2009b). Terns may forage up to 24 km from their colonies (Rock et al. 2007a, 2007b), thus, potentially overlapping with vessel and platform activity situated 5 to 50 km from Sable Island. Little is known about the foraging ranges or critical foraging habitats for terns on Sable Island (Horn and Shepherd 1998), information which is required to assess spatial-temporal overlap between terns and offshore platform activities. Terns were caught on nests using walk-in Potter traps with drop-down doors or remotely activated bow nets (60 cm diameter).

Leach's Storm-petrels - Storm-petrels are naturally attracted to light of any kind due to their nocturnal foraging habits on vertically migrating bioluminescent prey (Imber 1975), thus, they are susceptible to attraction and mortality at flares (Sage 1979) or support vessels around platforms (Ronconi, pers. obs.). Storm-petrels may nest on Sable Island but if they do, the population is very small and dispersed, making it impractical to conduct studies. Instead, storm-petrels are being tracked from mainland colonies at Country Island and Bon Portage Island (Figure 4.1), the two largest breeding colonies in Nova Scotia. At these colonies, they were captured by reaching into burrows during late incubation stage. Leach's Storm-petrels are regularly seen far offshore on the Scotian Shelf and in the vicinity of platforms around Sable, but the origin of these birds is unknown. VHF tracking from the mainland colonies revealed foraging trip durations of 3 to 5 d, suggesting the potential to travel to the Sable Island area where interactions with platforms may occur.

Sparrows - Ipswich Sparrow is a sub-species of Savannah Sparrow endemic to Sable Island. It is listed federally as a species of special concern (COSEWIC 2009a; Environment Canada 2006). They migrate annually across the ocean between Sable Island and coastal areas of Nova Scotia and New England, and it is during these short migratory periods that they are most vulnerable to platform interactions. Although their general seasonal patterns of migration are well known (Stobo and McLaren 1975), the exact timing (day of year and time of day) and departure direction – factors that may affect risk for interactions with offshore platforms – are unknown. Adults were passively caught using mistnets and call playback systems as well as actively by flushing birds into the net.

Warblers - In eastern Canada, Blackpoll Warblers undertake a transoceanic migration to South America in the fall (Nisbet et al. 1995). They are known to depart south from SW Nova Scotia to southern New England, but it is not known whether birds from further east (Cape Breton & Newfoundland) also fly directly south, or whether they first move SW towards southern Nova Scotia before embarking on their transoceanic voyage (Mitchell et al. 2011). In other words, the geographic longitude, west of which most birds depart on their trans-oceanic voyage, is unknown. Individuals that depart on the trans-oceanic voyage from areas of Cape Breton or southern Newfoundland would fly directly over Sable Island and the surrounding offshore natural gas platforms. If a large portion of individuals from these areas do this, then they are at heightened risk of direct collision or negative interaction with the flare stack. Blackpoll Warblers have previously been found dead on at offshore platforms in the vicinity of Sable Island (CCWHC 2009). Their populations are declining in the east (Environment Canada 2010b).

4.2 VHF receiver development

Deployments of VHF receivers on vessels in 2011 showed large amounts of extraneous VHF noise that impaired our ability to detect individually tagged birds. This problem, coupled with the data storage limits of commercially available receivers limited our ability to run VHF receivers autonomously for long periods of time. To address these problems, we developed a new VHF receiver using commercially available 'off the shelf' components. These receivers continuously record potential tag signals on the appropriate VHF frequency and can run continuously for many months. Post deployment, the detections are processed with a simple pattern-matching algorithm, to search for detections of particular VHF tags. We are still in the process of examining 2012 data, but we anticipate that these new receivers and the associated tag extraction algorithm, will enable us to better detect tags in noisy environments. Here we describe a) the basic design and components of the receiver, b) current functionality with the receiver, and c) data processing.

4.2.1 Receiver design and components

The developed receiver has been named a "Sensor Gnome". Details on the current list of components can be found at www.bonedongle.org. The unit is built around a programmable radio receiver (the Funcubedongle Pro -- "FCD", www.funcubedongle.com) coupled with a low power embedded computer (The Beaglebone; www.beaglebone.org). Multiple FCD can be connected to VHF antennas, and fed into a USB hub that is polled by the beaglebone. A USB GPS is used to determine location and ensure that the system clock is accurate. Data are written to a 32 GB flash memory stick. The USB hub and Beaglebone computer were supplied with 5 volts DC from either a DC voltage converter (for battery-powered systems) or an AC adapter.

4.2.2 Receiver functionality

At present, the receivers allow us to continually and simultaneously listen to VHF signals from multiple antennas, and store a complete record of the pre-processed signals detected. These are run through a simple pattern-matching algorithm to extract tags. Receivers were tested in 'over-winter' conditions, and successfully ran continuously for periods exceeding 3 months. During the summer of 2012 we encountered a number of minor problems with receiver deployments related to both hardware and software issues. Such problems have enabled us to develop procedures for deployment setups that now allow for minimal down times.

4.2.3 Data processing

Data collected by individual units are uploaded to a central server, and incorporated into a database of raw tag hits. These tag hits are run through a tag-detection algorithm (described below) and a file of putative tag hits is produced. The basic conceptual framework is to be highly liberal in allowing tag hits (e.g. allowing for a large number of errors of *commission* (false positives) to minimize errors of *omission*). The data file of putative tag hits contains several variables that can then be used to filter out false positives, while retaining most true positives. By exploring the trade-offs between the two we will be able to provide quantitative advice on how best to set up VHF receivers for detection of target signals.

4.2.3 Description of the tag detection algorithm

The tag-detection algorithm is still under development. At present, tags are detected in the data stream by both comparing the output from a single burst (in the case of Lotek 'nano-tags', four sequential 2 ms signals, with a specific spacing) to a library of pre-recorded tag bursts. It then searches for bursts at the appropriate intervals (the burst rates) and frequency offsets from the nominal tag frequency. We are exploring alternate tag algorithms in the coming months.

4.2.4. Wiki

We have created a wiki (www.bonedongle.org) where we describe the receiver's components, functionality, lab test results, post-processing procedures for data, and frequently asked questions. Users of the Sensor Gnome may also provide feedback and guidance on its use in the field. The wiki is an important tool to establish collaborative research efforts so that more effective VHF tracking networks can be established in the final year of the project. In 2013, Sensor Gnome and wiki users will include project partners in Maine and Massachusetts who will run receiver stations to complement tracking efforts for species in our study that may also travel to these areas.

4.3 Receiver deployments

A network of automated telemetry antennas and receivers (Figure 4.1-1) was established to track the movements of birds equipped with VHF radio tags. This network was established to monitor bird activities at nesting grounds (gulls, terns, storm-petrels, and Ipswich Sparrows), timing of migration between Sable Island and the mainland (Ipswich Sparrows), migration routes along coastal Nova Scotia (Ipswich Sparrows and Blackpoll Warblers), and potential interactions with offshore platforms (all species). Receivers were deployed at three seabird colonies (Sable Island, Country Island, Bon Portage Island), six mainland coastal sites (south-east Cape Breton, Taylor's Head, Martinique Beach, Conrad's Beach, Cherry Hill, Kejimukujik N.P. Seaside) and four offshore supply vessels. A total of 1095 receiver-tracking-days were successfully obtained between 03-Jun and 25-Nov, 2012, including 524 days from seabird colonies, 224 days from coastal sites along mainland Nova Scotia, and 347 days from vessels around offshore platforms (Table 4.3-1).

Antenna towers were equipped with either SRX-600, SRX-DL telemetry receivers (Lotek Wireless Inc.), or a Sensor Gnome (described above in section 4.2. Receivers were connected to antennas using RG58 coaxial cable (12.6 m lengths for all antennas except 15.2 m on most of the vessels). Antennas included single-pole omni-directional antennas (Comrod AV7M, height 1.25 m, frequency range 145-165 MHz VSWR < 2:1, PL259 to BNC adapter) on vessels and some bird colonies, or an array of 5- and 9-element Yagi directional antennas at stationary sites to provide data on directional bird movements. Receivers were plugged into external AC power sources, or powered by solar panel arrays (one or two 55 or 65 W panels) connected to a battery bank (one or two 12VDC deep-cycle batteries, 100 to 115 amh each).

*Table 4.3-1 – Summary of VHF receiver deployments in 2012. Receivers/antennas were scanning VHF frequency 166.380 MHz or 166.300 (indicated by *; for detection of Blackpoll Warblers). Additional data from Sable Island and supply vessels for 2012 is still to be downloaded). Receivers include SRX-600 and SRX-DL (www.lotek.com) and Sensor Gnomes (SG; custom made receivers described in section 4.2). 9-el and 5-el = 9-element and 5-element yagi antennas, respectively. Omni = omni-directional antenna. SOEP =Sable Offshore Energy Project, which includes vessels attending various platforms operated by ExxonMobil.* No data = days of equipment malfunction.

Platform	Location	Receiver type	Antenna type and (number of antennas)	Antenna configuration (compass degrees)	Start	End	No data (days)	Tracking (days)
Islands								
Sable	West Light	SRX-600	9-el (4), omni (1)	0, 90, 180, 270	3-Jun	22-Aug	0	80
	West Light	SG	9-el (4), omni (1*)	0, 90, 180, 270	22-Aug	15-Oct	31	23
	East Light	SRX-600	9-el (4)	0, 90, 180, 270	14-Jun	23-Aug	52	18
	East Light	SG	9-el (4)	*0, 90, *180, 270	23-Aug	15-Oct	0	53
	Main Station	SRX-DL	omni (1)	n/a	16-Jun	23-Aug	0	68
Country	Field camp	SG	omni (1)	n/a	8-Jul	31-Jul	0	23
	Lighthouse	SG	9-el (4)	66, 120, 210, 246	31-Jul	25-Sep	0	56
	Lighthouse	SG	9-el (4)	66, 150*, 246, 330*	25-Sep	25-Oct	0	30
Bon Portage	Lighthouse	SRX-600	9-el (4)	230, 300, 200, 140	12-Jul	4-Oct	0	84
	Lighthouse	SRX-DL	9-el (2)	105, 285	4-Oct	28-Oct	0	24
	Lighthouse	SG	9-el (2)	105, 285	28-Oct	16-Nov	0	19
	Banding Cabin	SG	omni (1)	n/a	12-Jul	24-Oct		
	EastTower	SRX-DL	9-el (2)	105*, 165*	2-Oct	4-Oct	0	2
	EastTower	SRX600	9-el (2)	45*, 105*, 165*	4-Oct	5-Oct	0	1
	EastTower	SG	9-el (3)	45*, 105*, 165*	5-Oct	26-Oct	1	20
	WestTower	SRX600	9-el (3)	225*, 285*, 345*	2-Oct	5-Oct	0	3
	WestTower	SG	9-el (4)	195*, 225*, 285*, 345*	5-Oct	26-Oct	1	20
Mainland								
Cape Breton	Pt Michaud East	SG	9-el (2)	110*, 170*	21-Sep	24-Sep	0	3
	Pt Michaud East	SRX-DL	9-el (2)	110*, 170*	24-Sep	29-Sep	0	5
	Pt Michaud West	SG	9-el (3)	150*, 210*, 270*	21-Sep	24-Sep	0	3
	Pt Michaud West	SRX600	9-el (3)	150*, 210*, 270*	24-Sep	29-Sep	0	5
Eastern Shore	Taylor's Head	SG	9-el (2)	94*, 338	13-Sep	24-Oct	0	41
	Martinique Beach	SG	5-el (1)	62	22-Sep	3-Nov	0	42
	Conrad's Beach	SRX-DL	9-el (2)	150, 350	8-Sep	22-Sep	0	14
	Conrad's Beach	SG	9-el (2*), 5-el (1)	110, 150*, 350*	15-Sep	8-Nov	12	42
South Shore	Cherry Hill	SG	9-el (1*), 5-el (1)	144*, 242	21-Sep	8-Nov	19	29
	Keji Seaside	SG	9-el (2*), 5-el (1)	24, 140*, 320*	21-Sep	3-Nov	3	40
Vessels								
Ryan Leet	Deep Panuke platform	SG	omni (2)	2nd omni* added 19-Sep	24-Jul	14-Nov	47	66
Atlantic Condor	Deep Panuke supply	SG	omni (1)	n/a	8-Aug	25-Nov	0	109
Panuke Sea	SOEP platforms	SG	omni (1)	n/a	23-Jul	21-Nov	9	112
Venture Sea	SOEP platforms	SG	omni (1)	n/a	18-Jul	11-Oct	25	60
Totals	**Islands**				3-Jun	16-Nov	83	524
	Mainland				8-Sep	8-Nov	34	224
	Vessels				18-Jul	25-Nov	81	347
	Grand Total				**3-Jun**	**25-Nov**	**198**	**1095**

Vessel-based receivers were used to track the presence/absence of VHF-tagged birds near to offshore platforms. These were deployed on ships that operate as standby and supply vessels for the Deep Panuke platform (2 vessels: Ryan Leet and Atlantic Condor) and the five SOEP platforms (2 vessels: Panuke Sea and Venture Sea). Because manned platforms are always attended by at least one standby vessel, typically within 1 km of the platform, continuous VHF monitoring was conducted at platforms with offshore workers (Thebaud and Deep Panuke). The vessels also travel between platforms, attend unmanned platforms during maintenance activities, and transit between platforms and the mainland, thus providing opportunistic coverage of surrounding waters and the four unmanned platforms (Alma, Venture, South Venture, and North Triumph). Vessel-based receivers were equipped with a single omni-directional antenna mounted to railings above the bridge and cabled back to the receiver inside the vessel. A second omni-directional antenna was added to the Ryan Leet on 19 September to allow simultaneous monitoring of a second frequency (166.300 MHz). Antenna height was between 10 and 20 m above sea level.

Receivers at mainland sites and colonies had various antenna configurations (Table 4.3-2) depending on the location and target study species. Stationary receivers were deployed with one to four directional antennas that included 5- or 9-element Yagis mounted to 9 m telescoping poles or to 3 m poles attached to lighthouse railings (Bon Portage, Sable, Country Island). At colonies, antennas arrays were oriented in directions (e.g. N, S, E, W) to detect arrival and departure direction of seabirds and migratory passerines. At coastal stations, single antennas were oriented towards beach and dune habitats (used by Ipswich Sparrows), and antenna pairs were oriented offshore and inland, thus creating a detection plane perpendicular to the shore to detect sparrows and warblers migrating along the coast.

4.4 Tag deployments

VHF radio telemetry tags (Lotek Wireless, avian nano-tags; www.lotek.com) were deployed on gulls, terns, storm-petrels, sparrows and warblers at study sites (see following sections for species specific details). These tags are individually coded with unique IDs which allowed us to track multiple individuals with a single VHF frequency (166.300 MHz for warblers and 166.380 for all other species). VHF tag model, programming, and attachment methods are summarized in Table 4.4-1, and deployments by species and locations are summarized in Table 4.4-2.

*Table 4.4-1 – Specifications of VHF tags deployed on seabirds and passerines in 2012. Tag model refers to nano-tag series manufactured by Lotek Wireless (www.**lotek**.com). Burst interval, the time interval (in seconds) at which tags transmit VHF signals, was approximately 10 seconds (staggered between 9.5 and 10.5 s) for all tags, except some tern tags had burst interval of 5 seconds. All tags were deployed on VHF frequency 166.380 MHz, except for Blackpoll Warblers (166.300).*

Species	Body mass (g)	Tag model	Tag weight* in g (% of body mass)	Antenna type	Expected life (d)	Attachment method
Great Black-backed Gull	~1700	NTQB-6-1	4.5 (0.3%)	heavy, braided	347	end-tubes, harness
Herring Gull	~1000	NTQB-6-1	4.5 (0.5%)	heavy, braided	347	end-tubes, harness
Common Tern	120	NTQB-3-2	1.4 (1.3%)	medium, non-braided	124**	end-tubes, suture
Arctic Tern	110	NTQB-3-2	1.4 (1.4%)	medium, non-braided	124**	end-tubes, suture
Leach's Storm-petrel	45	NTQB-3-2	0.81 (1.8%)	light, non-braided	124	glue/tape
Ipswich Sparrow	24	NTQB-3-2	0.72 (3%)	light, non-braided	124	harness
Blackpoll Warbler	13	NTQB-1	0.34 (2.6%)	light, non-braided	33	harness

*includes attachment materials, ** some tags with 5 sec burst interval had battery life of ~80 days

Table 4.4-2 – Summary of telemetry devices deployed on birds in 2012. VHF = Lotek nano-tags. GPS = Microwave Telemetry 20g satellite linked GPS tags. GLS = Global Location Sensing (also known as geolocation tags).

Location	Species	Tag type	N	Deployment dates	Notes
Sable Island					
	Herring Gull	VHF	27	23-May to 10-Jun	
	Herring Gull	GPS	6	26-29 May	one fell off and recovered in Aug
	Great Black-backed Gull	VHF	26	19-May to 08 Jun	
	Common Tern	VHF	20	11-14 Jun	at two main colonies
	Arctic Tern	VHF	15	11-14 Jun	at two main colonies
	Ipswich Sparrow	VHF	44	22-29 Aug	
Country Island					
	Leach's Storm-petrel	VHF	15	07-10 Jul	
	Leach's Storm-petrel	GLS	19	07-10 Jul	5 tags recovered in late July
Bon Portage Island					
	Leach's Storm-petrel	VHF	20	13-Jul to 15-Aug	
	Leach's Storm-petrel	GLS	18	13-Jul to 31-Aug	5 tags recovered in Aug/Sept
	Blackpoll Warbler	VHF	53	20-Sep to 21-Oct	
SE-Cape Breton					
	Blackpoll Warbler	VHF	4	21-Sep to 26-Sep	

4.4.1 Herring and Great Black-backed Gulls

Work on gulls included colour wing- and leg-banding of adults and juveniles, VHF tag deployments, colony-based monitoring of birds from VHF receiver stations, and GPS-satellite tag deployments. The goal was to compare and investigate differences in patterns of colony attendance, the timing of departure from the Sable Island area, and to quantify the frequency, duration, and timing of interactions with offshore platforms between two species of Gull (Herring and Great Black-backed).

Colour marking - 48 Herring Gulls (HERG) and 95 Great Black-backed Gulls (GBBG) from Sable Island were colour marked in 2011 and 2012 (Table 4.4-3). Each gull was fitted with a standard CWS/USGS metal leg band on the right leg and a unique 3-letter combination colour leg-band on the left (pink for HERG and green for GBBG; Pro Touch Engraving, Saskatoon, SK, www.protouch.ca). Some individuals were also fitted with colour wing-tags with matching 3-letter codes. Wing-tag design was based on those used on other seabird species (Southern and Southern 1985; Trefry et al. in press) made of 17-oz vinyl-coated polyester fabric (Precontraint Color Design by Ferrari Textiles, available through Creative Textile Solutions, Halifax, NS). Wing-tags were 17 × 8 cm (5.5 g) and 15 × 7 cm (4.3 g) for Great Black-backed and Herring Gulls, respectively. When attached to the wing, the exposed surface with ID label is approximately 8 × 5 cm (GBBG) and 7 × 4 cm (HERG). The 3-letter ID was written on the wing-tags with permanent marker (Allflex marking pen, www.allflexusa.com). HERG wing-tags were pink and deployed only during May and June on breeding adults. GBBG wing-tags were deployed on adult and sub-adult birds using two colours depending on the season: turquoise on non-breeding birds in January, and lime green/yellow on breeding birds in May and June. Colour leg-bands were deployed on GBBG chicks. Deployments by species, season, and age groups are summarized in Table 4.4-3.

Table 4.4-3 – Summary of colour leg-band and wing-tag deployments on Herring Gulls (HERG) and Great Black-backed Gulls (GBBG) from SableIsland. Age: adult = breeding adult, HY = hatch year bird (e.g. chicks born on Sable in that year), and AHY = after hatch year (mixture of adult and sub-adults). na = not applicable.

				Sample size		
Year	**Species**	**Age**	**Season (month)**	**Colour Band**	**Wing-tag + Colour Band**	**Wing-tag colour**
2011	HERG	adult	breeding (May/June)		21	Pink
	GBBG	HY	breeding (May/June)	29		na
2012	HERG	adult	breeding (May/June)	14	13	Pink
	GBBG	AHY	winter (Jan)		12	Turquoise
	GBBG	AHY	breeding (May/June)	1	25	Lime green
	GBBG	HY	breeding (May/June)	19		na
	GBBG	HY	post-breeding (Aug)	9		na
Totals	**HERG**			14	34	
	GBBG			58	37	

Information on bird movements from colour marking relies on reports from field observers. We have received reports from workers on platforms, supply vessels, and Sable Island, and the public. Personnel on platforms and supply vessels within the study region were notified about the deployments and asked to submit sighting reports and photos of any tagged birds that they observed. Additional outreach about the colour-banding program was conducted through birding list-servers and news letters, handouts to Canadian Coast Guard and NOAA vessels, and through a blog: http://sableislandgulls.wordpress.com/.

Radio tagging – VHF radio transmitters (NTQB-6-1, 2.4 g, braided antenna 14 cm long and 0.7 mm thick, Lotek Wireless) were deployed on 53 gulls (n = 27 HERG, and n = 26 GBBG) between 19 May and 10 June, 2012. Transmitters were attached using a leg loop harness (Mallory and Gilbert 2008) made of Teflon tape (Bally Ribbon #8476, Natural Brown, 6.35 mm width: Bally Ribbon Mills, Bally, PA, U.S.A.) that passed through end-tubes (inner diameter 4.5 mm) on the tags. Total weight of tag plus harness was ~4.5 g, less than 0.5% of gull body mass. Herring Gulls were captured at nests and, therefore, were breeding adults, but Great Black-backed Gulls were captured with traps at seal carcasses and, therefore, included a mix of breeding adults and sub-adults. Birds were tracked continuously from receivers and directional antennas mounted in each of the Sable Island lighthouses, providing information on movements around the island, patterns of colony attendance and departure dates from the study area. Receivers on vessels provided data on the frequency, timing, and duration of gull interactions with offshore platforms.

GPS-satellite tagging – GPS-satellite tags (Solar Argos/GPS PTT-100, 22 g, Microwave Telemetry Inc., Columbia, MD, U.S.A.) were deployed on Herring Gulls (n = 6) in May, 2012. Tags were attached with leg-loop harness as per VHF tags (above) with a total weight of less than 2.5% of the bird's body mass. Tags were programmed with two seasonal duty cycles to optimize use of solar power: 1) spring/summer/fall: 21-Feb to 21 Oct, 15 GPS positions daily at hours 00, 1, 2, 4, 6, 8, 9, 10, 12, 14, 16, 17, 18, 20, 22, and transmit cycle = 4 d; 2) winter: 21-Oct to 21-Feb, n = 8 positions at 00, 3, 6, 9, 12, 15, 18, 21, and transmit cycle = 5 d. Satellite tags provide bird locations from anywhere on the planet and do not rely on our network of receiver stations.

4.4.2 Common and Arctic Terns

Work on terns included VHF tag deployments two main breeding colonies on Sable Island and colony-based monitoring of birds from VHF receiver stations. The goal was to compare differences in patterns of colony attendance, foraging ranges and critical foraging habitats around Sable Island, quantify the frequency, duration, and timing of interactions with offshore platforms, and timing of departure from the Sable Island area for two species (Common and Arctic Tern). Dietary analysis, through blood samples, also provide information on differences in feeding preferences between the two species.

Sable Colonies/Receivers - A combined total of 39 Common and Arctic Terns were captured and banded on Sable Island between 11 and 17 June, 2012. The period was chosen to be during mid to late incubation in order to minimize abandonment from handling in early incubation. Study sites for tern captures included the two largest mix-species colonies on the island. Main Station colony (43° 55' 53.184" N and 60° 0' 23.580" W) is situated on the western end of the island adjacent to the Environment Canada weather station and in proximity to three wind turbines and several small ponds. East Light colony (43° 57' 35.136" N and 59° 46' 59.700" W) is situated at the eastern end of the island within a fenced area that excludes horses from grazing around the East Light field camp. The colonies are about ~20 km apart and both are <150 m from the ocean.

To track tagged terns, receivers and directional antennas were mounted at the top of each Sable Island lighthouse (locations in Figure 4.1-2) < 1 km from the center of each colony. An additional receiver was mounted to the roof of a building within 100 m of the Main Station colony to provide more detailed monitoring at this colony.

Capture and Radio Tagging - Terns were captured using bow nets (~60 cm diameter with remotely activated release) and modified Potter traps (Lincoln, 1947) with wooden frames measuring 30 × 30 × 35 cm. All terns were breeding adults, captured at nests. Once captured, mass, relaxed wing chord, tarsus length, bill length, and bill depth were measured and recorded. Blood and tail feather samples were then collected from all captured terns to compare diets between the two species and the two colonies using stable isotope analysis – dietary information will provide complimentary information to VHF tracking to investigate separation in foraging habitats between species and colonies.

VHF radio transmitters (NTQB-3-2, 1.4 g, braided antenna 14 cm long and 0.5 mm thick, Lotek Wireless) were deployed on 35 of 39 terns captured (Table 4.4-4). Tags were mounted to the back of each tern using 2 subcutaneous sutures (Ethicon, Prolene, 45 cm length, 4.0, FS-2 reverse cutting, 19 mm 3/8 cm, catalog # 8683G), Tessa tape and super glue. Sutures were inserted into the skin of the birds and then fed through the tubing of the VHF tag using sterilized hemostat clamps; these were tightened with several surgeon knots. Tessa tape and glue were used to wrap around a few feathers and the tag for added stability. Handling time (processing, banding and tagging) ranged from 15-25 min per individual.

Table 4.4-4 - Total number of VHF tags deployed on terns on Sable Island in June 2012

Colony	Common Terns	Arctic Terns	Total
Main Station	10	10	20
East Light	10	5	15
Total	20	15	35

A small blood sample (< 0.1 ml) was taken from each individual to investigate dietary differences between species and colonies by comparison of stable isotope ratios. Stable nitrogen isotope signatures ($\delta^{15}N$) are representative of foraging trophic levels and generally increase from prey to predator. Stable carbon isotopes ($\delta^{13}C$) are representative of food sources and do not change when prey are consumed by predators. $\delta^{13}C$ values generally reflect an inshore-offshore gradient in prey items from marine environments, and so $\delta^{13}C$ may inform differences in foraging habitats between species.

4.4.3 Leach's Storm-petrel

Work on Leach's Storm-petrels included VHF tag deployments at two mainland breeding colonies, colony-based monitoring of birds from VHF receiver stations, and deployment and recovery of geolocation tags. The goal was to compare foraging patterns between the two colonies in order to identify potential overlap with offshore platforms, and to directly quantify the frequency, duration, and timing of interactions with offshore platforms.

Colonies - Bon Portage Island (Outer Island on most maps, 43° 28' N, 65° 44' W) is situated off the south-west coast of Nova Scotia 480 km from the closest offshore platform. The island is ~ 3.0 × 0.5 km, oriented roughly on a north-south axis. An estimated 50,000 pairs of storm-petrels breed there annually (Oxley 1999). Country Island (CI, 45° 06' N, 61° 32' W) is situated in Guysborough County along the eastern shore of Nova Scotia, 170 km from the closest offshore platform. The island is roughly circular, about 500 m in diameter.

Radio Tagging - On 8-9 July, Leach's Storm-petrels (LHSP) were retrieved from their burrows on Country Island and banded with a unique USFWS/CWS stainless steel leg bands. Morphometric measurements were taken, along with blood and feather samples. 15 VHF tags (NTQB-3-2, 0.81 g, non-braided antenna, Lotek Wireless) were deployed by wrapping a ~ 5 mm strip of Tesa tape around the tags and approximately 8-12 back feathers. A few drops of glue were used to bond the tape to the back of the birds. Between 14 July and 14 August, 20 VHF tags were deployed on LHSP on Bon Portage Island, using the same technique.

Tracking: Movements of LHSP were detected on Country Island using an Omni-directional antenna connected to a Sensor Gnome, close to the center of the colony (July 8 to 31) and 4, 9-element Yagi antennae facing 66°, 120°, 210°, and 246°situated at the top of the lighthouse (after July 31). On Bon Portage Island, detections were obtained using an omni-directional antenna connected to a Sensor Gnome within 70 to 300 m of the study burrows and 4, 9-element Yagi antennae facing 230°, 300°, 200°, and 140°at the top of the lighthouse connected to an SRX 600. Colony monitoring of VHF signals provided information on patterns of colony attendance, as well as timing and direction of departures from and arrivals to the colony.

GLS Tagging: On 8-9 July, 21 Global Location Sensing (GLS) tags were deployed on LHSP on Country Island. About half (n = 10) were deployed using a modified leg-loop harness (Haramis and Kearns 2000), the remaining (n = 11) were deployed using the same technique as for the VHF tags. Between 19 July and 22 August, 17 GLS were deployed on LHSP on Bon Portage Island using the same technique as for the VHF tags.

Table 4.4-5 – Summary of devices deployed on LHSP on 2011 and 2012, on Country Island and Bon Portage Island.

Year	Island	VHF	GLS
2011	Bon Portage	30	0
	Country Island	15	0
2012	Bon Portage	20	17
	Country Island	15	21

Burrow monitoring: Each burrow was monitored at regular intervals (approximately weekly on BP and every 3 to 4 weeks on CI) to confirm the status of nesting birds. The purpose was to confirm hatching dates as well as hatching success rates and chick rearing success rates (hereafter fledging success) so that bird activity patterns, recorded by VHF receivers, could be attributed to different stages of the nesting period (i.e. incubation and chick-rearing). We also monitored 25 and 100 control burrows, where adult birds were handled but no tags were deployed, in order to evaluate potential effects of tags on hatching and fledging success, which would also influence patterns of colony attendance monitored by VHF.

4.4.4 Ipswich Sparrow

Work with Ipswich Sparrows in 2012 included early summer banding, VHF tag deployments in late August, and migration tracking from September through to December. The goal was to investigate differences in migration timing, potential interactions with offshore platforms while in transit, and proportion of successful migrations to the mainland Nova Scotia for three groups (adult males, adult females, and juveniles).

Spring Banding - Between 23 May and 23 June, individuals were captured, processed and banded at various locations between Main Station and West Light, in an area approximately 2 km × 400 m, on Sable Island, Nova Scotia. Adults were passively caught using mist nets and call playback systems, and actively captured by deliberately flushing birds into nets. Captured adults were banded with a unique USFWS/CWS aluminum leg band and sexed by assessing whether the individual had brood patch (a female characteristic), and colour-banded accordingly (males=red, females=blue). The purpose of colour banding in early summer was to provide a marked population of known sex individuals for August VHF tag deployments, a period when new feathering of female brood patches begins (Stobo and McLaren 1975) and determination of sex would be difficult. Mass, relaxed wing chord, tail, and tarsus length were measured. Fat stores were scored on a categorical index of 0 to 5 by visual inspection of subcutaneous fat deposits in the furculum [a modified Kaiser (1993) index]. Moult pattern was determined by examining wing and tail feathers for moult limits or new growth.

We intended to deploy VHF tags in August on the oldest juveniles, to ensure that we were tagging individuals with higher migratory survival probabilities. To facilitate aging of juveniles and distinguish them from late broods during August tagging, we captured and banded first brood chicks in the nest in mid-June. Nests were found when incubating females were flushed or when we observed parents bringing food to nestlings. Nestlings were banded 6-8 days after hatching. At 7 days old nestlings have a mean tarsus length that is 95% of the adult tarsus length (Ross 1980), and chicks can be force fledged soon after this (Stobo and McLaren 1975). Mass and tarsus length was measured and they were banded with a purple coloured leg band and a unique USFWS/CWS aluminum leg band.

GPS locations were recorded for each nest and capture location. The nest site habitat (inland or pond), proximity to freshwater, vegetation type, and vegetation density (dense or sparse) were recorded.

Radio Tagging: Between 22 and 29 Aug, 270 IPSP were captured and banded with a unique USFWS/CWS aluminum band. Adults were targeted by observing territorial individuals and flushing them into mist nets. Juveniles were caught incidentally while targeting adults. Attempts were made to locate and recapture adults and juveniles colour banded in early summer, with limited success. However we discovered that it was still possible to sex most adults and early vs. late brood juveniles were distinguishable based on moult patterns. These observations were confirmed through recaptures of spring banded birds. Adult females still retained brood patches at this time of year or were just beginning to refeather. Birds were aged as hatch-year (HY) or after-hatch-year (AHY, i.e. adults) using a combination of plumage characteristics and skull ossification (Pyle 1997): AHY birds had primary, secondary and tail feathers that were extremely worn compared to the fresh plumage of HY birds. Hatch-year birds were also determined to be from early or late broods based on plumage characteristics and colouration of the wing coverts and (primarily) the tail feathers. Late brood birds had even length tail feathers which were still growing or fully grown and fresh, i.e. newly grown or growing tail. Conversely, first brood birds were moulting tail feathers sequentially (from inner to outer tail feathers) and symmetrically between right and left sides of the tail, a pattern that was confirmed from recaptured spring-banded birds. Birds that seemed to be growing only one tail feather were assumed to have lost the feather by chance, rather than a true seasonal moult observed in the early brood birds. We also looked for any presence of growing feathers (pins) on other parts of the wing or breast which helped affirm aging by tail moult; often the birds with short or no tail feathers still had a lot of breast feathers growing, i.e. newly fledged birds.

A total of 44 birds, 20 AHY and 24 HY from earlier broods (Table 4.4-6), were radio tagged using figure-8 leg-loop harnesses (Rappole and Tipton 1991). Leg-loops made of nylon elastic thread (0.5 mm thick and lengths of 41-42 mm) were fixed to the tags using glue (Loctite 422). Each bird that received a VHF transmitter was also fitted with a unique combination of two colour leg bands on the left leg in order to facilitate re-sightings. For birds where sex determination was uncertain, blood was collected with capillary tubes, 0.1mL per bird from one wing, for sex determination in the lab using molecular techniques.

Table 4.4-6 *- Total number VHF tags deployed on Ipswich Sparrows on Sable Island in August 2012*

	Adult (AHY)			Juvenile (HY)
	Male	Female	Unknown	
# Tagged	5	13	2	24
Total		20		24

Manual Tracking and searching on mainland Nova Scotia: Manual tracking of tagged birds was conducted 1-2 times weekly at 23 selected coastal sandy dune locations between Taylor's Head Provincial Park, and Cape Sable Island using a handheld SRX-600 telemetry receiver (Lotek Wireless Inc.), coupled with a 5-element Yagi antenna. At each location the beach was scanned in all directions for 5 minutes. No birds were detected between 23 Sept and 14 Oct after which we abandoned that approach.

Volunteers were also enlisted to conduct beach searches for Ipswich Sparrows in the Halifax Regional Municipality. The search effort, number seen, date, location, and time were recorded for each visit will be used to help determine future focus sites and timing of migration. Sightings of colour banded Ipswich Sparrows along the eastern coast of Canada and the United States would also add to our knowledge of individuals location and migration.

4.4.5 Blackpoll Warbler

Work on Blackpoll Warblers (BLPW) included VHF tag deployments at two mainland locations, and monitoring of movements via the coastal and offshore network of receiver stations. The goal was to compare timing and direction of migration departure in order to assess the relative risk of platform interactions for warblers departing from different locations on mainland Nova Scotia.

Study sites: BLPW were captured in mist nets and radio-tagged at two locations in Nova Scotia: Point Michaud (45°35'10.31"N, 60°41'17.94"W) and Bon Portage Island (43°27'52.71"N, 65°44'45.17"W). Point Michaud is situated in southeastern Cape Breton, 190 km north-northwest of Sable Island. Bon Portage Island is a small island located in southwestern Nova Scotia, 3 km offshore and 475 km west of Sable Island. At Point Michaud, mist nets were operated from 19 – 28 Sept, and on Bon Portage Island, mist nets were operated from 19 Sept – 25 Oct.

Banding and radio tagging: We radio-tagged 57 BLPW between the two sites (4 at Point Michaud and 53 on Bon Portage Island; Table 4.4-7). Median tagging dates were 24 Sept 2012 at Point Michaud and 6 Oct 2012 on Bon Portage Island. Individuals were fitted with digitally coded radio transmitters (Avian NanoTag model NTQB-1; Lotek Wireless Inc., Newmarket, ON, Canada) using a figure-eight leg loop harness (Rappole and Tipton 1991). Transmitters operated on 166.300 MHz (burst interval = 9.5-10.5 s), had approximate lifetimes of 33 d, and weighed 0.29 g, which comprised $2.1 \pm 0.3\%$ of the body weight of the individuals tagged. Captured individuals were also banded with a unique USFWS aluminum band and their mass (g), un-flattened wing chord (mm), tarsus length (mm), age (hatch-year/after-hatch-year), and fat score were recorded. Ages were assigned based on species-specific plumage characteristics, moult criteria, and extent of skull ossification (Jenni and Winkler 1994, Pyle 1997), and fat was scored on a categorical index of 0-7 [a modified Kaiser (1993) index] by visually inspecting subcutaneous fat deposits in the furculum, breast, and abdomen. All individuals were released within 1 h of initial capture.

Table 4.4-7 *- Summary of Blackpoll Warblers tagged by site, age, and fat score (*n = *57).*

Site	Hatch-year		After-hatch-year	
	Fat < 5	Fat ≥ 5	Fat < 5	Fat ≥ 5
Point Michaud	2	0	0	2
Bon Portage Island	36	13	0	3

Radio-telemetry: Local, stopover, and departure movements of tagged individuals were monitored using a pair of automated digital telemetry towers installed at each capture site. At Point Michaud, towers were situated 1 km northeast (45°35'31.85"N, 60°40'40.26"W) and 1 km southwest (45°34'52.30"N, 60°41'56.54"W) of the banding station. On Bon Portage Island, towers were located side-by-side at the south end of the island (43°27'28.01"N, 65°44'35.53"W), 0.8 km south-southeast of the banding station. Coastal and offshore movements were monitored using an array of automated digital telemetry towers along the coast of Nova Scotia and Sable Island (Figure 4.4-1). When signals from a given individual at either capture site remained at a relatively constant strength for more than 24 h, suggesting that the transmitter had been dropped or that the bird was dead, we attempted to locate and recover the transmitter using a hand-held SRX600 telemetry receiver and a 5-element Yagi antenna.

5. Results

5.1 Receiver development

Early in the season, Lotek Wireless receivers (SRX-600 and -DL) were deployed on Sable Island before Sensor Gnome receivers were ready for field deployment. Sensor Gnome receivers were successfully developed and deployed over the second half of the summer, and used extensively in our VHF tracking efforts from islands, mainland sites and vessels, resulting in more than 1000 receiver tracking days (Table 4.3-1). The results of these efforts are described below.

Some deployments suffered from technical issues which resulted in data gaps for VHF receiver monitoring – these periods are described here to provide context for the interpretation of tracking results presented below (see also Table 4.3-1 above for details on site specific receiver deployments).

On Sable Island, SRX-600s were deployed at each of the lighthouse towers and one SRX-DL was deployed in the tern colony at Main Station. Due to weather, the installation these receivers and antennas were delayed until early June and, therefore, we have no tracking data for tagged birds that may have departed the colony before this time. Once installed, the West Light and Main Station receivers worked from June until August 22 when we next visited the island. The East Light receiver failed ~ 2 weeks after deployment due to a faulty charge controller from the solar panel system. We therefore have limited data for terns at this colony and for gull tags deployed on the east end of Sable. In late August receivers were replaced with Sensor Gnomes at both towers. The West Light receiver failed at the end of August, again due to solar power failure. The power supply was re-connected at the beginning of October. This failure resulted in no tracking data for a few remaining gulls on the island and no monitoring of Ipswich Sparrow departures during this time.

On Country Island and Bon Portage Island, receiver towers worked for the entire tracking period with no significant gaps in data collection. On the mainland sites, three receivers suffered from intermittent data gaps (Keji, 3 days; Conrad's Beach, 12 days; Cherry Hill, 19 days) which results from bugs in Sensor Gnome software and/or power related issues. These data gaps would primarily impact the monitoring of Ipswich Sparrow and Blackpoll Warbler migrations along the coast. Nonetheless, we successfully tracked both species at all three sites.

Receivers were deployed on four offshore supply vessels opperating around Sable. The earliest deployments on the Ryan Leet and the Venture Sea suffered from equipment failure related to GPS devices associated with the receivers. A second deployment on the Ryan Leet also failed because the receiver was knocked from its shelf during a storm and destroyed upon impact. The infrequent port calls of these vessels (typically once every 4 weeks) limited our ability to monitor and troubleshoot equipment problems and, therefore, resulted in extensive gaps in receiver monitoring early in the deployments (primarily July and August). This will impact our VHF monitoring of gull-platform interactions, which occur most frequently during this period, and also limit our investigations of tern-platform interactions since most terns had departed the Sable Island area by mid August (see results below).

Due to the extensive amount of electrical and communications equipment aboard supply vessels, receivers deployed on the vessels recorded large amounts of "noise" in the frequency range of our VHF tags. An algorithm error in the initial versions of our Sensor Gnome software exacerbated this problem. We are refining the algorithms to extract tag detections from ambient VHF noise levels and looking more directly at the temporal patterns of noise, and the variation among vessels.

We believe that we have identified and fixed the issues encountered with power supplies and software within the SensorGnome receivers. These fixes are being extensively tested over the winter of 2012-2013, so that systems will be ready for re-deployment in April 2013.

5.2 Bird movements

The primary objective of this study is to investigate bird-platform interactions. We used various tracking techniques to monitor the movements of birds around their colonies, in the vicinity of platforms and throughout coastal Nova Scotia. This section examines preliminary analysis of all bird movement data from colour marking, VHF tracking, satellite tracking, and geolocation tracking performed in 2012. Interpretation of these results and implications for monitoring bird-platform interactions are presented I section *6 Discussion* below.

5.2.1 Herring and Great Black-backed Gulls

Colour marking – From 21 Herring Gulls tagged in 2011, only 8 individuals (38%) were resighted on Sable Island during the May/June field season in 2012 (Table 5.2-1). Most search effort was concentrated in the same areas where gulls were tagged in 2011, and other areas of the island were searched opportunistically. During this same period, at least one individual was also sighted in Sydney, NS (see Table 4 in Ronconi and Taylor 2012) which, in concert with low return rates in 2012, suggests that many individuals did not return to Sable Island in 2012 to breed. Of the 8 resighted, none were recorded breeding in 2012.

Wing-tags were deployed on 13 HEGU and 25 GBBG in May and June 2012. Between 1 Jun and 31 Dec we received 7 sighting reports of HEGU and 13 reports of GBBG (Table 5.2-1). More than half of the resightings were reported from offshore areas including waters around Sable, north shore of PEI and the Gulf of Maine. In offshore areas ~45% of all resightings were associated with offshore platforms showing a peak in attendance from mid July to mid August, and one additional sighting in late September. Thus far, all of the Great Black-backed Gulls observed around offshore platforms were spring tagged birds (yellow tags deployed in May/Jun) and none of the winter tagged birds (Jan) have been observed in the offshore platform areas. On the mainland 9 resighting were reported between May and December (4 HERG and 5 GBBG).

*Table 5.2-1 Resightings of wing-tagged gulls between June and December, 2012. HERG = Herring Gull, GBBG-S = Great Black-backed Gull banded in the spring, GBBG-W = Great Black-backed Gull banded in the winter. * indicates supply vessel Ryan Leet.*

Location	Species	No. sightings	% of sightings	Confirmed individuals (no. of sightings)	Dates
Sable Island					
spring 2012	HERG	multiple	n/a	AAC(1), AAF(2), AAH(1), AAL(2), AAN(1), AAV(4), AAT(2), AAZ(1)	18-May to 12-Jun
Offshore					
Supply vessel* - Deep Panuke	HERG	2	10.0	AHF(2)	30-Jul, 05-Aug
Thebaud platform	HERG	1	5.0	AFJ(1)	16-Aug
Gulf of Maine – 120 km south of NS	GBBG-S	1	5.0	AET(1)	25-Jun
Supply vessel* - Deep Panuke	GBBG-S	5	25.0	AEU(2), others not identified	12-Jul to 07-Aug
Alma platform	GBBG-S	1	5.0	yellow tag (not identified)	29-Sep
Fishing vessel - 4 km offshore PEI	GBBG-W	1	5.0	AEE(1)	21-Aug
Mainland					
Glace Bay, NS (Cape Breton)	HERG	2	10.0	AAF(2)	10-12 Sep
Sydney, NS (Cape Breton)	HERG	1	5.0	pink tag (not identified)	24-Sep
Cape Cod, MA	HERG	1	5.0	AFR(1)	01-Nov
Wellington, PEI	GBBG-S	1	5.0	AEY(1)	01-Aug
Lower West Pubnico, NS	GBBG-S	1	5.0	AFJ(1)	15-Aug
Wellington, PEI	GBBG-W	1	5.0	AEE(1)	23-Oct
Swans Island, ME	GBBG-S	1	5.0	AEP(1)	06-Nov
Canso, NS	GBBG-W	1	5.0	ACY(1)	13-Nov
Total - Herring Gulls		**7**	**35.0**	**4**	
Total - Great Black-backed Gulls		**13**	**65.0**	**7**	
Total - all gulls		**20**	**100**	**11**	**18-May to 13-Nov**

VHF tracking – VHF tags (n = 53) were deployed on Herring Gulls and Great Black-backed Gulls between 19 May and 10 June, 2012, and colony based receivers monitored gull presence/absence during the breeding and post-breeding period, until 22 August 2012 (data from late August to November will be compiled at a later date). In 2011 most tags (15/20) stopped being detected after 1 day to 3 weeks, but in 2012 we experienced much higher tag retention rates with continuous tracking data from more than 65% of the birds. Incomplete data for birds in 2012 was again a result of birds removing tags (3 confirmed incidents out of 53 tags; 5.6%) but also some birds that may have departed the colony before receivers were activated in early June. For GBBG, incomplete tracking data was obtained from 9 birds which included 2 adults that removed their tags. Of the other 7 tags, 4 were on immature birds which, because they were not rearing young, likely left the island after tag attachment. Apparently "incomplete" tracking records at the colony may also have resulted in some breeding adults which abandoned the colony or departed on extended foraging trips. For example, one VHF tagged GBBG, identified by wing-tags, was observed on 25 June in the Gulf of Maine, 120 km south of Nova Scotia and 530 km away from Sable (Table 5.2-1), suggesting either colony abandonment, post-breeding dispersal, or very long-distance foraging trips. We received incomplete tracking data from 10/27 HERG, due to receiver failure at East Light and possibly because some individuals were tagged too far out of range of the receiver towers for complete tracking; we will further investigate the data to assess the number of detections in relation to distance of tagging site from the receiver towers.

From the remaining 34 tags (Table 5.2-2), mean departure dates from Sable Island were 20-July (± 15.5 d) for GBBG and 26-Jul (± 16.7 d) for HERG, with two individuals of each species still remaining on the island after 22-August (therefore not included in the calculation of these means). Figure 5.2-1 shows an example of colony attendance patterns for three individual HERG on Sable Island. The upper panel (tag ID 196) shows near continuous detections at the colony for the entire receiver activation period, with day-long absences from the colony scattered throughout. The middle panel (tag ID 200) shows similar patterns but earlier departure from the colony on 29 Jul. The lower panel (tag ID 202) shows only a few days of initial colony attendance, departure on 24 Jun, and a brief, one day, return to the colony on 20 Jul. We ultimately aim to quantify these periods of absence from the colony (e.g. timing and duration of absence events) as indices of foraging activity away from the island to predict when gulls are most likely to interact with platforms. We will also assess patterns of platform attendance through detections at receivers on vessels.

*Table 5.2-2 Summary of Herring Gull (HERG) and Great Black-backed Gull (GBBG) departure dates from Sable Island inferred from VHF tags deployed on 53 gulls on Sable Island. This represents data analyzed from automated receiver stations at East Light and West Light on Sable Island from 20 June to 22 August 2012. *mean departure date excluded those birds still detected on 22 Aug when the receiver experienced malfunction and data recording was terminated.*

			Departure dates			
Species	**Tags deployed (n)**	**incomplete data (n)**	**mean***	**SD (days)**	**earliest**	**number of gulls departing after 22-Aug-2012**
GBBG	26	9	20-Jul	15.5	25-Jun	2
HERG	27	10	26-Jul	16.7	2-Jul	2

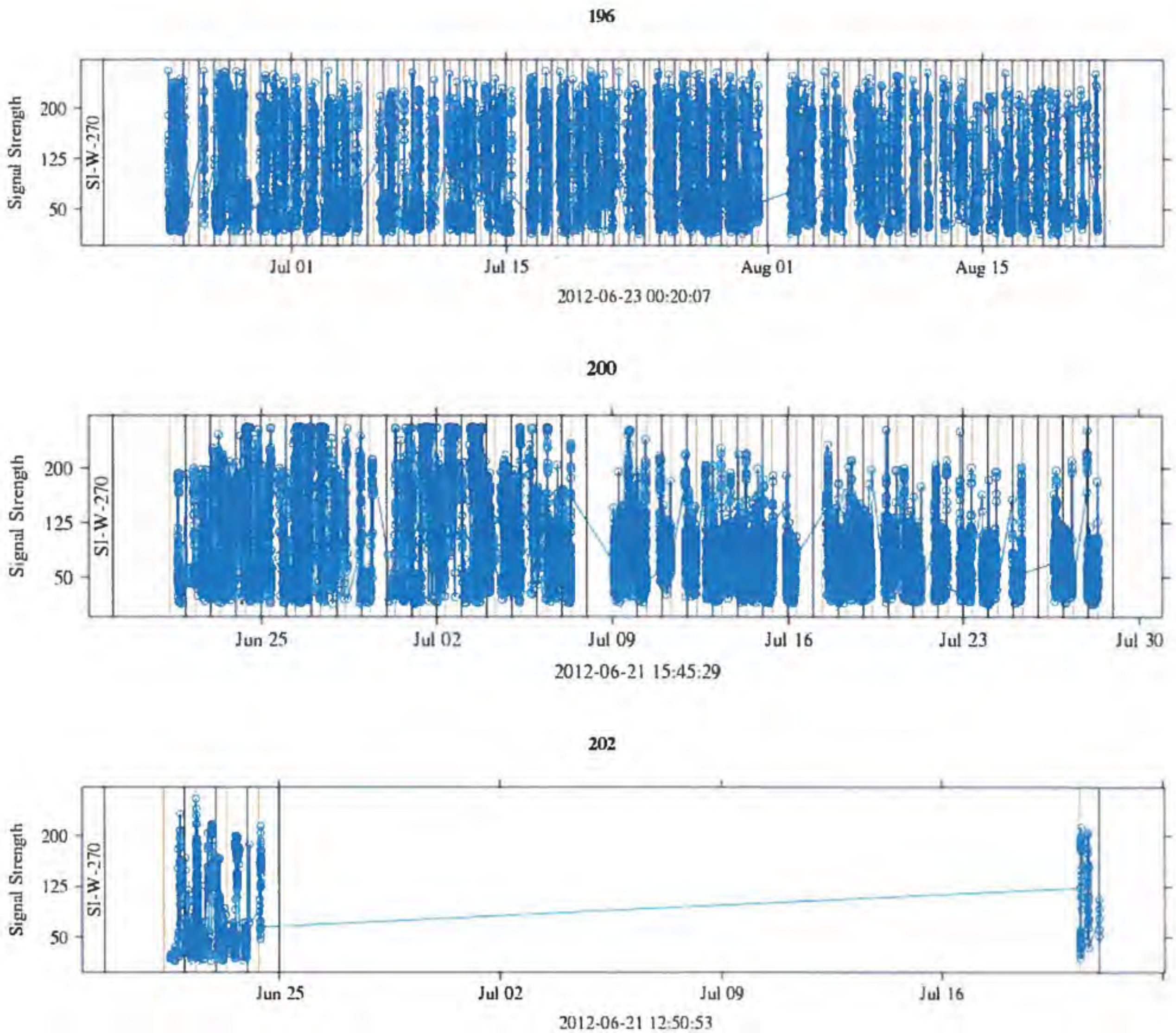

Figure 5.2-1 Example plots showing patterns of colony attendance by three Herring Gulls tagged on Sable Island. Individual gulls are identified by their tag ID number at the top of each plot. Each circle represents a VHF tag detection and blue lines connect detections in sequence. Gaps in detection periods indicated gull absence from the Sable Island colony. Date is presented along the x-axis (note change in scale among panels) and signal strength, on the y-axis, represents the relative strength of VHF tag detection on a scale of 1-255. Date and time stamp at the bottom of each graph represents the time of first VHF detection in each plot. In this figure, data are presented for a single antenna (SI-W-270) from Sable Island (SI) West Light (W) oriented west (270). Vertical lines represent time of local sunrise (yellow) and sunset (black) during periods of VHF detections. See text above for interpretation of these plots for individual birds.

Satellite tracking – Satellite tags deployed on 6 Herring Gulls resulted in a total of 516 bird-tracking days and 5,343 GPS locations in the Sable Island area, prior to migration departure (Table 5.2-3). Preliminary data analysis was conducted on unfiltered data of GPS positions which have a typical accuracy of < 15 m (as specified by the tag manufacturer). There was a high degree of individual variability in movement behaviour demonstrating that some individuals forage almost exclusively on Sable Island, while others make long foraging trips at sea to areas north of Sable where no platform activity exists (Fig. 5.2-2). This confirms the high variability in behaviour among individual gulls which has been observed in VHF activity patterns recorded by receiver stations at the colony (analysis not yet complete).

*Table 5.2-3 – Summary of tracking data and GPS locations obtained from 6 satellite tags deployed on Herring Gulls on Sable Island. Tags were deployed on 26-28 May, 2012. * Departure date not given for bird 115927 because tag fell off bird 22 June 2012.*

				Locations within 200m of platform							
Tag ID	Departure from Sable*	Days tracked in Sable area	# GPS locations	Deep Panuke	Thebaud	North Triumph	Alma	Venture	South Venture	All platforms	% of total GPS locations
115925	23-Aug-12	89	1259	0	0	0	0	0	0	0	0.0
115926	19-Oct-12	145	1171	74	42	1	22	0	0	139	11.9
115927	n/a	26	266	0	0	0	0	0	0	0	0.0
115928	9-Aug-12	74	1017	0	0	0	0	0	0	0	0.0
115929	26-Jun-12	29	414	0	0	0	0	0	0	0	0.0
115930	28-Oct-12	153	1216	5	66	0	1	0	0	72	5.9
TOTAL		516	5343	79	108	1	23	0	0	211	3.9

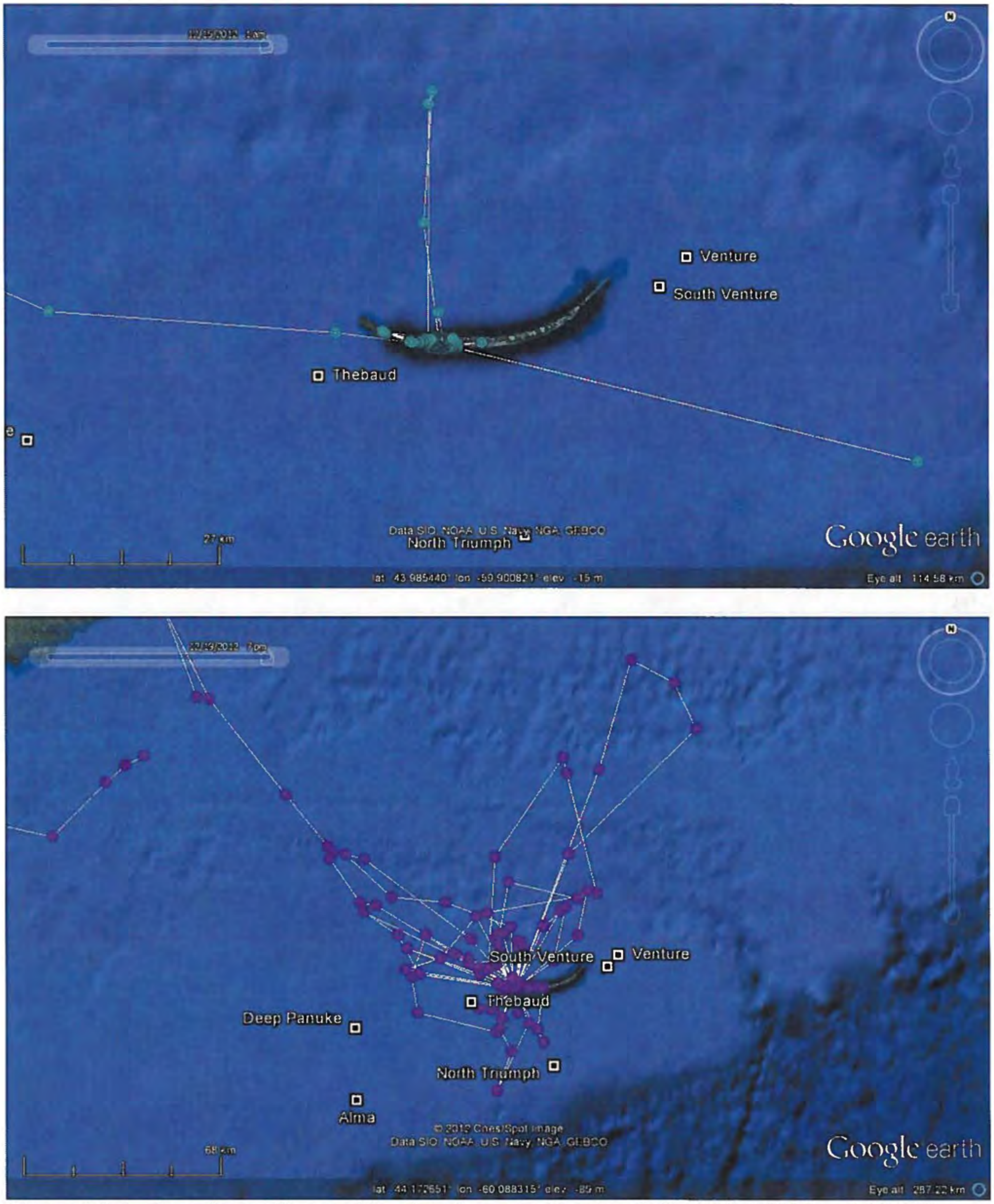

Figure 5.2-2 – Sample satellite tracking data from two Herring Gulls (ID# 115925 and 115928, upper and lower panels respectively) which show contrasting foraging strategies between individuals that remain on Sable Island (upper) and individuals making long-distance, offshore foraging trips offshore (lower).

Two of six birds interacted with the platforms each having 12% and 6 % of their GPS locations occurring within 200 m of any platform during 298 days of tracking (Table 5.2-3, Figure 5.2-3). Interactions with platforms were categorized into bird-platform interaction events, defined as a series of consecutive GPS positions occurring with 200 m of a platform, and event duration was calculated from the time between first and last detections in a series. Interaction events are summarized in Table 5.2-4. Fifty two events were recorded at four of six platforms: Thebaud (73% of events), Deep Panuke (19%), Alma (6%), and North Triumph (2 %, representing a single event). Thirty-seven percent of the events (19/52) included only a single detection within 200 m of a platform suggesting short interactions (likely < 1 or 2 hrs) or birds passing by. The overall mean event duration was 5.2 h (including events of single locations recorded as 0 hrs): 33% of events were between 1-5 h, 17% between 6-10 h, and 13% were > 10 h. The longest sustained interaction was a 40 h event recorded at the Deep Panuke platform beginning on 28-July. Most interactions occurred from mid July and late August with only two events in September/October (Figure 5.2-4).

Table 5.2-4 – Summary 52 gull-platform interaction events recorded by satellite tags from 2 Herring Gulls. An event was defined as a series of consecutive GPS locations occurring within 200 m of a platform. Duration of event was calculated from the first and last time stamp in a series of consecutive detections. When only one detection occurred, the duration was recorded as zero hours.

			Duration of event (h)		Date of event		
Platform	**# of events**	**# events with 1 detection**	**Mean**	**Max**	**First**	**Last**	**Mean**
Alma	3	1	10.7	16	9-Jul	11-Aug	29-Jul
Deep Panuke	10	4	11.7	40	19-Jul	9-Aug	29-Jul
Thebaud	38	13	3.2	11	4-Jul	7-Oct	10-Aug
North Triumph	1	1	n/a	0	7-Aug	7-Aug	7-Aug
TOTAL	**52**	19	5.2		4-Jul	7-Oct	7-Aug

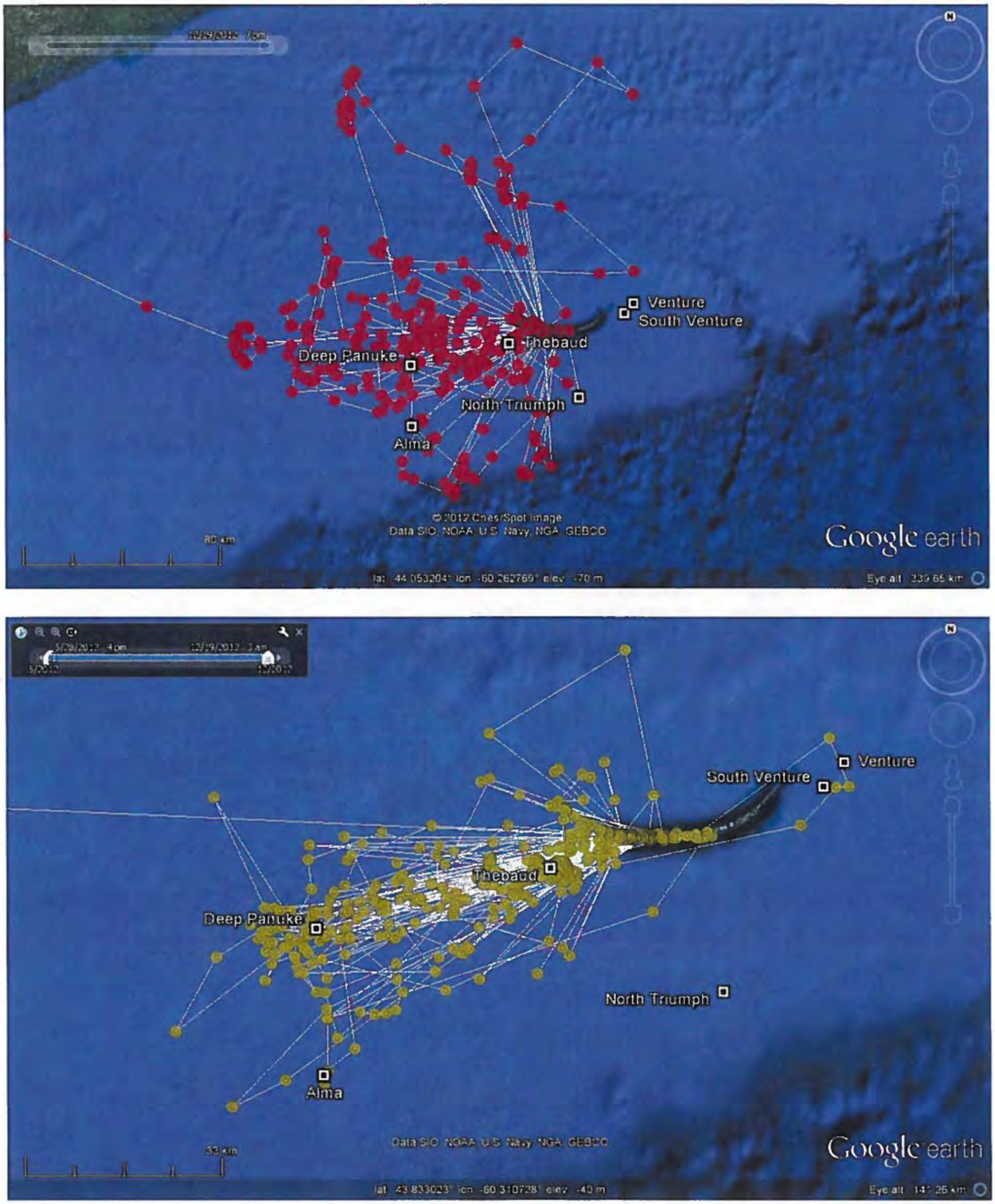

Figure 5.2-3 – Tracking data from Herring Gull ID# 115926 (upper panel) and 115930 (lower panel) that showed frequent interactions with offshore platforms around Sable Island.

Figure 5.2-4 – Timing and duration of gull-platform interaction events recorded by satellite tags deployed on Herring Gulls in 2012. Bird ID refers to satellite tag number (see Table 5.2-3 above). An event was defined as a series of consecutive GPS locations occurring within 200 m of a platform. Duration of event was calculated from the first and last time stamp in a series of consecutive detections. "X" indicates start time of events and the red line indicates the duration of the even. An "X" that is not followed by a red line represents a single detection within 200 m of a platform, therefore event < 2h.

From satellite telemetry data we can also determine true departure dates from the Sable Island area which can help inform the interpretation of VHF data (i.e. when we would expect the cessation of VHF tag detections on the island) and seasonal periods when Sable Island gulls will no longer interact with offshore platforms. From five satellite tracked individuals (Table 5.2-3, above), departure dates were highly variable including late June (1 individual), August (2), and late October (2). Departures were followed by direct migration to mainland Nova Scotia and eventual migrations to southern Nova Scotia and New Jersey (Figure 5.2-5).

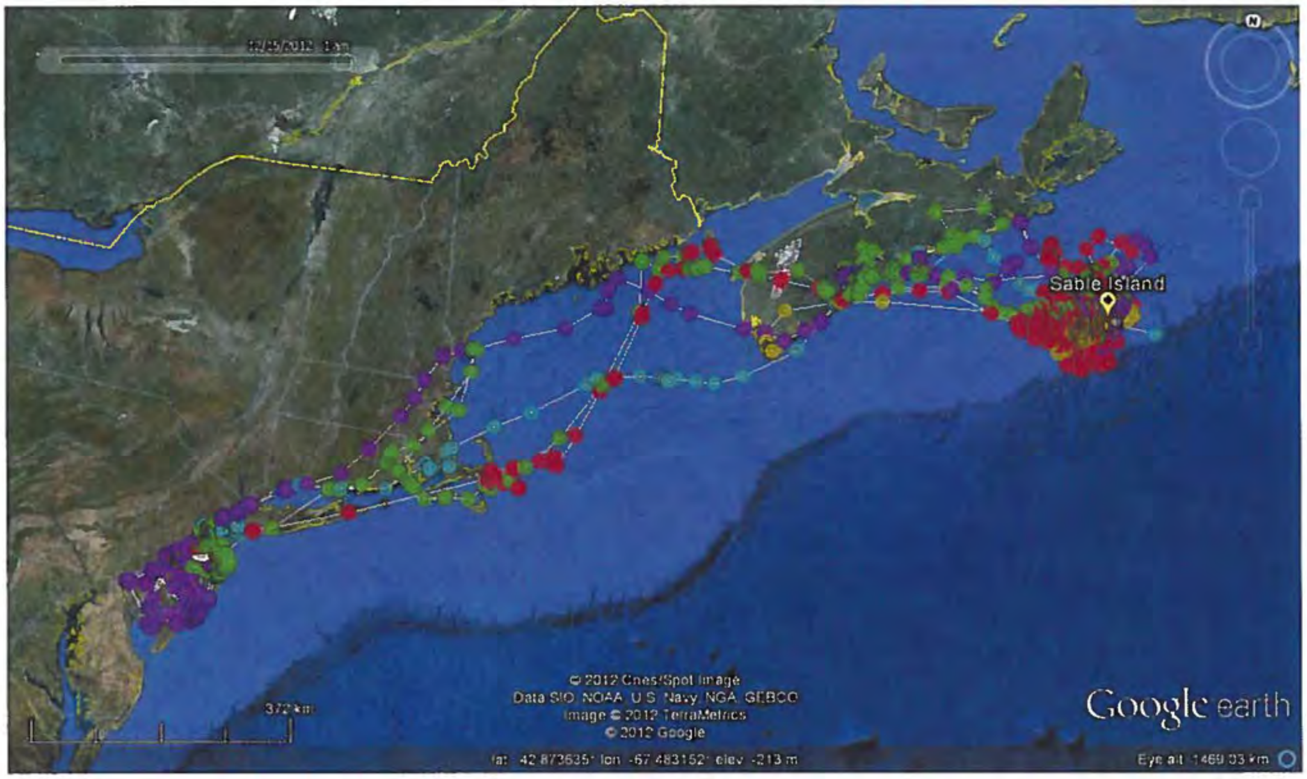

Figure 5.2-5 – Satellite tracking data from five Herring Gulls tagged on Sable Island (26-28 May 2012) until 20 December 2012. Migration routes are shown between Sable Island and New Jersey (4 birds) and southern Nova Scotia (1 bird in yellow).

5.2.2 Common and Arctic Terns

Of the 35 transmitters deployed on Common and Arctic Terns on Sable Island in June 2012, 33 were recorded on multiple occasions by one or more of the active receivers on the island. Receiver failure at the East Light colony (~ 2 weeks after tag deployments) resulted in limited tracking data and no information on departure dates from this colony. The absence of detections for the remaining 2 tags is likely the result of abandonment or the tag falling off. Preliminary assessment of tern detections/movement is summarized in Table 5.2-5. Terns from the Main Station colony were tracked continuously throughout the chick rearing and post-breeding period documenting departure dates in by the end of August; most terns had departed the island by early-mid August.

*Table 5.2-5 - Summary of Common and Arctic Tern detections on Sable Island (first two columns) and on the mainland. *represent detections at the receiver station closest to their respective colonies.*

Colony	# of tags detected on Sable Island*	# of tags detected at opposite colony	approximate time of departure from Sable
Main Station	18	3	Early August
East Light	15	7	Unknown

Preliminary analysis of tern activity patterns was completed for 3 individuals to examine patterns of colony attendance/absence (as per gull activities in Figure 5.2-1). The results suggest an equal distribution of colony attendance and foraging effort between nesting pairs of both Common and Arctic Terns. At the Main Station colony, attendance for both species tended to fluctuate between 3-6 h present or absent at a time. Future analysis of colony attendance patterns will focus on comparison of foraging bouts between species and colonies in order to assess foraging time and potential interaction time with platforms. Moreover, data on directional movements (from directional antennas at the receiver stations) will assess departure and return directions of foraging trips in order to identify important foraging areas around Sable Island. Detections from offshore supply vessels will confirm at-sea foraging locations and overlap between tern activities and platform locations.

Stable isotope analysis of tern blood samples suggested dietary differences between the two species (Figure 5.3-4). General linear models were used to test for differences in stable isotope values between species and colonies. There were no differences between colonies ($\delta^{15}N$, $p = 0.50$; $\delta^{13}C$ $p = 0.78$) but significant differences between species in both $\delta^{15}N$ ($p = 0.002$) and $\delta^{13}C$ ($p < 0.001$) values. A colony by species interaction term was not significant for either isotope ($\delta^{15}N$, $p = 0.46$; $\delta^{13}C$ $p = 0.56$). Common Terns foraged at a slightly higher trophic level (mean $\delta^{15}N = 13.0 \pm 0.3$ SD, n = 22) than Arctic Terns (12.6 ± 0.4, n = 15). Arctic Terns had lower $\delta^{13}C$ (-19.7 ± 0.2) than Common Terns (-19.3 ± 0.2). Sand lance (*Ammodytes sp.*) are thought to be the primary prey of terns on Sable Island and $\delta^{13}C$ from whole fish captured around Sable Island (-19.8 ± 0.5) aligned more closely with Arctic Terns than Common Terns, suggesting that Common Terns may be feeding on other prey items not yet identified. Together these results suggest that the two tern species are feeding on different prey which may be a result of segregation in foraging habitats which has consequences for the interpretation of VHF data and the identification of foraging areas for these species around Sable.

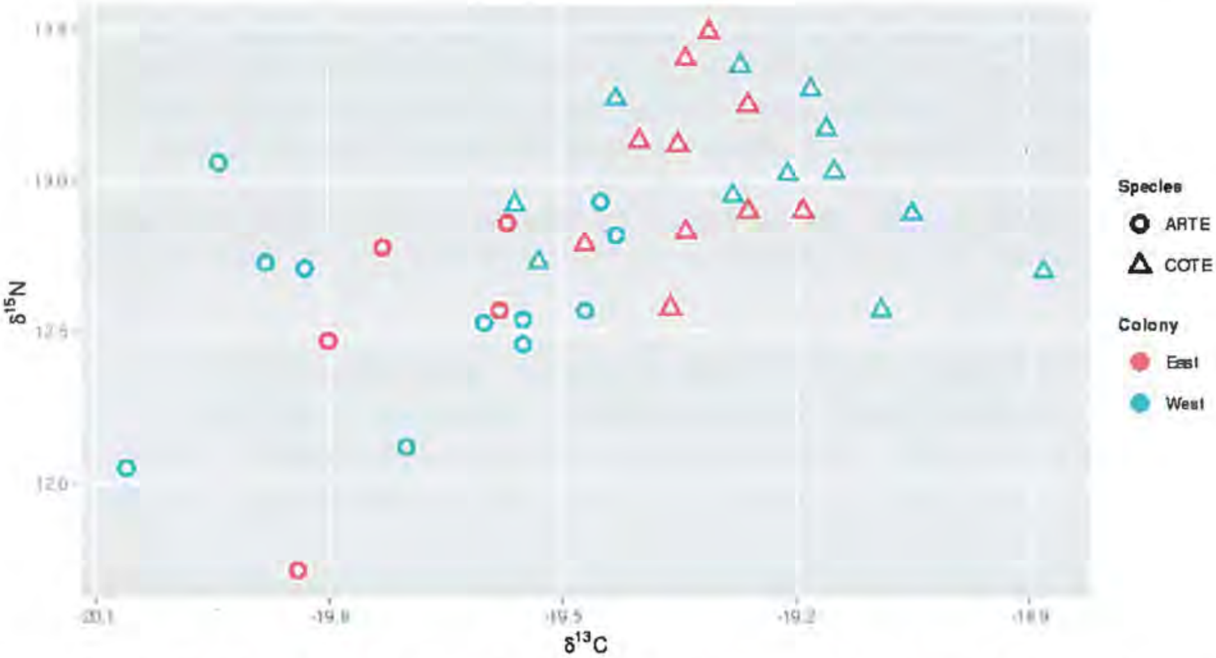

Figure 5.2-6 – Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope values from blood samples of Common Terns (COTE) and Arctic Terns (ARTE) collected from two colonies on Sable Island: East Light (East) and Main Station (West) colonies. $\delta^{15}N$ values represent relative trophic level and $\delta^{13}C$ are related to dietary source.

5.2.3 Leach's Storm-petrel

VHF tracking **-** In 2012 VHF tags were deployed on Leach's Storm petrels on Bon Portage Island (n = 20) and Country Island (n = 15) to monitor activity patterns and record the duration of foraging trips away from the colony. Average retention time for VHF tags, measured from the time of deployment to the date of last detection at the colony, was 16.8 ± 6.7 days in 2011 and 23.8 ± 11.3 days in 2012. We monitored egg hatching and chick fledging success for tagged birds and control burrows to investigate potential effects of tags on activity patterns of birds. Fledging success rate on Bon Portage Island was 63.6 % for burrows with VHF tags compared to 37.1 % for control burrows, suggesting a reverse tagging effect, or possibly a non-random allocation of controls. In contrast, fledging success on Country Island was 6.7% for burrows with VHF tags and 15.8% for control burrows. On Country Island, both hatching and fledging success rates were extremely low due to vole predation on eggs and chicks; it was therefore difficult to independently assess tag effects.

Data on foraging trip and colony visit duration have been analyzed for Bon Portage Island in 2011 and 2012, and Country Island in 2011 and comparisons were made using analysis of variance tests (ANOVA). Duration of colony visits differed significantly among years ($F = 6.1$, $p = 0.02$), colonies

(F = 10.28, p = 0.002), and breeding stages (F = 58.7, p < 0.001; Table 5.2-6) with longer visits during incubation periods (~1.5 to 3.5 d) than during chick rearing (~1.5 d for Country Island and 3 to 8 h for Bon Portage Island). In contrast, foraging trip durations did not differ significantly among years of colonies for either the incubation period (typically 3.5 to 5 days; F = 1.9, p = 0.53) or the chick rearing period (2 to 3 days; F = 0.75, p = 0.53). In general most foraging trips lasted 3 or 4 d but some were as long as 7 d, suggesting the potential for long-range foraging trips that could bring these birds in proximity to the Sable Island natural gas production area.

Table 5.2-6 - Mean duration of colony visits and foraging trips (h ± sd) during incubation and chick–rearing on Bon Portage (BP) and Country Island (CI; 2011 only). Within columns, means with the same letters indicate durations are that not significantly difference from each other.

	Colony visit duration (h)		Foraging trip duration (h)	
Year	Incubation	Chick-rearing	Incubation	Chick rearing
BP 2011	34.7 ± 30.4 A	2.6 ± 3.4 A	88.1 ± 58.0 A	70.3 ± 31.1 A
CI 2011	74.7 ± 7.1 B	38.1± 17.1 B	86.8 ± 13.3 A	50.8 ± 4.7 A
BP 2012	87.3 ± 43.8 B	8.8 ± 9.1 A	122.1 ± 48.6 A	74.4 ± 5.1 A

Information on the foraging trip arrival and departure directions of Leach's storm-petrels also increases our understanding of the movement patterns and potential overlap with offshore platforms areas in Nova Scotia (Figure 5.2-6). From Bon Portage Island, mean departure directions were southerly and return directions were more variably but typically from the SE, S and SW. This suggests that few birds are departing or returning from platform production areas around Sable Island, to the northeast of Bon Portage. From Country Island, mean departure directions were SE but return directions were from the E and NE. This suggests that departing birds may overlap with the platform areas when leaving from Country Island but are returning to the colony from areas further to the north.

Figure 5.2-6 – Departure (left panel) and arrival (right panel) directions of Leach's Storm-petrels from colonies at Bon Portage Island (2012) and Country Island (2011). Movements were inferred from VHF telemetry and an array of directional antennas at each site. On Bon Portage, the array included 4 antennas oriented at 140°, 200°, 230°, and 300°. On Country Island in 2011, the antenna array included only 2 antennas oriented at 80° and 170°, limiting directional inference at this site.

GLS result - GLS tags were recovered from 5 Storm-petrels from each colony representing a 26% recovery rate (5/21 from Country Island and 5/17 from Bon Portage Island). The average duration of tracking for those tags that were recovered was 16.6 ± 6.1 days from Country Island and 9.4 ± 4.4 days from Bon Portage Island. For some individuals, multiple foraging trips were recorded during deployments; in total 8 and 9 foraging trips were recorded for birds from Bon Portage and Country Island, respectively. Foraging trips for Country Island cover periods from mid incubation to very early chick rearing, whereas trips from Bon Portage Island span late incubation to mid chick rearing. Fledging success rate for burrows with GLS tags was 38.8 % compared to 37.1 % for control burrows. Based on calibration from known locations, estimated accuracy for GLS was 170 ± 88 km which translates, at this location, to a latitudinal span of 1.06 ± 1.16° and a longitudinal span of 0.86 ± 0.47°. These analyses of bird movements and distribution maps are preliminary.

The data revealed that the foraging areas for Leach's Storm-petrels from the two colonies are largely separate. Distances traveled and maximum distances from the colonies were greater for Country Island than Bon Portage colonies (Table 5.2-7). Foraging locations from individuals nesting on Country Island likely overlap with the platform areas around Sable Island (Figure 5.2-7). These results, however, should be treated with caution since they represent such as small sample of the total number of individuals from each colony, and represents data only from one time of the year.

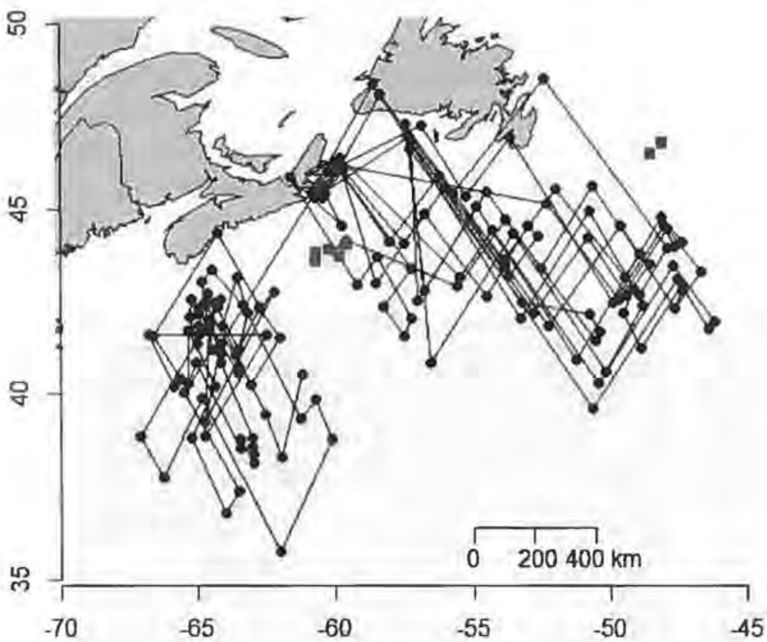

Figure 5.2-7 – Foraging ranges of Leach's storm-petrels obtained from geolocation tags deployed at Bon Portage Island (n = 5 birds) and Country Island (n = 5). Twice-daily locations are plotted Offshore oil and gas platforms in Nova Scotia and Newfoundland are indicated by red squares Locations recorded by these tags generally have an accuracy of ± 180 km. Note: this map presents preliminary data that require more validation to assess location accuracy.

Table 5.2-7 - Average distance traveled per trip and maximum distance from both Bon Portage and Country Islands colonies. n = number of trips recorded from 10 birds tracked by GLS (n = 5 birds from each colony).

	Bon Portage Island (n=8)	Country Island (n=9)	t	p
Distance traveled per trip	1125 ± 390	2653 ± 699	5.6	< 0.001
Maximum distance from colony	684 ± 209	1087 ± 220	2.9	0.018

5.2.4 Ipswich Sparrow

In early summer we captured and banded 164 sparrows (64 males, 38 females, 2 unknown sex adults, and 60 chicks) on Sable Island. Very few of these individuals (1 male, 1 female, and 12 chicks) were recaptured in August for VHF tagging. Nonetheless, these few recaptures provided confirmation that we could easily and reliably identify the sex of adults and the age of birds captured in late August. At present we have obtained VHF receiver data from Sable Island from 22 August to 14 October and from mainland sites from mid September until mid November. These data form the basis of preliminary analysis presented here until all data are retrieved from all sites.

Movements on Sable Island – All sparrows were tagged within 2 km of the West Light receiver and all individuals were subsequently detected on this receiver. No sparrows were detected at the East Light receiver, 20 km away. This suggests limited movement within the island. Many birds were only detected during the day on the island, indicating that once under cover of vegetation during the night they are out of range of the receivers.

Departure timing – One of the goals of this study was to assess the timing of migration departure from Sable in order to assess the time of year when birds may interact with offshore platforms. Receiver malfunctions on Sable, due to power supply failure between 28 August and 28 September, has limited our ability to accurately assess timing of migration departures. Nevertheless the following data provide evidence of migration departure timing. First, 18 Birds were initially present on Sable Island before equipment malfunction (28 August), and were not detected again on Sable Island after receiver was reactivated (28 September). Second, 13 birds were present (8 adults, 5 juveniles) on Sable Island on the last date the data was acquired (15 October). Therefore, from 44 tagged birds, 41% departed between 28 August and 28 September, 30% departed between 28 September and 15 October, and the remainder were still on the island after 15 October.

Detections on the mainland – Twenty three Ipswich Sparrows were detected at receiver stations along the mainland coast of Nova Scotia (Table 5.2-8). The majority of detections occurred at night and all appear to be birds flying past in active migration. For example, in the plot of an adult male detected at Taylor's Head Provincial Park on October 31st (Figure 5.2-8) shows consecutive detections over a five minute period of an approaching bird (increasing signal strength) which passes by the antenna shortly after 00:21 h (peak in signal strength) and then continues past the receiver (decreasing signal strength). Ten of the 18 birds that departed during the receiver malfunction period 28 Aug to 29 Sep, were subsequently detected on the mainland. The group of 8 birds that were not detected may have arrived on the mainland prior to receiver deployments in mid September, arrived at other locations on the mainland where they remained undetected, or were not successful at completing their transoceanic migration. 11 individuals were detected multiple times along the coast. For example, an adult female was detected flying past Kejimkujik Seaside and Bon Portage Island on the night of November 3rd (Figure 5.2-9). Assuming non-stop flight between same-night detections, sparrows appear to be traveling at approximately 11.5 m/s, or 41.4 km/h (average from two adults, one male and one female).

Table 5.2-8 - Location of initial detection of VHF tagged Ipswich Sparrows on mainland Nova Scotia.

	Country Island	Taylor's Head Provincial Park	Martinique Beach	Conrad's Beach	Cherry Hill	Kejimkujik Seaside Adjunct	Bon Portage Island	Total
Hatch Year	3	5	2			2	3	**15**
Adult Female	1	2	1					**4**
Adult Male		3						**3**
Unknown Adult							1	**1**
Total	**4**	**10**	**3**	**0**	**0**	**2**	**4**	**23**

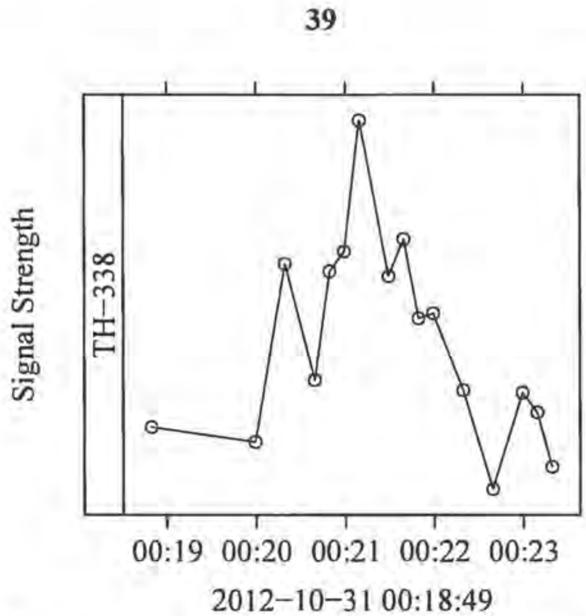

Figure 5.2-8 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#39) passing by a receiver station located at Taylor's Head (TH) Provincial Park (antenna orientation of 338°). Signal strength is a measure of the relative strength of the VHF signal detected and higher strength indicates closer proximity to the receiver station/antenna. Open circles represent individual tag detections and consecutive detections are joined by lines.

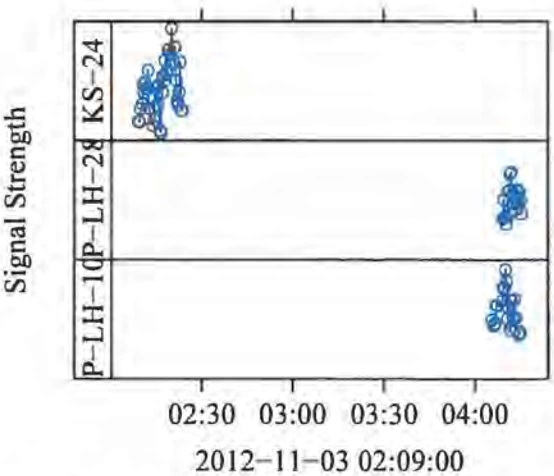

Figure 5.2-9 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#143) detected at multiple receiver stations in a single night. The sparrow was first detected at Kejimkujik National Park Seaside Adjunct at 02:09 h (upper panel) and ~2 h later detected by two antennas receivers on Bon Portage Island at 04:15 h (middle and lower panels). These sites are situated approximately 84 km apart, which translates into a ground speed of approximately 40 km/h (11 m/s). Symbols as per Figure 5.2-8.

Of the 23 birds detected on the mainland, the majority (61%) were first detected at Taylor's Head Provincial Park or Country Island (Table 5.2-8). This was true of both sexes and age classes: 8/15 hatch year, 3/4 adult females and 3/3 adult males were first detected at Taylor's Head or Country Island on the mainland. It appears that hatch year birds arrived on the mainland earlier than after hatch year birds. Apart from 1 hatch year sparrow that was first detected on the mainland on November 23rd, hatch years (14) first appeared on the mainland between September 20th – October 30th, whereas adult birds (4 female, 3 male, and 1 unknown) appeared between October 17th and November 13th (apart from one which was detected September 15th). At this point there are too few adult detections to compare differences among timing of arrival between sexes.

5.2.5 Blackpoll Warbler

We recorded departure flights from 61% ($n = 35$) of 57 Blackpoll Warblers tagged across two sites (4 at Point Michaud and 53 on Bon Portage Island). 37% (21/57) of these were re-detected at one or more coastal towers after having departed from their initial capture site. This data provide information on the timing and orientation of migratory and pre-migratory movements from two locations in Nova Scotia, one north and one southwest of the offshore platforms. At the time of reporting no warblers were detected from towers on Sable Island (data available until 14 Oct) and detections from offshore vessels have not been fully investigated.

Point Michaud - The one departure flight we recorded at this site was oriented S-SW, suggesting that this individual was migrating along the coast and not initiating a trans-oceanic flight directly from Cape Breton. Of the three remaining individuals tagged at this site, one was detected at both

Country Island and Taylor Head, another was detected at Taylor Head only, and the third was detected moving east from Point Michaud.

Bon Portage Island - Five tags deployed on Bon Portage were subsequently dropped from birds and recovered prior to detection of migration movements. Two of the transmitters recovered were from individuals that appeared to have been killed by raptors, but causes for the other three transmitters being dropped were less clear (i.e. no direct evidence of predation). Of the 34 departure flights obtained from this site, 82% ($n = 28$) were oriented between NW and E, towards the coast of Nova Scotia, and 18% ($n = 6$) were oriented between SE and SW. Half of the southerly flights were oriented between S and SE, suggesting that these individuals were initiating long-distance, trans-oceanic flights, and the other half were oriented between SSW and SW, suggesting that these individuals may have been crossing the Gulf of Maine and moving further south along the eastern seaboard. None of these six individuals were re-detected elsewhere along the coast of Nova Scotia.

Nineteen individuals were re-detected at one or more coastal towers after having departed Bon Portage Island (Figure 5.2-10), including 7 individuals at Kejimkujik Seaside, 3 at Cherry Hill and 1 at Taylor's Head. This suggests considerable landscape-scale movements of warblers within Nova Scotia prior to autumn migration. ,

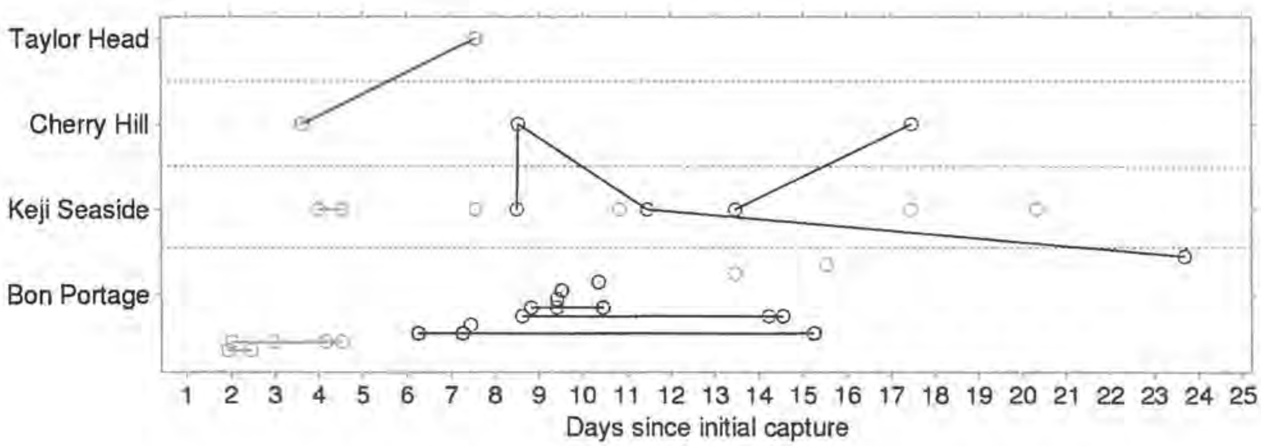

Figure 5.2-10 - Summary of coastal detections for Blackpoll Warblers tagged on Bon Portage Island (n = *19). Individuals detected flying by Bon Portage Island one or more days after their initial departure from the island are included. Each point represents a detection event and solid lines connect detections of the same individual.*

6. Discussion and Recommendations

The following provides discussion of the results presented above and recommendations for data field studies in 2013.

6.1 Evidence of bird-platform interactions

Field studies using telemetry and other tags were conducted from Sable Island, Country Island, Bon Portage Island and various mainland sites. Data obtained through this approach will directly address objectives 1 and 2 (Section 3 above) to 1) quantify the species-specific temporal and spatial patterns of attraction or repulsion of birds around offshore platforms; and 2) identify the environmental and anthropogenic factors that influence the spatial and temporal variation in bird distribution, abundance and movements at offshore platforms. Preliminary results presented in this report (Section 5.0) provide direct and indirect evidence of observed and potential bird-platform interactions occurring around Sable Island, NS. This evidence is discussed here.

In this study, direct evidence of bird-platform interactions is derived from bird tracking which reveals the proportion of time that birds spend in proximity to platforms and supply vessels. VHF receivers on supply vessels are the primary source of data to quantify bird-platform interactions for all study species, however, these data are still being processed and will be presented later. Other types of tag deployments (wing-tags, satellite telemetry and geolocation sensors) provide complimentary information on bird-platform interactions from a smaller subset of animals.

Gulls tagged on Sable Island showed numerous interactions with platforms, but with considerable variance among individuals. Wing-tagged gulls of both species were most frequently sighted from supply ships and platforms between mid July to mid August (3 HERG and 5 GBBG) with one additional GBBG sighting in September. The timing of these interactions are in general agreement if patterns observed in 2011 (Ronconi and Taylor 2012) and suggest that platform interactions are mainly restricted to post-breeding periods after chick rearing is complete (approximately mid July for this population; Lock 1973), with lingering effects into the autumn. Even though more wing-tags were deployed in 2012 (n = 13 HERG and n = 25 GBBG), lower resighting rates this year (9 in total and 3 confirmed individuals), compared to the same time of year in 2011 (21 HERG wing-tags deployed, 18 resightings, and 5 confirmed individuals) suggests a lower frequency and/or proportion of Sable Island gulls were attending offshore platforms in 2012. It is difficult, however, to compare resighting rates between years without accurate data on observation effort. In both years, platforms and supply vessels were notified of the research program and requested to report all observations of tagged birds, however, the "novelty" of reporting tagged birds may have diminished in year two resulting in fewer reports.

Satellite tag deployments on 6 HERG were in general agreement with patterns observed from wing-tag resightings. These tags revealed that only some individuals attend platforms (2 out of 6 tagged birds) with most interactions occurring in Jul/Aug and less frequent interactions through Sep and Oct. From the time of tag deployments to their departures from the Sable area in late October, these individuals spent 6 and 12% of their time within 200 m of offshore platforms. These time budgets include time on Sable Island when gulls could be incubating eggs, feeding young, and/or roosting, therefore these percentages under represent the total proportion of at-sea foraging that was associated with platforms.

Satellite tracked Herring Gulls also provide additional detailed information on the characteristics of bird-platform interactions. First, based on the time-stamps from obtained GPS locations, we observed that most gull-platform interactions were brief (37% of 52 platform interaction events included only a single location within 200 m of a platform), but some events are long (13% > 10 h) and the longest series of detections near a platform was 40 h. A next step will be to investigate the time of day and environmental conditions surrounding these platform events to better understand the factors that correlate with gull-platform interactions.

Because GPS tags track birds anywhere regardless of observer effort or receiver deployment locations, we will also be able to quantify the spatial-temporal patterns of gull interactions with all platforms in the area. Data reveal that most of the 52 interaction events occurred at the Thebaud platform (73%) which is closest to Sable Island, followed by Deep Panuke (19%). These are the only two manned platforms in the region, suggesting that human presence (both platforms) and proximity to the breeding colony (Thebaud) may influence gull-platform interactions. However, these patterns also differ between individual birds making general conclusions difficult (Table 5.2-3). One gull had 139 locations within 200 m of platforms, which included 53, 30, 21, and <1% near Deep Panuke, Thebaud, Alma and North Triumph, respectively. In contrast, the other gull had 72 locations within 200 m of platforms, which included 7, 92, and 1% near Deep Panuke, Thebaud, and Alma. Variation in the behaviour of individual birds must be taken into account when understanding and managing gull-platform interactions, however, this conclusion is based on a limited sample size of GPS-tracked birds (6 individuals) and more tracking in 2013 will reassess this variability among individuals.

Geolocation sensor (GLS) tags were the only other tags deployed which can track birds away from their colonies, independent of VHF receiver stations or observational effort. Tags recovered from a limited number of Leach's Storm-petrels at the two study colonies revealed that the foraging areas of Country Island petrels overlap with the platform area during their > 2000 km round trips. Bon Portage Island petrels also foraged on long-distance trips, capable of reaching the platforms around Sable, however, their trajectories were al southward and thus not overlapping with platform areas.

VHF receiver stations coupled with wing-tag resightings, provide data on seasonal and daily patterns of colony attendance and departure, which provide information on the timing and duration of bird foraging trips away from their respective colonies. As we are interested in the potential frequency, timing and duration of bird interactions with offshore platforms (Objectives 1 and 2), information on bird departures from their colonies provide information on periods during which birds are absent from the colony and may, potentially, interact with offshore platforms and vessels. Conversely, data on colony attendance indicated periods when birds will not show interactions with offshore platforms. This section discusses patterns of colony attendance and departure for gulls and terns from Sable Island and Leach's Storm-petrels from Bon Portage and Country Islands.

Together, wing-tag resightings, colony based-VHF monitoring, and satellite tracking reveal a wide range in timing of colony departure for both species of gulls. Satellite tags showed departures from the Sable area ranging from 26 Jun to 28 Oct. Likewise with Great Black-backed Gulls, the first report of wing-tagged gull away from the colony was on 25 June when it was seen from a US oceanographic vessel in the Gulf of Maine, 120 km south of Nova Scotia and 530 km south west of Sable, which suggests a long-distance dispersal away from Sable immediately after breeding. VHF monitoring at the colony shows that most gulls depart in the second half of July. Mainland sightings of wing tagged HERG and GBBG increased in Aug and early September, which is consistent with the VHF observations. By November wing-tagged GBBG were seen in Maine and wing-tagged HERG in Massachusetts. Together these resighting reports and tracking data, along with data from 2011 (Ronconi and Taylor 2012), suggest a) colony departures in mid July correspond with periods of platform attendance by gulls, b) both HERG and GBBG typically arrive on the mainland sometime in August/September, though with considerable variation among individuals, and c) HERG move further south for the winter than do GBBG. Moreover, winter-tagged GBBG were not observed on Sable Island or offshore areas around Sable Island in the spring, summer or fall, suggesting that the winter population of GBBG on Sable are not part of the breeding population and are likely only visitors to Sable in the winter during the grey seal pupping season.

Preliminary analysis of VHF monitoring of tern colony attendance patterns shows regular foraging trips of 3 to 6 h for both species. This suggests that birds may readily travel to offshore areas for foraging. However, on visits to the east and west spits of Sable island, we observed large numbers of terns foraging in the shallows, at distances that likely exceed the detection range for our receivers. In 2013 we will deploy receivers at each spit to monitor the use of these area, which will help determine what proportion of time that individuals may be foraging offshore, as opposed to more locally, in areas around the island.

Stable isotope analysis revealed dietary differences between the two tern species, suggesting that they may forage on different prey types and/or in different areas. Likewise, Rock et al. (2007a) demonstrated foraging habitat segregation between Common and Arctic Terns at a colony in coastal Nova Scotia, even though dietary partitioning was not strong. Subsequent analysis will investigate the differences in foraging patterns between species in order to assess vulnerability of each to offshore platform interactions. VHF tracking also revealed that most individuals had departed the colony by mid August, therefore we would not expect any platform interactions beyond this period.

Foraging trips by Storm-petrels from Bon Portage (BP) and Country Island (CI) lasted 3-5 days and GLS tracking suggests that they may be traveling as far as 1000 km offshore during these trips. Bon Portage Island and Country Island are ~ 480 and 170 km away from the Sable region, therefore both colonies have the potential to interact with platforms. Although it has poor resolution, GLS tracking shows a separation in foraging locations between the two colonies with only Country Island individuals overlapping with platform areas. Directional departure and return data from the VHF tracking also support the conclusion that Bon Portage petrels typically forage south of Nova Scotia while Country Island petrels depart east and north east on foraging trips that likely include the Sable area. GLS tracks are from only a few birds during a small number of trips, therefore additional tracking in 2013 will provide more insight into the foraging ranges and proportion of overlap with platform areas.

Tracking Ipswich Sparrows from their nesting grounds was conducted to quantify the timing and direction of migratory movements, in order to assess their relative risk to platform interactions. Ipswich Sparrows tagged in August undertook migratory departures from Sable Island between

September and November; juveniles departed earlier than adults. About half (61%) of sparrows detected on the mainland were first detected at the northerly stations (Taylor's Head and Country) which suggests a north-westerly migration path for these individuals. The Country Island region of the eastern shore is the closest point of land to Sable, suggesting that birds may be minimizing over-water flight distances and durations by selecting a direct route to coastal Nova Scotia. Conversely, Stobo and McLaren (1975) report high densities of autumn Ipswich in central portions of the eastern shore in areas between Conrad's Beach and Martinique Beach, where we also deployed receiver stations. The proximity of these places to the Halifax area may have biased perceptions on bird densities since more people are looking for birds in this region. If most Ipswich do follow a direct route from Sable Island to the northern regions of the eastern shore (e.g. Country Island and Taylor's Head), this would bring them away from the Deep Panuke Platform during migration and thus decrease the potential risk of interactions. We will explore this hypothesis more directly in 2013.

Blackpoll Warblers were tagged at two sites to assess difference migration orientation. The very small sample size at Point Michaud precludes us from making general statements about Blackpoll Warblers in that area and to properly quantify the risk of offshore platforms for individuals migrating through this region. However, three of four individuals showed evidence of south-westerly movements along the coast of Nova Scotia rather than long-distance over water departures and 50% ($n = 2$) of the individuals tagged at Point Michaud had high fat scores, which indicates that at least some individuals in eastern Nova Scotia are physiologically capable of extended migratory flight at more easterly locations.

At Bon Portage Island, three individuals initiated southerly-southeasterly flights over the Atlantic Ocean, but the majority of departures were directed towards the mainland coast of Nova Scotia. Of the 28 individuals departing north and east from Bon Portage, 19 were re-detected at coastal mainland sites which suggests considerable landscape-scale movements of this species within Nova Scotia prior to migration. Assuming those that departed over the ocean maintained their initial heading, it is unlikely that they would have encountered even the most westerly of the natural gas platforms currently operating in the vicinity of Sable Island. On the other hand, those individuals that left Bon Portage Island and moved eastward along the coast could encounter platforms, depending on how far east they moved and where they ultimately depart for their wintering grounds in South America.

6.2 Problems encountered and recommendations

During the course of the summer field season we encountered several problems with respect to equipment failures and bird capture and recapture. These are discussed throughout the text, and are re-iterated here along with recommendations as to how to proceed with fieldwork in 2013.

Throughout the field season receiver deployments suffered from failures due to issues with both software and hardware (see section 5.1 for details). Software problems have now been fixed. Most of the hardware issues were related to solar power supply systems. We are now researching new charge controller and battery options that will remedy problems. One important step forward will be the purchase of solar charge controllers with 'low voltage disconnect' switches which will allow receivers to shut down when battery power goes bellow a critical threshold so that the system can recharge safely without damage to batteries. Other considerations will be to add redundancy (e.g. 1-

2 additional units that are completely independent) to systems in remote locations where receivers are infrequently checked. Such a plan will minimize data loss when failures do occur.

With several study species we experienced difficulties in capturing target individuals at certain times of the year. In May, when we first arrived on Sable, Great Black-backed Gull eggs were hatching during the first 5 days which limited our ability to catch incubating adults (only one was captured on nest). Instead we used noose carpets around seal carcasses which resulted in captures of adequate numbers of adult and sub-adult birds. We will continue to use this technique in 2013 which means we do not need to arrive as early as the Great Black-backed Gull incubation period.

In August it was very difficult to recapture Ipswich sparrows that had been colour banded in the spring because adults were wary of the net and less attracted to playback calls. Banded juveniles were difficult to recapture due to post-fledging dispersal and the large numbers of fledglings encountered on the island. However, we were still able to sex the majority of adults, and were able to distinguish earlier broods from later broods based on moult patterns (see above). This means that pre-marking adults and chicks in the early spring is not necessary for the VHF tagging work being conducted in August. Despite our ability to determine sex of adults in August, locating and capturing male sparrows was difficult. There was a strong male bias during spring capture and banding, which may have resulted in males avoiding nets in August in the same locations. It is also possible that males dispersed once the last brood was fledged and so would not be as territorial (and therefore less likely to respond to playback systems or human intrusion on their territories). Conducting Ipswich Sparrow tagging in the first half of August, when birds are still breeding, may reduce the difficulties associated with captures of males.

In September we caught very few Blackpoll Warblers at Point Michaud, despite catching high numbers of other birds, including Yellow-rumped Warblers (*Setophaga coronota*), that are known to prepare for the initial stages of migration in similar regions and habitats as Blackpoll Warblers. A priority for next year will be to find new locations in eastern Nova Scotia and/or in Newfoundland where sufficient numbers of Blackpoll Warblers can be captured.

Other problems encountered include potential effects of tags on some of the study species. During the 2012 spring field season on Sable we observed a low return rate of wing-tagged gulls that were tagged in 2011; only 8 of 21 marked gulls were resighted throughout May and June and a 9th was reported on Cape Breton during this same period. This suggests that wing-tags may be affecting the over-winter survival of individuals or causing birds to skip breeding in subsequent years. Of those 8 individuals that did return in 2012, none were observed breeding. A recent review of wing-tags on a variety of bird species suggests that tags may affect the reproductive behaviour and success of some species (Trefry et al. in press). We therefore marked only half of the VHF tagged HERG with wing-tags in 2012 to test whether wing-tagging influences behavior (measured by VHF receiver stations) and to determine if it influences return rates in 2013. Despite these potential effects on breeding, wing-tags have provided valuable data on gull-platform interactions and timing of dispersal to the mainland.

With Leach's Storm-petrels, control burrows demonstrated little or no effects of tag deployments on hatching success or rearing of young. However, we did have difficulties recovering Geolocator (GLS) tags on both study islands. On Country Island we did not recover any GLS tags that had been attached using the modified leg-loop harness, therefore we have abandoned this attachment technique. Moreover, we suspect that the vole population present on Country Island was responsible for high rates of burrow depredation which resulted in abandonment by breeding adults and, consequentially, overall low rates of recapture for GLS recovery (5/21; 24%) and possibly early colony abandonment by VHF tagged birds. If vole predation continues to be a problem in 2013 we will improve our tag recovery rates by using < 2 week deployment periods. Abandonment of VHF tagged birds, due to vole predation, is not a problem for our study as VHF tagged birds will continue to fly around the Scotia Shelf where we can still test for platform interactions. Slightly higher GLS recovery rates on Bon Portage Island (5/17; 29%) can be improved with earlier deployments in 2013.

7. Deployment Bird-Radar and Other Sensors

The next step in all equipment installations on the Deep Panuke platform, including use of radar, low-light camera and acoustic sensor, is to provide a detailed Scope of Work document to SBM for approval and implementation. This document was completed in March 2012. However, due to unforeseen delays in hook up and commissioning activities of the PFC, at the request of Encana, the scope of work will be forwarded to SBM at a later date for implementation of the equipment installation in 2013.

8. Literature Cited

Baird, P.H., 1990. Concentrations of seabirds at oil-drilling rigs. Condor 92, 768-771.

Burke, C.M., Davoren, G.K., Montevecchi, W.A., Wiese, F.K., 2005. Seasonal and spatial trends of marine birds along support vessel transects and at oil platforms on the Grand Banks, In Offshore Oil and Gas Environmental Effects Monitoring: Approaches and Technologies. eds S.L. Armsworthy, P.J. Cranford, K. Lee, pp. 587-614.

CCWHC, 2009. Canadian Cooperative Wildlife Health Centre: annual report 2008-2009. Available on-line: http://www.ccwhc.ca/publications/2008_2009_CCWHC_Annual_Report_v7.pdf.

COSEWIC, 2009a. COSEWIC assessment and status report on the Savannah Sparrow *princeps* subspecies *Passerculus sandwichensis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC, 2009b. COSEWIC assessment and update status report on the Roseate Tern *Sterna dougallii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 48 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

EnvironmentCanada, 2006. Management plan for the Savannah Sparrow, princeps subspecies (Passerculus sandwichensis princeps), in Canada. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iv + 19 pp.

EnvironmentCanada, 2010. Amended recovery strategy for the Roseate Tern (*Sterna dougallii*) in Canada. *Species at Risk Act* Revocerty Strategy Series. Environment Canada. Ottawa. vii + 36pp.

Farnsworth, A., Russell, R.W., 2007. Monitoring flight calls of migrating birds from an oil platform in the northern Gulf of Mexico. Journal of Field Ornithology 78, 279-289.

Fraser, G.S., Russell, J., Von Zharen, W.M., 2006. Produced water from offshore oil and gas installations on the Grand Banks, Newfoundland: are the potential effects to seabirds sufficiently known? Marine Ornithology 34, 147-156.

Gauthreaux, S.A., Livingston, J.W., 2006. Monitoring bird migration with a fixed-beam radar and a thermal-imaging camera. Journal of Field Ornithology 77, 319-328.

Haramis, G.M, and Kearns, G.D, 2000. A radio transmitter attachment technique for soras. Journal of Field Ornithology 71, 135-139.

Hope Jones, P., 1980. The effect on birds of a North Sea gas flare. British Birds 73, 547-555.

Horn, A.G., Shepherd, P., 1998. Sable Island tern project: 1998 final report. Prepared for Sable Offshore Energy, Inc. 38pp.

Huettmann, F., Diamond, A.W., 2000. Seabird migration in the Canadian northwest Atlantic Ocean: moulting locations and movement patterns of immature birds. Canadian Journal of Zoology-Revue Canadienne De Zoologie 78, 624-647.

Hüppop, O., Dierschke, J., Exo, K.M., Fredrich, E., Hill, R., 2006. Bird migration studies and potential collision risk with offshore wind turbines. Ibis 148, 90-109.

Imber, M.J., 1975. Behaviour of petrels in relation to the moon and artificial lights. Notornis 22, 302-306.

Kerr, R., Kintisch, E., Stokstad, E., 2010. GULF OIL SPILL - Will Deepwater Horizon set a new standard for catastrophe? Science 328, 674-675.

Lincoln, F. 1947. Manual for bird banders US Fish and Wildl. Serv. Washington, DC, 116p.

Mallory, M.L., Gilbert, C.D., 2008. Leg-loop harness design for attaching external transmitters to seabirds. Marine Ornithology 36, 183–188.

McLaren, I.A., 1981. The birds of Sable Island, Nova Scotia. Proceedings of the Nova Scotia Institute of Science 31, 1-84.

Mitchell, G.W., Taylor, P.D., Warkentin, I.G., 2011. Movements of juvenile Blackpoll Warblers prior to autumn migration in Newfoundland reconsidered. Condor 113, 711-712.

Montevecchi, W.A., 2006. Influences of artificial light on marine birds, In Ecological consequences of artificial night lighting. eds C. Rich, T. Longcore, pp. 94-113. Island Press, Washington, D.C., USA.

Nisbet, I.C.T., McNair, D.B., Post, W., Williams, T.C., 1995. Transoceanic migration of the Blackpoll Warbler: summary of scientific evidence and response to criticisms by Murray. Journal of Field Ornithology 66, 612-622.

Ortego, B., 1978. Blue-faced boobies at an oil production platform. Auk 95, 762-763.

Oxley, J. R. 1999. Nesting distribution and abundance of Leach's Storm-petrel (*Oceanodroma leucorhoa*) on Bon Portage Island, Nova Scotia. – M.Sc Thesis, Acadia University

Pyle, P., 1997. Identification Guide to North American Birds: Part 1. Slate Creek Press, Bolinas, CA.

Rappole, J.H., Tipton, A.R., 1991. New harness design for attachment of radio transmitters to small passerines. Journal of Field Ornithology 62, 335-337.

Rock, J.C., Leonard, M.L., Boyne, A.W., 2007a. Do co-nesting Arctic and Common Terns partition foraging habitat and chick diets? Waterbirds 30, 579-587.

Rock, J.C., Leonard, M.L., Boyne, A.W., 2007b. Foraging habitat and chick diets of Roseate Tern, *Sterna dougallii*, breeding on Country Island, Nova Scotia. Avian Conservation and Ecology 2, 4.

Ronconi, R.A., Taylor, P.D. 2012. Assessment of bird-human interactions at offshore installations: Year 1 Report – August 2012. Report prepared by Acadia University, Wolfville, NS, for Encana Corporation, Halifax, NS.

Ross, H.A., 1980. Growth of nestling Ipswich Sparrows in relation to season, habitat, brood size, and parental age. Auk, 721-732.

Russell, R.W., 2005. Interactions between migrating birds and offshore oil and gas platforms in the northern Gulf of Mexico: Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.

Sage, B., 1979. Flare up over North Sea birds. New Scientist 81, 464-466.

Southern, L.K., Southern, W.E., 1985. Some effects of wing tags on breeding Ring-billed gulls. Auk 102, 38–42.

Stobo, W.T., McLaren, I.A., 1975. The Ipswich Sparrow. Proc. N.S. Inst. Sci. 27 (Suppl. 2), 105 pp.

Tasker, M.L., Jones, P.H., Blake, B.F., Dixon, T.J., Wallis, A.W., 1986. Seabird associations with oil production platforms in the North Sea. Ringing & Migration 7, 7-14.

Trefry, S.A., Diamond, A.W., Jesson, L.K., in press. Wing marker woes: a case study and meta-analysis of the impacts of wing and patagial tags. Journal of Ornithology, DOI 10.1007/s10336-10012-10862-y.

Wallis, A., 1981. North sea gas flares. British Birds 74, 536-537.

Whittam, R.M., Leonard, M.L., 1999. Predation and breeding success in roseate terns (*Sterna dougallii*). Canadian Journal of Zoology 77, 851-856.

Wiese, F.K., Montevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W., Linke, J., 2001. Seabirds at risk around offshore oil platforms in the North-west Atlantic. Marine Pollution Bulletin 42, 1285-1290.

APPENDIX C

Beached Seabird Survey on Sable Island

OFFSHORE ENVIRONMENTAL EFFECTS MONITORING PROGRAM
SABLE OFFSHORE ENERGY PROGRAM
2012 SUMMARY REPORT

COMPONENT: beached seabird surveys on Sable Island

REPORTING ORGANIZATION: Zoe Lucas, Sable Island

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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 on Sable Island during 1996-2005 are reported in [1], and results of beached bird surveys conducted on the island 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. 2012 Sampling:

Contractor: Zoe Lucas, Sable Island.

- Between January 1 and December 31, 2012, eleven surveys for beached seabirds were conducted on Sable Island, with no survey during December.

- All surveys were conducted 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 >70% of body intact) during 2012.

- Samples of oiled feathers (representing contamination on various seabird species) and beached oil 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 extracted with Hexane. This extract, filtered to remove solids, was injected on a glass capillary column (HP5-MS) on an HP 6890 Gas Chromatograph with Flame Ionization Detector (GC/FID). Outputs from the GC were retrieved on HP Chemstation software, with chromatograms produced and assessed manually. Concurrently standard oils such as Marine Diesel, Jet (Helicopter) Fuel, Heavy Fuel Oil (Bunker C), Arabian Crude Oil, Lubricating Oil and n-alkane standards (C12 to C36) were run under the same conditions. This permitted identification of the n-alkane peaks in the sample and standard oil chromatograms. The n-alkane maximum, range of n-alkanes and unresolved peak maximum were identified by carbon number and relative response. These results were compared to standard oils to permit identification of oil within that class and determine roughly degree of weathering or time at sea. Oils with mixtures of fuel and lube oil were identified as bilge or slop tank sources, oils identified as heavy fuel oil or marine diesel oil were identified as fuel oil sources, and those identified as crude oil were identified as tanker cargo oil sources.

- Oil samples found on bird corpses and on the beach 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 2012**
Platform	beach, Sable Island
Type of Sample	oil on seabird feathers and on beach
Test Sample Locations	n/a
Reference Sample Locations	n/a
Number of Samples	17 oil samples
Sample Preparation	frozen
Equipment	collection by hand into metal foil containers

5. Analyses

5.a. Data Analyses

For number of clean birds/km and oiling rate (see Section 9, 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 17 oil samples collected from the feathers of seabird corpses and from the beach during January, August, and November 2012.

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 Section 9, Tables 1, 2 and 3, and Figures 1 – 8.

7. Summary

- During 2012, the corpses of 606 beached seabird corpses collected on Sable Island. Fulmars and shearwaters accounted for 57.6% of total corpses recovered, and alcids comprised 26.2% (Table 9.1).

- Seasonal occurrence of clean complete corpses (Code 0) varied by bird group and species (Table 9.1). Most Northern Fulmars, Larus gulls, and alcids occurred in winter (69.6%, 77.8%, and 93.5%, respectively). Most Northern Gannets (79.2%) and all shearwaters occurred in summer.

- The overall oiling rate for all species combined (based on complete corpses, Codes 0 to 3) was 7.8%.

- The highest oiling rate for a seabird group, 40.4%, was observed in alcids (i.e., 21 of 52 complete corpses). The oiled alcid species were Razorbill (11 of 13 complete corpses), Common Murre (2 of 4 complete corpses), and Thick-billed Murre (8 of 20 complete corpses). No oil was found on corpses of Atlantic Puffin and Dovekie. Table 9.1.

- The 2012 oiling rate for alcids (all species combined) is markedly higher than that observed in 2011 (i.e., 40.4% compared with 9.7%).

- In August patches of small pellets of oil (0.5 - 1.0 cm in diameter) occurred along the north and south sides of the island, but were not continuous along the shoreline (Figure 9.8). The oil, identified as "lube+weathered crude" (Table 9.2), appeared to wash ashore over several days, on both sides of the island during the same period, and then no more was seen. In November a single lump of oily substance was found on the north beach and was identified as lightly weathered crude.

- Seventeen samples of oil were collected in 2012, and likely represented five separate discharge events (Tables 9.2 & 9.3).

- Of the 17 samples collected from the feathers of birds and from the beach, 8 contained fuel oils in the mid-range distillate (or marine diesel) range. Marine diesel is commonly used by most vessels, including vessels associated with the offshore energy industry. None of the samples contained light distillate fuels or condensates that would be typical of oils produced on offshore gas facilities such as SOEP processing platforms offshore 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. 2012. *Beached bird surveys on Sable Island, Nova Scotia, 1993 to 2009, show a decline in the incidence of oiling.* Proceedings of the Nova Scotian Institute of Science 47, Part 1, 91-129.

9. Tables & Figures

Table 9.1.

Beached seabird corpses collected on Sable Island during 2012. Totals & linear densities for clean complete corpses (Code 0) for winter (November-April) and summer (May-October), and annual oiling rate based on complete corpses (i.e., with >70% of body intact, Codes 0 - 3).

Bird species & groups	Total [1] number corpses	Code 0 number Winter	Code 0 number Summer	Code 0 number/km Winter	Code 0 number/km Summer	Oiling rate %
Common Loon	6	2	0	0.005	0	66.7
Northern Fulmar	26	16	7	0.038	0.014	4.2
Shearwater	323	0	210	0	0.412	0.5
Northern Gannet	25	5	19	0.012	0.037	0
Larus Gulls	45	28	8	0.066	0.016	0

Alcids [2]	159	29	2	0.068	0.004	40.4
Common & Thick-billed Murres	36	12	2	0.028	0.004	41.7
Dovekies	58	9	0	0.021	0	0
other species [3]	22	2	2	0.005	0.004	20.0

[1] Codes 0 - 4 combined.
[2] All alcid species combined.
[3] Includes Black-legged Kittiwake, Common Tern, Double-crested Cormorant, and Leach's Storm Petrel. Of these, only five were complete corpses, one of which, a kittiwake, was oiled.

Table 9.2.
Generic identification of 17 oil samples collected from bird corpses during 2012.

Month	Number of Samples	Matrix	Generic Identification of Oil
January	4	feathers, alcids & loon	marine diesel, moderate weathering
January	4	feathers, alcids	marine diesel, moderate weathering
January	4	feathers, alcids & loon	heavy fuel (Bunker C), moderate weathering
August	4	beach; feathers, shearwater	lube + crude, severely weathered
November	1	beach	crude, light weathering

Table 9.3.
Discharge events identified by generic oil source of samples collected on Sable Island during 2000-2012.

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
2012	1	3	1 [3]	5
Total	60	17	15	92

[1] One specimen possibly bilge or fuel oil.
[2] Bilge or slop tanks.
[3] Lube + weathered crude.

Figure 9.1. Northern Fulmar
Number Corpses/km (Code 0): $F_{1,17}$=3.08, P=0.10
Oiling Rate for Complete Corpses: $F_{1,17}$=24.45, P=0.0001*

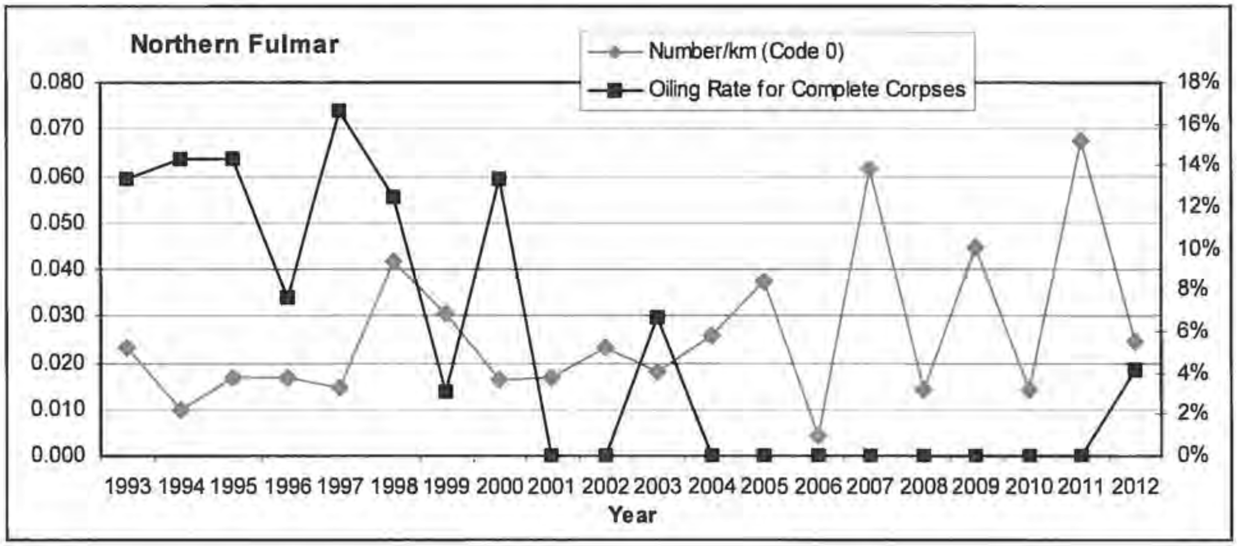


Figure 9.2. Shearwaters
Number Corpses/km (Code 0): $F_{1,17}$=0.34, P=0.56
Oiling Rate for Complete Corpses: $F_{1,17}$=4.55, P=0.047*

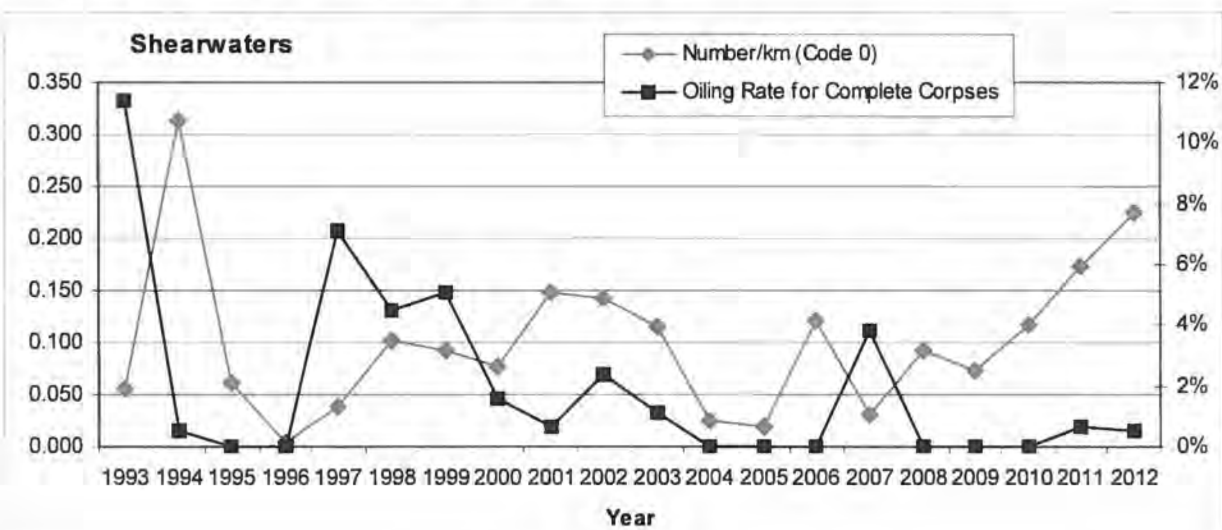


Figure 9.3. Northern Gannet
Number Corpses/km (Code 0): $F_{1,17}$=0.33, P=0.57
Oiling Rate for Complete Corpses: $F_{1,17}$=5.13, P=0.036*

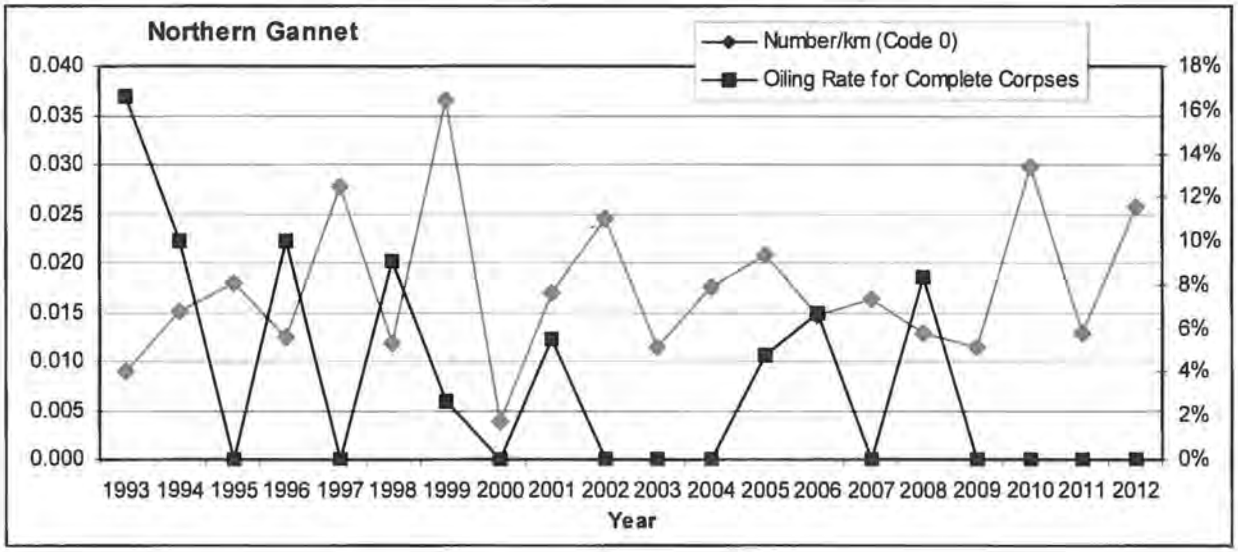


Figure 9.4. Larus Gulls
Number Corpses/km (Code 0): $F_{1,17}$=0.03, P=0.85
Oiling Rate for Complete Corpses: $F_{1,17}$=7.72, P=0.0124*

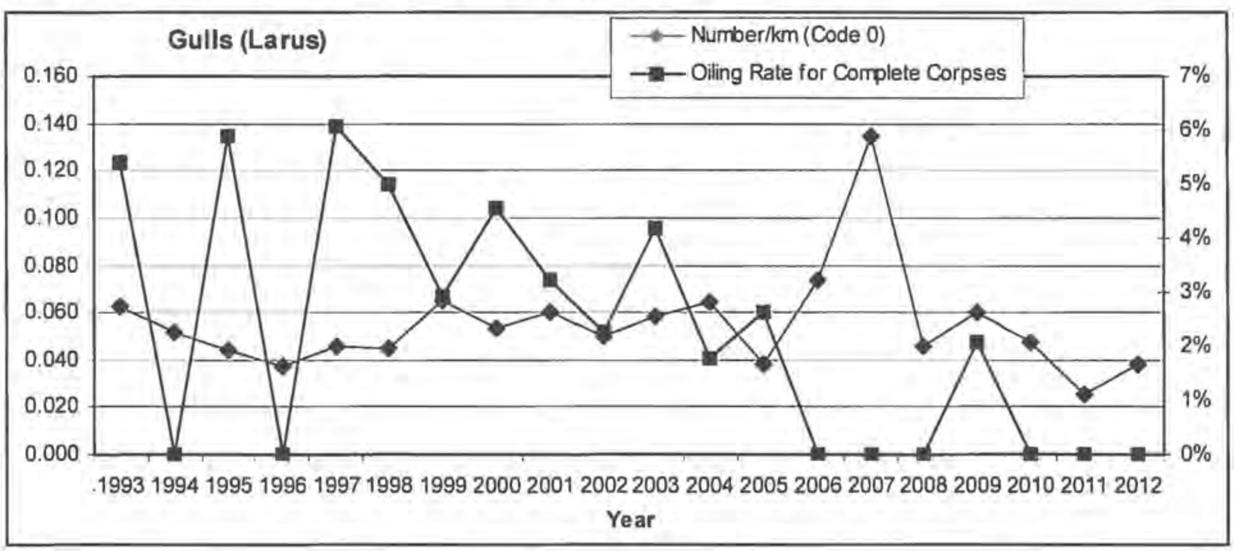


Figure 9.5. Alcids (all species combined)
Number Corpses/km (Code 0): $F_{1,17}$=0.14, P=0.71
Oiling Rate for Complete Corpses: $F_{1,17}$=26.54, P<.0001*

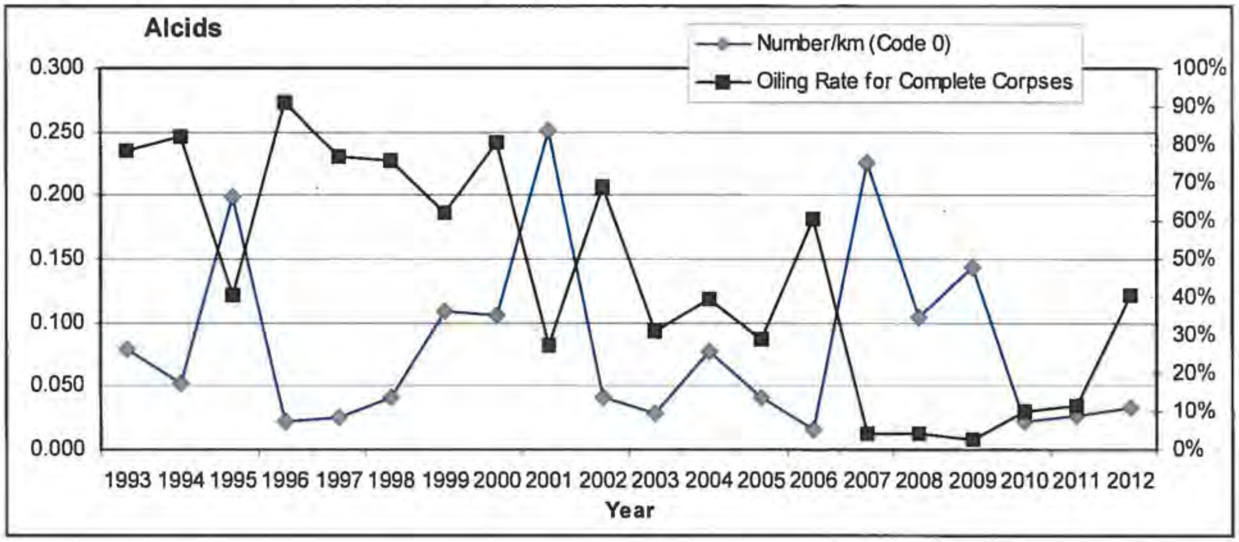


Figure 9.6. Common & Thick-billed Murres
Number Corpses/km (Code 0): $F_{1,17}$=0.09, P=0.77
Oiling Rate for Complete Corpses: $F_{1,17}$=10.53, P=0.0045*

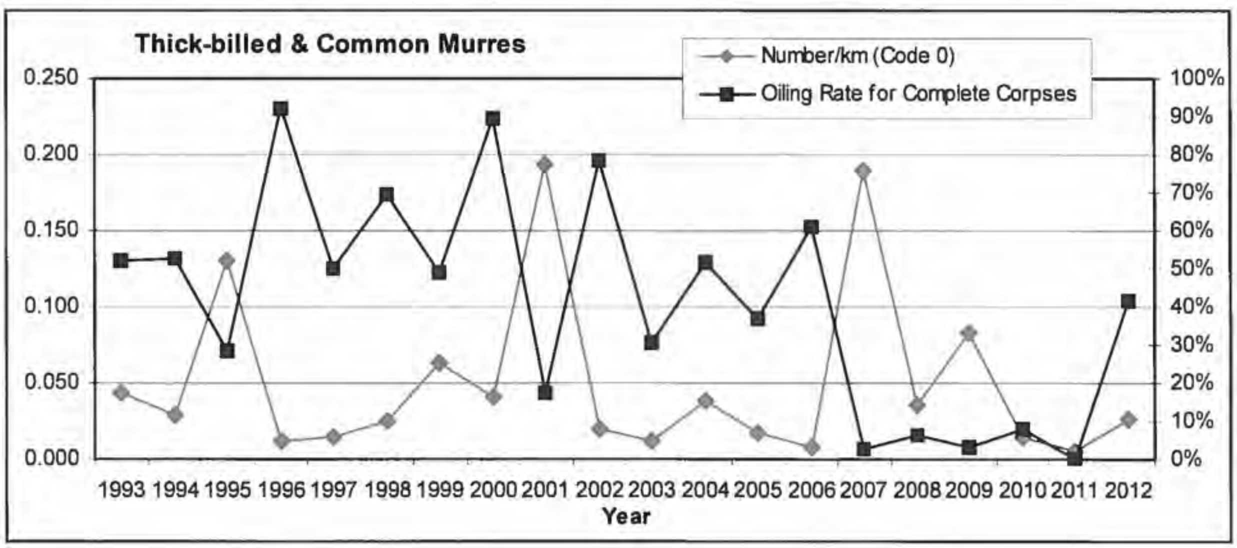


Figure 9.7. Dovekie
Number Corpses/km (Code 0): $F_{1,17}$=0.03, P=0.87
Oiling Rate for Complete Corpses: $F_{1,17}$=49.93, P<.0001*

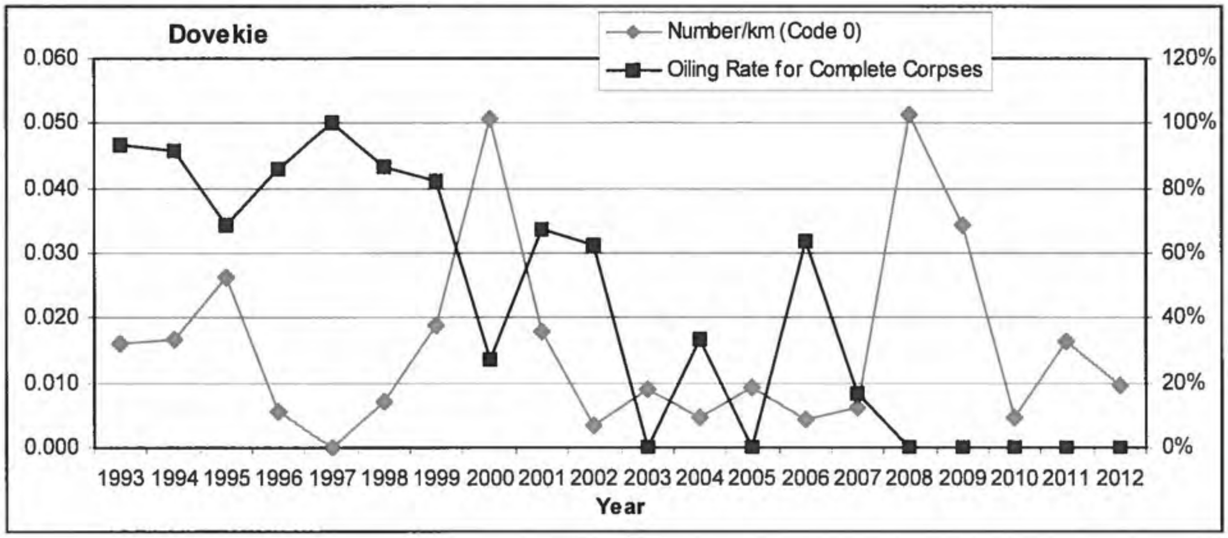


Figure 9.8. A patch of greatest concentration of the beached oil found on Sable Island in August 2012. The oil pellets are amongst pieces of peat (grey, black and dark brown fragments) that commonly wash ashore, and were more numerous than the oil pellets.

APPENDIX D

Stranded Bird 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, 2012 to December 31, 2012_ under the authority of Permit # __LS 2568.

NAME Marielle Thillet (Environmental Advisor) _______ TELEPHONE # ____(902) 492-5422

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, 2013

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 [Mar/Apr & Sep/Oct 2012 for well and PFC locations; Aug-Oct 2012 for gas export pipeline]

Vessel Name: Atlantic Condor

Position: Between PFC and well locations (H-08, M-79A, F-70, D-41 and E-70) and gas 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) PFC Commissioning [ongoing]

Vessel Name: PFC and two supply vessels (Ryan Leet and Atlantic Condor)

Position: PFC area (see attached map)

General activity of vessel: as per above

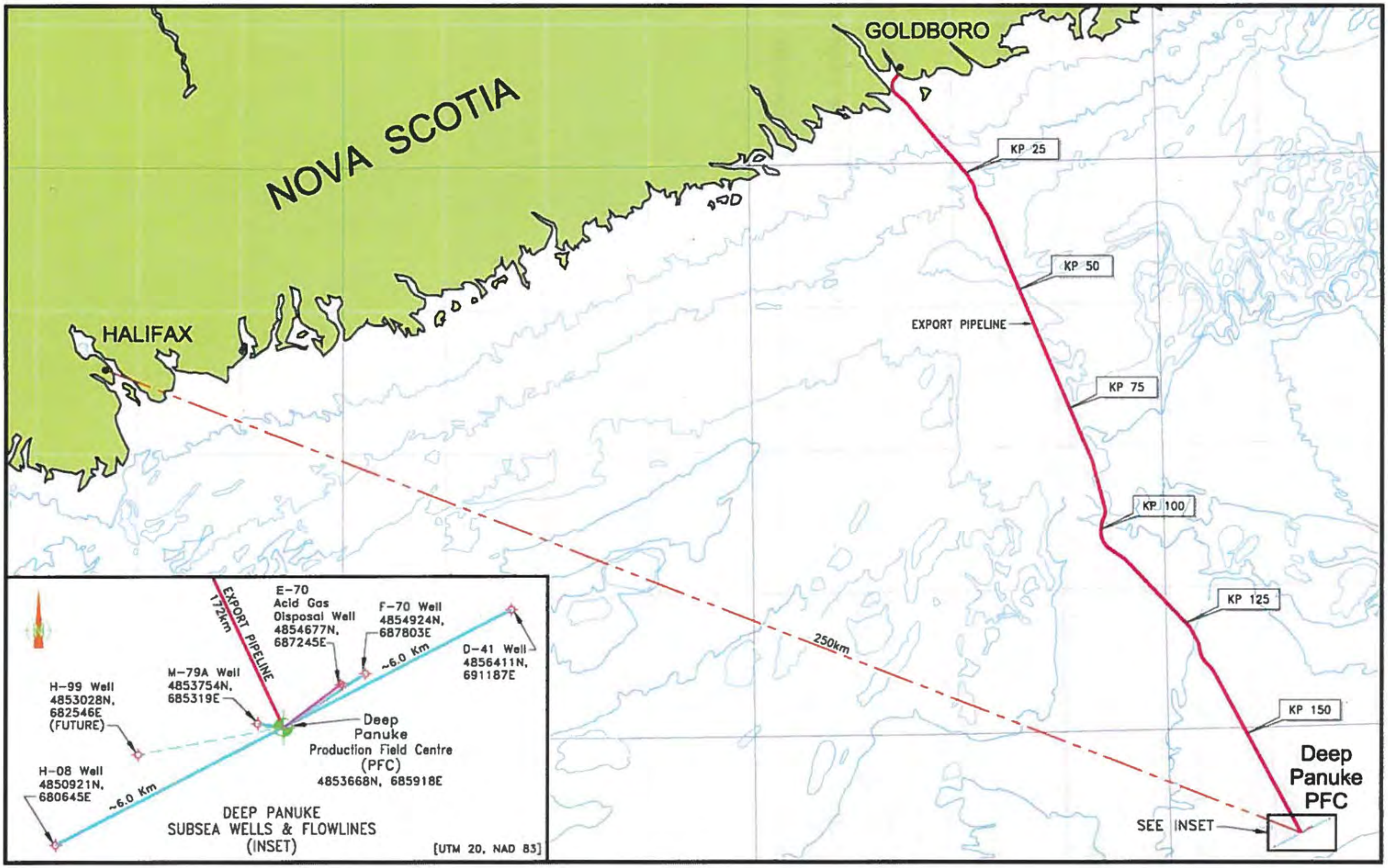
Search effort for live birds: Conducted by vessel staff during activities

One stranded bird was found during the 2012 Deep Panuke offshore programs. The bird was a Leach's Storm Petrel stranded on the PFC and was successfully released offshore.

Live Bird Events (PFC)

Date	Species	Condition	Action Taken	Fate of Bird
23-Nov-12	LHSP	Inactive, dry, not oiled	Found on the side of the platform sheltered under some equipment. Took the bird to the Radio Operator who put it in a box, let it rest and released it approximately half an hour later while the bird started to be active again. See attached picture. Bird was released facing the wind and took off.	Successfully released offshore

Leach's Storm Petrel recovered and released on the PFC (November 23, 2012)


NOVA SCOTIA
HALIFAX
GOLDBORO
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
M-79A Well
4853754N,
685319E
H-99 Well
4853028N,
682546E
(FUTURE)
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

Air Quality Monitoring

TECHNICAL NOTE

Topic:

Proposed Sable Island air emission monitoring plan during Deep Panuke production activities.

Discussion:

1. Background / Objective

Encana's recommended environmental effects monitoring (EEM) program for 2012 (Table 4.1 from Encana's 2011 EEM report, DMMG-X00-RP-EH-90-0001.03U) includes the following component under air quality monitoring:

"*Sable Island Air Quality Monitoring Station: data to be provided by Nova Scotia Environment (NSE)/Dalhousie and to be analyzed by Contractor.*"

The CNSOPB has approved Encana's recommended 2012 EEM program with the following request (letter from E. MacDonald dated October 19, 2012):

"*The CNSOPB requests an update on the status of preparation for air emissions monitoring from Sable Island during start-up, including H_2S monitoring.*"

This technical note describes Encana's proposal to monitor air emissions on Sable Island during production activities, including start-up activities.

2. Proposed Sable Island Air Emissions Monitoring Program

Mark Gibson, who is leading the ongoing ESRF funded project "Data display and source apportionment of VOCs on Sable Island" with his research team at Dalhousie University, will conduct the tasks outlined below. For regional monitoring consistency, these tasks will be completed for both Deep Panuke and the Sable Offshore Energy Project (SOEP) with a joint report issued for both operators.

This proposed air emission monitoring is meant to be a continuation of the ESRF study which, between 2003 to 2006, identified "elevated pollution events" for five air emission parameters (NOx, SO_2, H_2S, O_3 and $PM_{2.5}$) along with possible causes for the events, and compared them to health criteria (Waugh et al. 2010). The proposed program's components are described below.

Rev.	Date	Reason for Issue	Prepared	Checked	Approved	Approved
03U	2013-Mar-01	Issued for Use	M. Thillet	D. Morykot		J. Hurley
02U	2013-Jan-09	Issued for Use	M. Thillet	D. Morykot		J. Hurley
01R	2012-Nov-08	Issued for Review	M. Thillet	D. Morykot		J. Hurley

Title:

Proposed Sable Island Air Emission Monitoring Plan

DM	EN	X00	TN	EH	90	0002	03U
Project	Originator	Location	Type	Disc.	System	No.	Rev.

2.1 Investigate Spikes in Air Monitoring Data

Monitoring parameters will include the five metrics used during the ESRF study (NOx, SO_2, H_2S, O_3 and $PM_{2.5}$) as well as total volatile organic compound (VOC) concentration.

The proposed air emission thresholds to be used to determine what "spikes" need to be investigated are included in Appendix 1. These thresholds have been chosen based upon analysis of historical data by Mark Gibson. Please note that these thresholds correspond to elevated emission levels compared to ambient historical levels on Sable Island and are much lower than regulated air quality standards for all air pollution metrics (with the exception of ozone because of historical elevated ozone levels in the area).

The NOx, SO_2, H_2S, O_3, $PM_{2.5}$ and total VOC Sable Island will be monitored in near real time (1 min to 1-hour temporal resolution) and a password-protected data display will provide access to this air quality data. An automatic alarm system will notify Mark Gibson, Encana and SOEP when any of the thresholds are exceeded. Mark Gibson will then investigate each spike of any of the air pollution metrics. Investigative analysis will include: QA/QC of the equipment (NSE may be contacted for that purpose), validation of the near real-time data (i.e. removing zero and calibration spans and other erroneous data), checking wind direction (wind roses and pollution roses) and conducting air mass back trajectory analysis to investigate medium to long-range emission sources outside of the Scotian shelf airshed (using the HYSPLIT Langrangian model - http://ready.arl.noaa.gov/hysplit-bin/trajtype.pl?runtype=archive). Mark Gibson will contact SOEP/Encana to identify potential correlation with a particular facility's operations, as required.

Please note that the near real-time data is not QA/QC'd, a process that can take up to a year to be completed by NSE and validated by the National Air Pollution Surveillance network (NAPS). This time frame will likely be shorter for the new instruments being deployed on Sable Island as part of the ESRF project managed by Mark Gibson but there will inevitably be a delay of a number of months as QA/QC calibrations are normally only conducted every quarter. However, directional analysis of the un-QA/QC'd near real-time spike data (as described above) will allow reliable investigation of suspected facility emissions impacting the Sable Island airshed.

2.2 Airshed Monitoring Report

Once annual QA/QC'd data has been made available by NSE/Dalhousie, Mark Gibson will write a short report summarizing the airshed monitoring data including any changes in equipment, service trips, data availability and data values (above/below air quality standards), highlighting any correlation with oil and gas production activities. If easily available, the source of anomalies not explained by oil and gas activities will be identified (e.g. frontal passages, transboundary pollutants, natural influences, sea-salt aerosol loading in storms, Sable Island-specific activities). This report will be submitted to the CNSOPB as part of Encana's annual EEM report by the end of March. It is understood that there may be delays in obtaining QA/QC'd and validated data and in this situation either the available QA/QC'd data over the preceding 12-months would be used or some un-QA/QC'd data may be used as well (with obvious span checks and outliers removed) with a rider to state this. A decision to included un-QA/QC'd data for a preceding year in the final report will be made on a case by case basis.

2.3 Equipment Status

The air quality instruments that will be used for this monitoring are listed in Appendix 2. With the exception of total VOC, the air quality instruments are currently operating on Sable Island and are maintained by NSE as part of the NAPS network. The total VOC instrument will be installed on Sable island in Q1/2013 and will be maintained by Dalhousie University. Mark Gibson's research team has agreed to provide assistance to NSE if required when they travel to Sable Island to maintain the ESRF instruments, e.g. performing basic preventative maintenance.

The password-protected display of real-time instrument data and the automatic alarms for threshold breaches will be set up before First Gas. NSE will provide threshold alarms for the instruments on Sable Island that are part of the NAPS network. Mark Gibson will provide threshold alarms for the new total-VOC instrument.

References

Waugh, D., T. Inkpen., M. Hingston., S. Keast., J. McPherson., D. Worthy., G. Forbes. 2010. Sable Island Air Monitoring Program Report: 2003-2006. Environmental Studies Research Funds Report No. 181. Dartmouth. 56 p.

Appendix 1 – Proposed Air Emission "Spikes" Thresholds

Metric	Reference: extreme value analysis (1-hr data period) [1]	Suggested threshold value (1-hr)	Canada Ambient Air Quality Objectives [5]
NOx [2]	3/year return threshold for data available from 01/01/10 to 16/07/10	17.0 ppbv	213 ppb (1-hr)
SO_2	1/year return threshold for data available from 01/04/08 to 01/10/11	6.0 ppbv	344 ppb (1-hr)
H_2S [3]	1/year return threshold for data available from 02/05/12 to 09/10/12	3.11 ppbv	30 ppb (1-hr, NS)
$PM_{2.5}$	1/year return threshold for data available from 01/01/07 to 01/10/11	168.0 $\mu g/m^3$	120 $\mu g/m^3$ (24-hr)
Ozone	1/year return threshold for data available from 01/01/07 to 01/04/11 (1-hr data period)	104.0 ppbv	82 ppb (1-hr)
Total VOC [4]	1/year return threshold to be calculated based on 2013 data	to be determined in Q1/2014 (ppbv)	N/A

Note 1: An extreme value analysis (see Appendix 4 for details) was conducted on air emissions data available between 2007 and 2011. For each metric, the period mentioned in this column indicates the period for which data was available for this specific metric during these five years. For H_2S, the data available for these five years was poor quality; therefore, 2012 H_2S emission data was obtained from NSE to calculate the H_2S threshold. All thresholds will be reviewed on an annual basis and recalculated with the new emissions data that becomes available.

Note 2: A higher return threshold (3/year) was used for the extreme value analysis for NOx (which should results in a higher number of spikes to investigate) because "elevated pollution events" identified during the 2003-2006 ESRF study for this parameter were linked to oil and gas operations as a possible causal factor.

Note 3: When Deep Panuke first starts flaring acid gas during the start-up phase, in addition to the automatic alarm system (i.e. even if H_2S levels are below the alarm threshold), H_2S data will be monitored by Dalhousie personnel in real-time to confirm EA predictions that levels of H_2S generated by acid gas flaring would be negligible on Sable Island. Observer(s) will be monitoring H_2S values in conjunction with acid gas flaring activities and weather conditions to identify any potential correlation between acid gas flaring and H_2S levels on the island.

Note 4: Threshold value of total VOC to be calculated using the first 12 months of monitoring data from the new total-VOC analyzer to be installed on Sable Island in Q1 of 2013.

Note 5: Canada Ambient Air Quality Objectives (CAAQO), maximum acceptable 1-hr thresholds are provided as a reference. For $PM_{2.5}$, the 24-hr CAAQO threshold was provided because a 1-hr threshold was not available. For H_2S, the Nova Scotia 1-hr ground-level concentration threshold was used because a CAAQO threshold was not available. As mentioned earlier, the proposed air emission ("spike") monitoring thresholds are significantly lower than regulated air quality standards, with the exception of ozone because of historical elevated ozone levels in the area (please note that none of the elevated ozone events from the ESRF study were attributable to the offshore oil and gas industry; Waugh et al. 2010).

Appendix 2 – Air Emission Monitoring Instrumentation

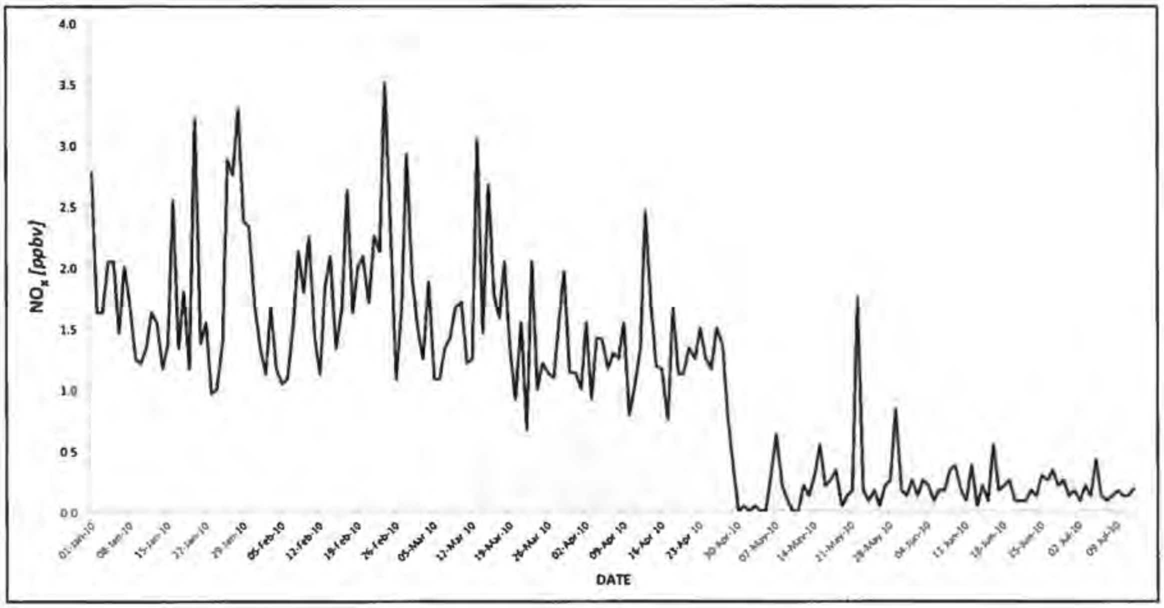
Metric	Instrument	Units	Temporal Resolution	Equipment Funder
Nitrogen Oxides (NOx)	Teledyne-API, NOx 200E Analyzer	ppbv	1 min, 5 min and 1 hour averages	NAPS (100%) - Original instrumentation from the 2003-2006 ESRF air emission study had to be replaced
Fine Particulate ($PM_{2.5}$)	MetOne® 1020 Beta Attenuation Monitor (BAM)	$\mu g/m^3$	Hourly	NAPS (100%) - Original instrumentation from the 2003-2006 ESRF air emission study had to be replaced
Sulphur Dioxide (SO_2)	Teledyne-API, 100E SO_2 Analyzer	ppbv	1 min, 5 min and 1 hour averages	NAPS (100%) - Original instrumentation from the 2003-2006 ESRF air emission study had to be replaced
Hydrogen Sulphide (H_2S)	Teledyne-API 101E H_2S Analyzer	ppbv	1 min, 5 min and 1 hour averages	Encana Corporation (100%) - Original instrumentation from the 2003-2006 ESRF air emission study had to be replaced.
Ozone (O_3)	Teledyne-API 400E O_3 Analyzer	ppbv	1 min, 5 min and 1 hour averages	Environment Canada (100%)
Total VOC	Thermo 55i	ppbv	Hourly	ESRF – Dalhousie 2012
Thresholds alarms	EcoTech AERODIS	N/A	N/A	ESRF – Dalhousie 2012
Data display	Dalhousie display	N/A	N/A	ESRF – Dalhousie 2012

Appendix 3 – Descriptive statistics and graphs of the air pollution metrics used to generate the threshold values

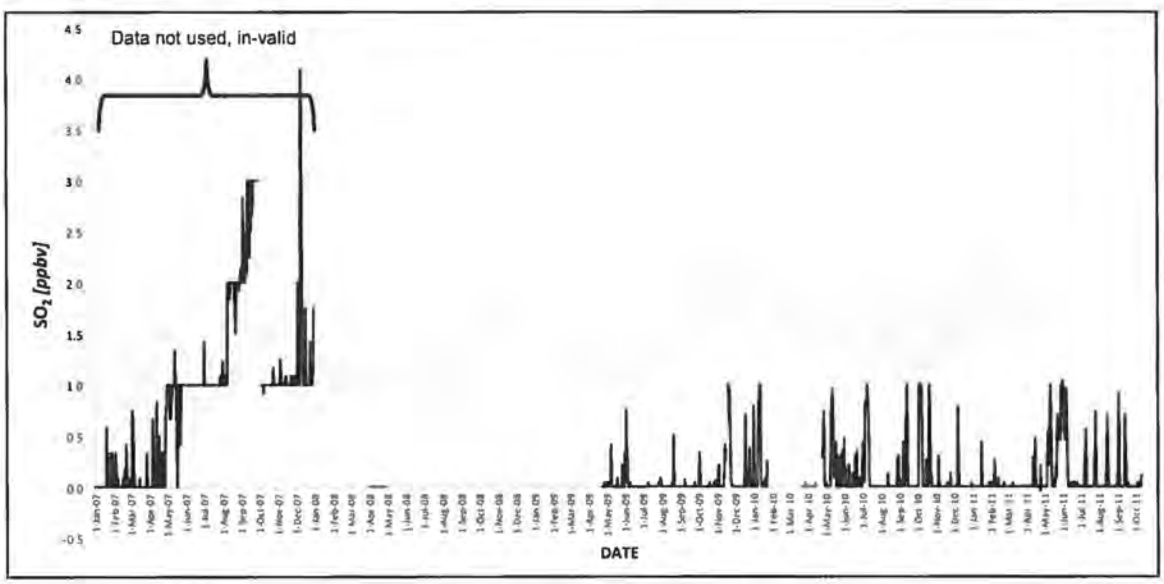
Table of descriptive statistics for NOx, SO_2, $PM_{2.5}$, O_3 and H_2S [1]

Variable	n	Mean	Std Dev	Max	Median	Min
NOx ppbv	4591	1.06	1.32	18.0	1	0
SO_2 ppbv	12798	0.09	0.29	6.5	0	0
$PM_{2.5}$ $\mu g.m^{-3}$	954	9.68	10.18	175.0	7	0
O_3 ppbv	16700	30.81	8.11	105.0	30	3
H_2S ppbv	2437	0.40	0.21	3.2	0.4	0

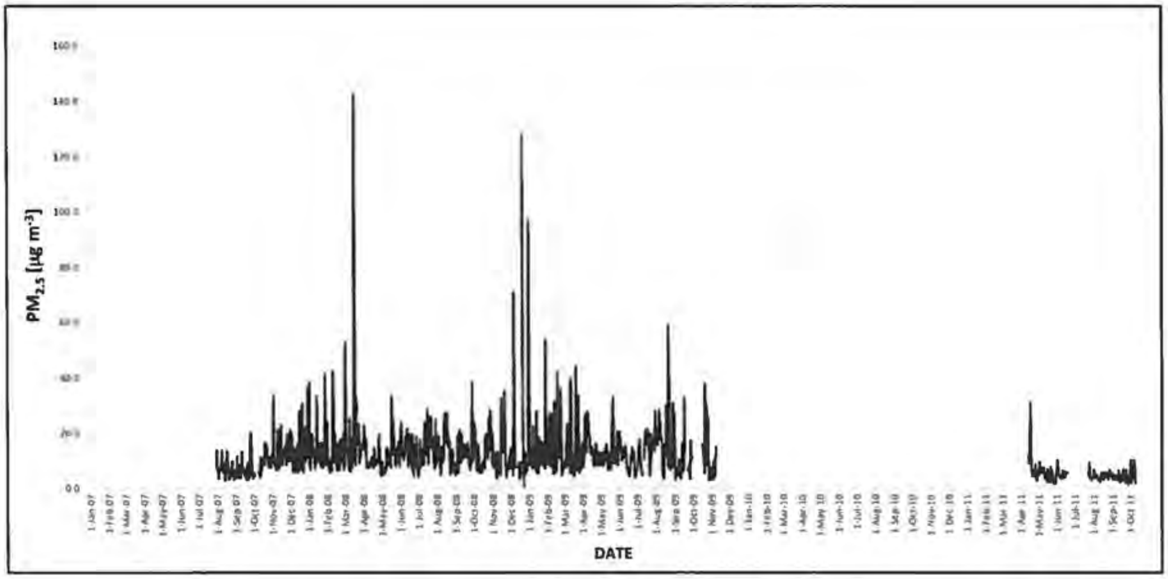
Note 1: air emissions data available between 2007 and 2011 were used for each metric; except for H_2S for which 2012 data was used (see graphs below).



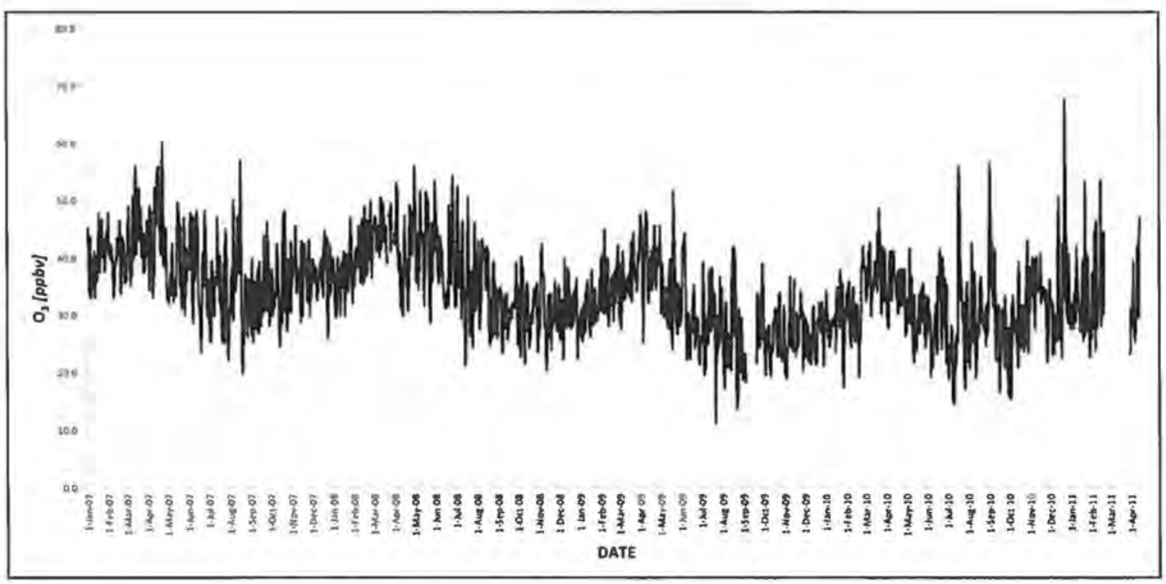
NO_x time series Sable Island air emissions 01/01/10 to 16/07/10



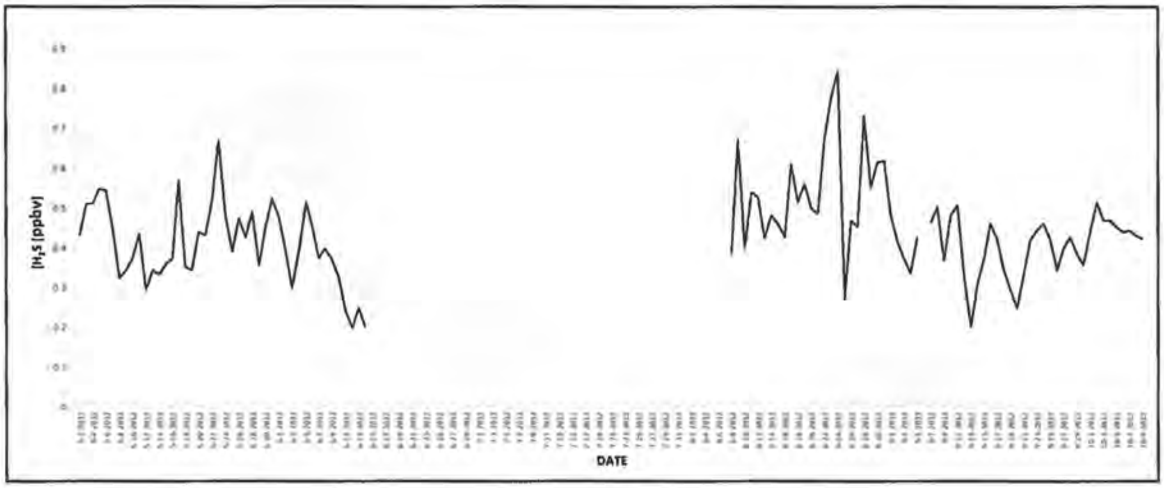
SO_2 monthly time series 01/04/08 to 01/10/11



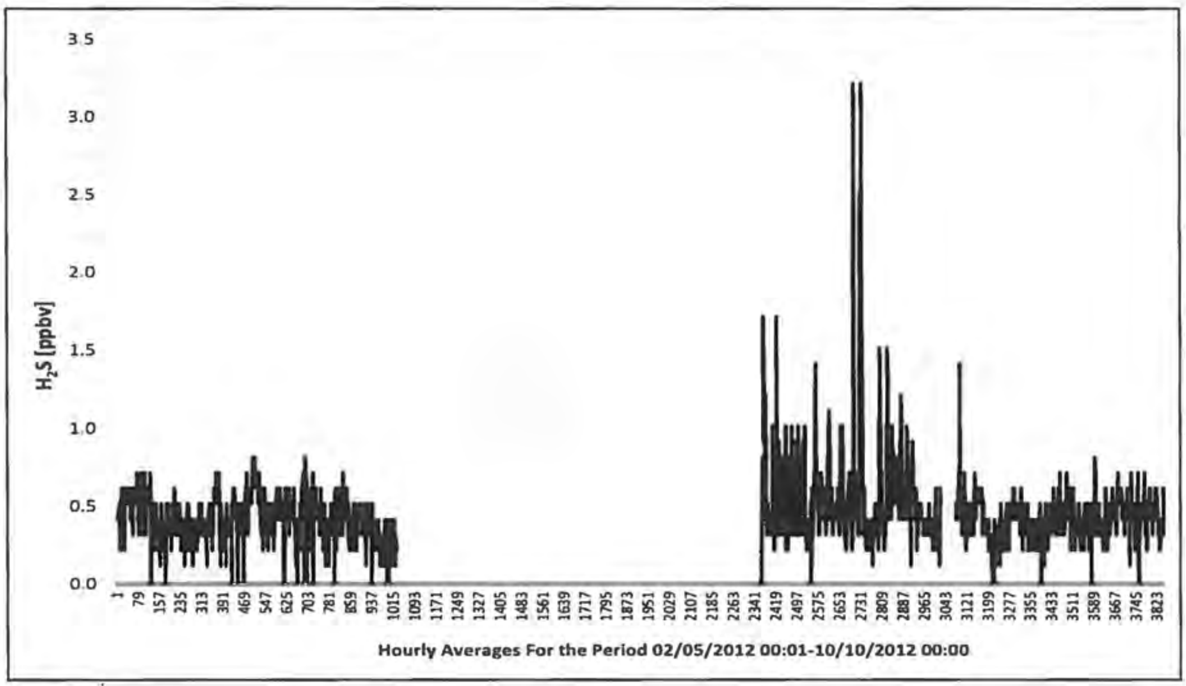
$PM_{2.5}$ monthly time series 01/01/07 to 01/10/11



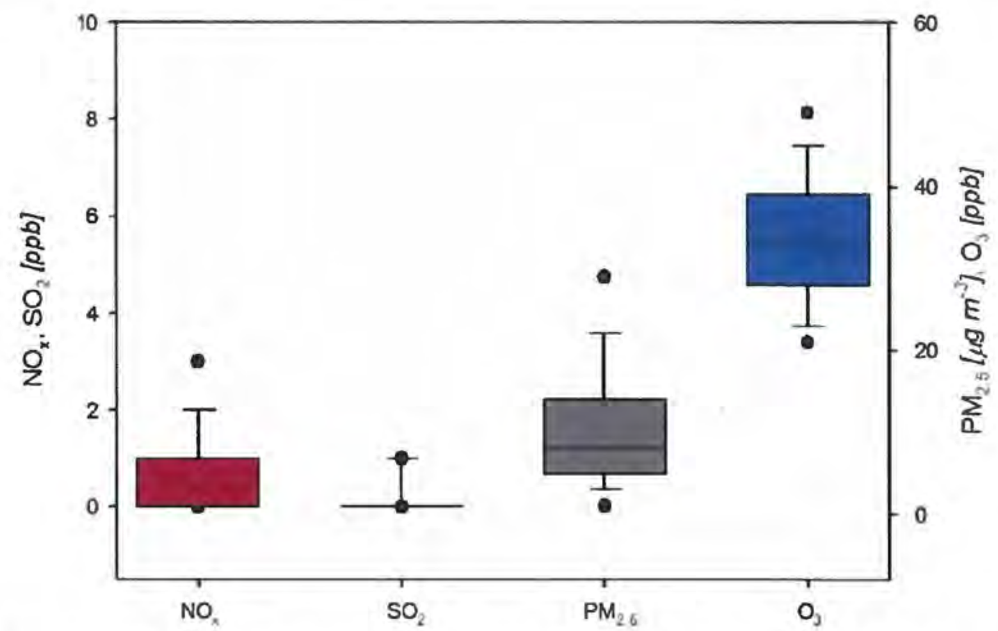
O_3 daily time series 01/01/07 to 01/04/11



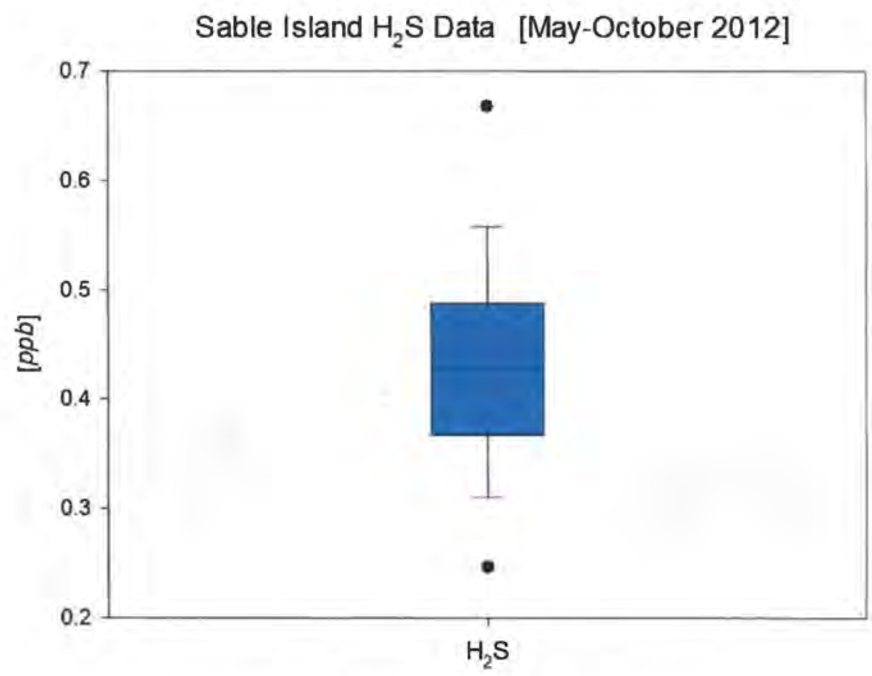
H_2S daily average time series 02/05/12 to 09/10/12



H_2S hourly time series 02/05/12 to 01/10/12



Box plot of NO_2, NOx, SO_2, $PM_{2.5}$, O_3; Sable Island Air Emissions Data 2007-2011



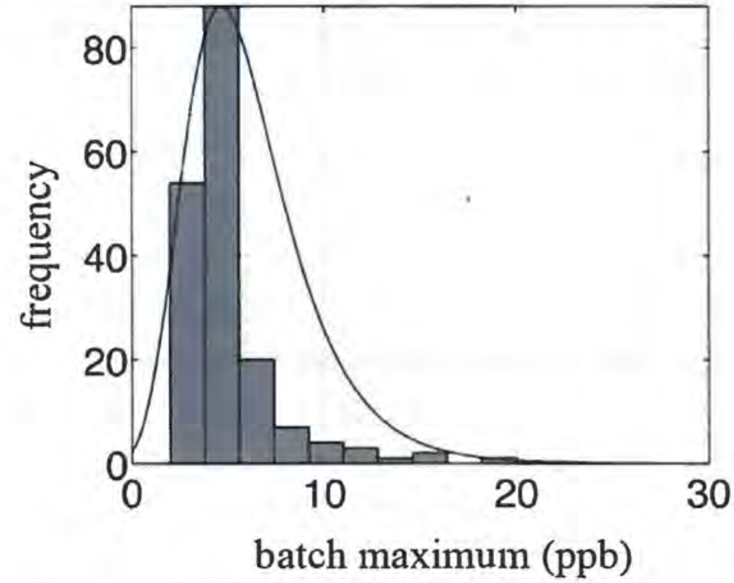
Box plot of H_2S 02/05/12 to 01/10/12

Appendix 4 – Extreme value analysis conducted to generate the threshold values

An extreme value analysis requires batches of independent measurements. Hourly measurements taken over the course of a day do not satisfy this requirement.

Batches of 24 measurements (representing one day of sampling) were therefore selected randomly and without replacement to get around this. This was repeated to obtain a large number of batches (1800). The maximum of each batch was selected, and the histogram of all maxima were fitted to the Gumbel distribution for extreme values.

NO_x



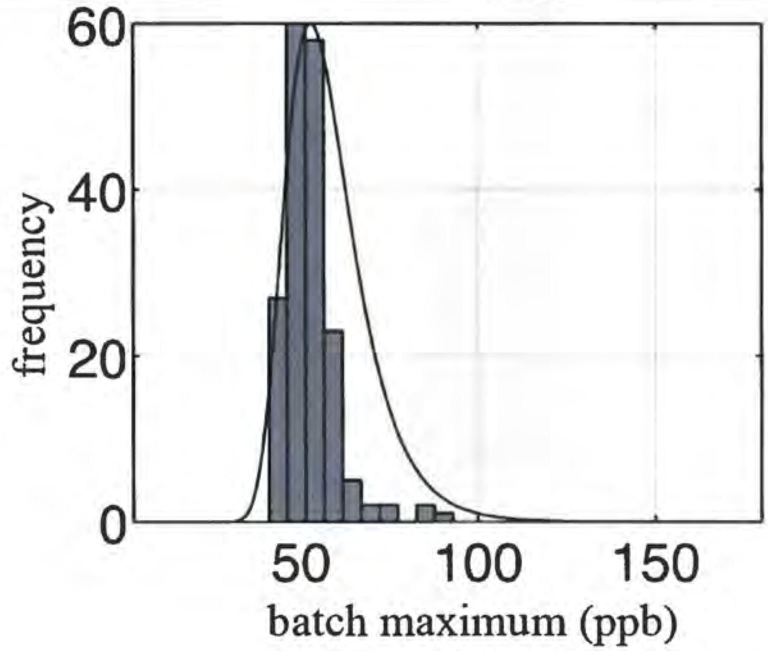
The histogram is of batch maxima. The curve is the Gumbel distribution fitted to the histogram. The mode of the distribution occurs at 5 ppb. The Gumbel distribution was used to compute the values shown in the following table (next slide).

NO_x x = the maximum of a batch of 24 measurements representing a day of measurements

t = threshold	p(x > t)	expected number of days in one year for which x > t (365 times p(x > t))
12 ppb	0.0563	20.5 days
13	0.0386	14.1
14	0.0263	9.61
15	0.0179	6.50
16	0.0122	4.45
17	0.0083	3.02
18	0.0056	2.04

This table is based on the assumption that 24 independent measurements are taken on a given day. This does not take into account seasonal effects evident in the data (the shift evident around the end of April 2010). A rare event might be classified as one expected to occur less than 5 times per year, for example, in which case a rare event equates to a concentration of more than 17.5 ppb.

O_3

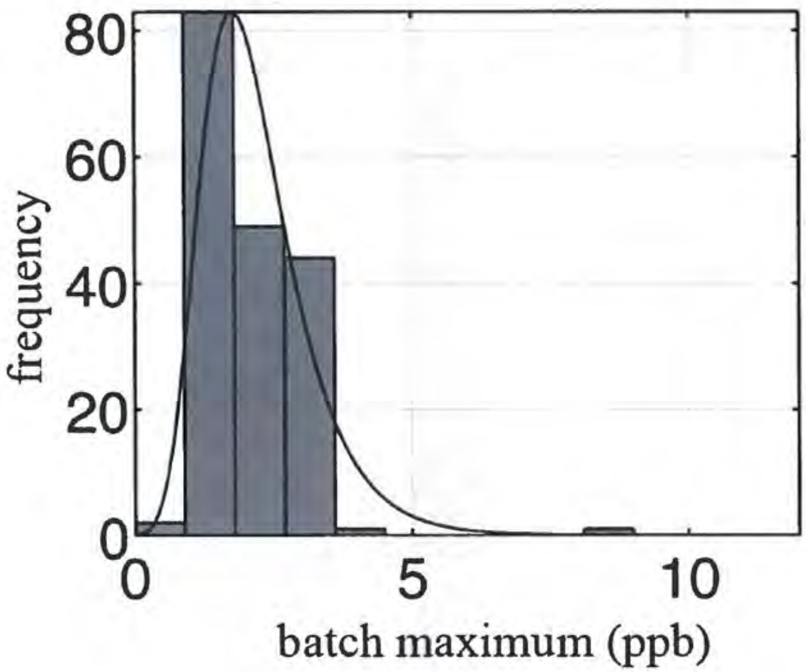


The mode of the distribution occurs at 53 ppb.

O_3

t = threshold	p(x > t)	expected number of days in one year for which x > t (365 times p(x > t))
80 ppb	0.0429	15.7 days
85	0.0243	8.9
90	0.0138	5.02
95	0.0078	2.83
100	0.0044	1.60
104	0.0028	1.00
105	0.0025	0.90

SO_2

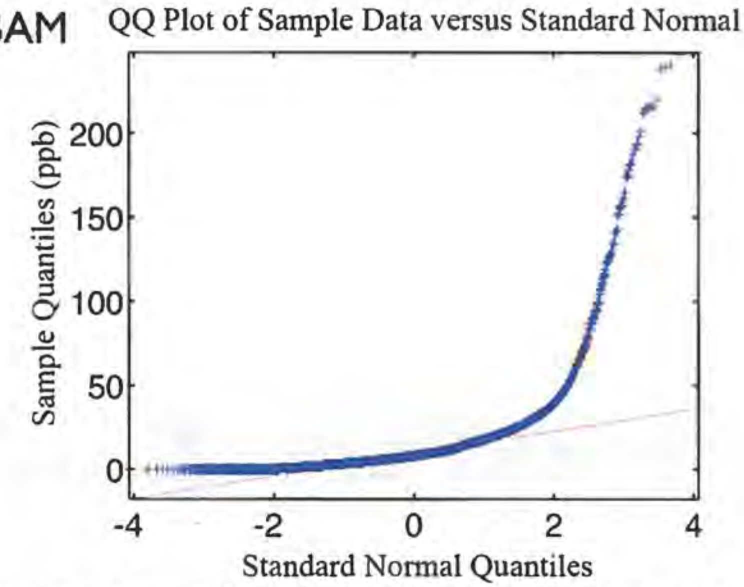


The mode of the distribution occurs at 1.8 ppb.

SO_2

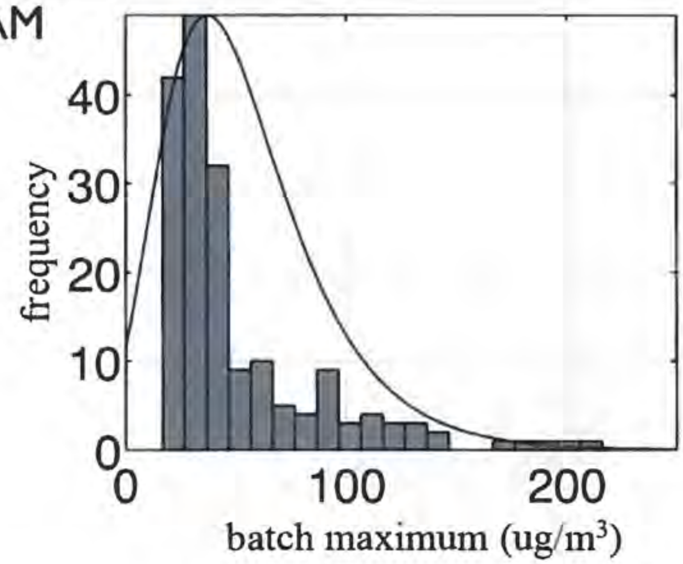
t = threshold	p(x > t)	expected number of days in one year for which x > t (365 times p(x > t))
4.0 ppb	0.0433	15.8 days
4.5	0.0222	8.09
5.0	0.0113	4.12
5.5	0.0057	2.09
6.0	0.0029	1.06
6.5	0.0015	0.54

PM25 BAM

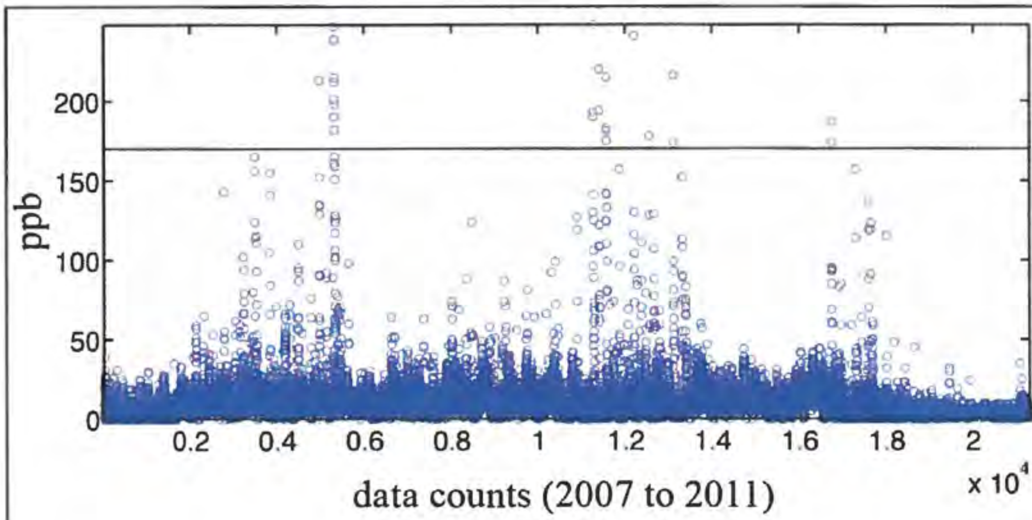


The distribution of PM25 BAM has a long skew to the right to values well above 200 ppb. The larger values may correspond to spray and aerosols generated by storm events. If this is the case, they should be discounted from the analysis.

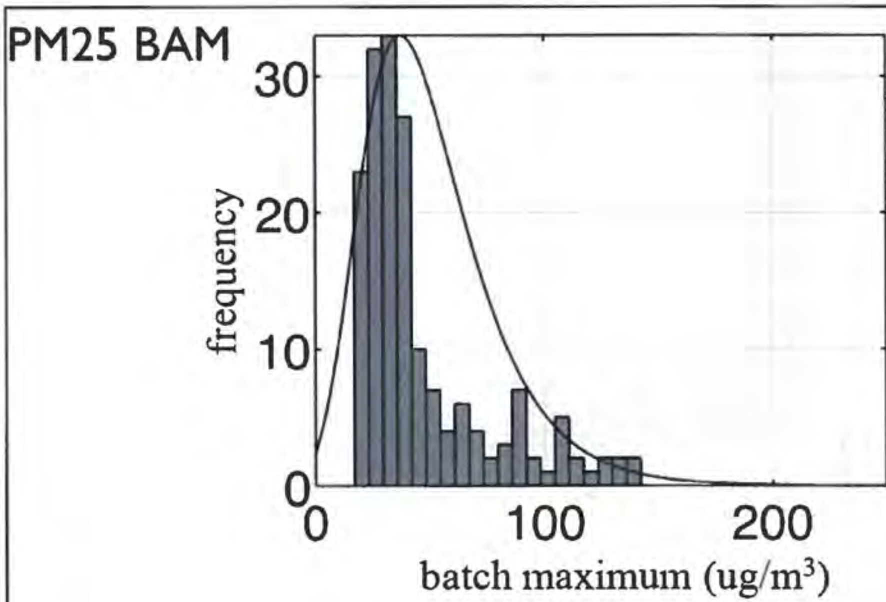
PM25 BAM



The distribution of the of batch maxima suggests that the larger values (greater than 170 ppb) are not contiguous with the rest of the distribution. It is not unreasonable to remove these from the analysis, based on the assumption that they correspond to storm events.



This plot shows the PM25 BAM values. The black line indicates the 170 ppb cutoff. (It would be useful to test whether these points correspond to storm events.)

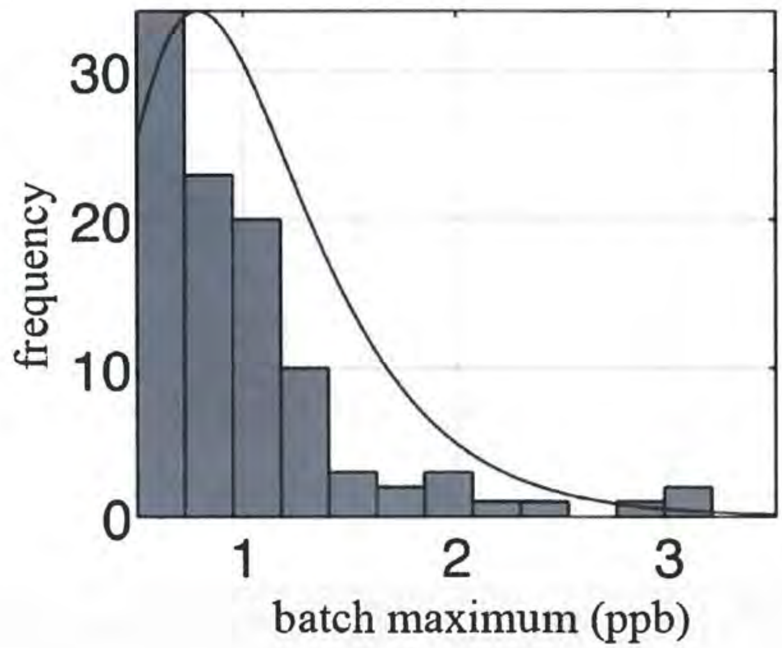


The histogram is of batch maxima with the values greater than 170 ppb removed. The mode occurs at 36 ppb.

PM25 BAM

t = threshold	p(x > t)	expected number of days in one year for which x > t (365 times p(x > t))
100 ug/m^3	0.0587	21.4 days
125	0.0196	7.17
150	0.0065	2.36
168	0.0028	1.00
175	0.0021	0.80

H_2S



The mode of the distribution occurs at 0.70 ppb.

H_2S

t = threshold	p(x > t)	expected number of days in one year for which x > t (365 times p(x > t))
1.50 ppb	0.1912	70 days
2.00	0.0610	2.39
2.50	0.0177	6.48
3.11	0.0028	1.00
3.25	0.0015	0.54