Offshore Environmental Effects Monitoring for Deep Panuke

Program Annual Report 2013

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Executive Summary

McGregor GeoScience Ltd. (McGregor) was contracted by Encana Corporation for provision of Environmental Effects Monitoring (EEM) services for the Deep Panuke Project. Since its inception in 2011, the objective of this project has been to provide a monitoring program addressing all production operations-related environmental effects monitoring commitments made during the Deep Panuke regulatory process as outlined in the 2007 Comprehensive Study Report (CSR) and environmental effects predictions made during the 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 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.

With 'First Gas' (full production rate) delayed to December 2013, no sampling for Produced Water Chemistry and Toxicity, Marine Water Quality Monitoring, Sediment Chemistry and Toxicity, and Fish Health Assessment was conducted. The 2013 survey program was limited to the monitoring of:

- Fish habitat alteration on the subsea production structures (section 6.4 of the EEMP):
    - PFC legs;
    - protective mattresses;
    - SSIV valve;
    - wellheads; and,
    - exposed sections of the pipeline to shore.
- Marine wildlife observations (section 6.6 of the EEMP):
    - marine mammals and sea turtles observations,

  - stranded-bird observations;
  - beached bird observation on Sable Island;
  - Ocean Tracking Network (OTN) tagged species program; and,
  - Acadia University's research study on assessment of bird-human interactions at offshore installations.
- Air quality monitoring (section 6.7 of EEMP):
  - air quality monitoring on Sable Island; and,
  - flare plume observations on Deep Panuke.

The results of the 2013 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 2012. Species composition was relatively homogenous across all wellhead sites.
- Dominant fish species at the WHPS continue to be pollock (*Pollachius sp*.) and cunner (*Tautogolabrus adsperus*). Sculpins (*Myoxocephalus sp*.) were also found this year at the WHPS and the base of the riser caisson, and were not present in the 2012 survey. Like the 2012 survey, Atlantic cod (*Gadus morhua*) were not present in 2013.
- Wellheads and protective structures 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.
- There was an increased abundance of blue mussel *Mytilus edulis* at the base of the riser caisson, becoming the dominant species colonizing the area, as opposed to the hydroid *Tubularia sp*. in 2012. Possible colonization of hydroids on a Cuprotect coverage area on the flowlines at the riser caisson (*e.g.* D-41).

Marine wildlife observations:

- Four bird strandings were reported. In two instances the birds were unharmed and later released and in the other two instances the birds ended up dying.
- Both the supply vessels the M/V Atlantic Condor and the M/V Ryan Leet reported wildlife sightings in 2013. The M/V Atlantic Condor observed three mike whales and one fin whale in May of 2013, a seal in June and a whale in August, along

with various untagged gulls year round. The Ryan Leet observed two pilot whales, a minke whale, approximately 10 porpoises and a grey seal in May of 2013.

- As part of the Acadia bird study, ongoing monitoring of bird movements was conducted from May to December on Sable Island, Country Island, Bon Portage Island, Conrad's Beach and North East Nova Scotia, where 343 birds were tagged in 2013. In 2013, vessel based VHF receivers were active throughout the entire tagging period and birds were effectively detected without interference from VHF “noise”. The installation of bird monitoring equipment on the PFC was postponed until spring 2014.
- Ongoing monitoring of oiling rates in beached birds on Sable Island was conducted over the course of 10 surveys carried out between January 1, and October 1, 2013, where 461 beached seabird corpses were collected. Fulmars and shearwaters accounted for 25.8% of total corpses recovered, and alcids comprised 55.5%. Of the 461 corpses, 217 (47.1%) were complete (>70% of body intact). The oiling rate for all species combined was <0.5%.
- The Ocean Tracking Network (OTN) tagged 20 juvenile female blue sharks in July/August of 2013. All twenty sharks were picked up on acoustic receivers in the region, however no detections of tagged blue sharks were obtained from Encana platforms or the Encana ROV in the period between July 2013 and December 2013.

Air Quality Monitoring:

- Air emissions were monitored on Sable Island throughout 2013. There was one event where the NO_X emissions ‘spike’ threshold (1-hr period) was exceeded, likely not as a result of O&G operations. Three H_2S spikes were investigated and determined to be due to instrument drift rather than O&G operations.
- No systematic flare smoke data was compiled for 2013, however, the flare is monitored on the platform during walk-arounds and was observed to be burning cleanly the majority of the time. Systematic flare smoke monitoring was initiated in February of 2014, recording flare smoke shade twice a day using the Ringelmann smoke chart.

In accordance with objectives stipulated in the Offshore Production EEMP, it is anticipated that the 2014 EEM sampling program will provide analyses and observations for the following monitoring components:

- Produced water chemistry and toxicity (section 6.1 of EEMP);
- Marine water quality monitoring (section 6.2 of EEMP);
- Sediment chemistry and toxicity (section 6.3 of EEMP);
- Fish habitat alteration analyses (section 6.4 of EEMP);
- Fish health assessment (section 6.5 of EEMP);
- Marine wildlife observations (section 6.6 of EEMP); and
- Air quality monitoring (section 6.7 of EEMP).

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GLOSSARY OF TERMS

APs	Alkyl Phenols
BTEX	Benzene, Toluene, Ethylbenzene, Xylene(s)
C	Celsius
cm	centimetre(s)
CCR	Central Control Room
CNLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
CO_2	Carbon Dioxide
COPAN	Cohasset and Panuke
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSR	Comprehensive Study Report
CTD	Conductivity, Temperature, Depth
CWS	Canadian Wildlife Service
d	Day
DVD	Digital Video Disc/ Digital Versatile Disc
EA	Environmental Assessment
EC	Environment Canada
ECSAS	Eastern Canada Seabirds at Sea
EEM	Environmental Effects Monitoring
EEMP	Environmental Effects Monitoring Plan
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
GBBG	Great Black-backed Gulls
GEP	Gas Export Pipeline
GLS	Global Location Sensing tags
GPS	Global Positioning System
GVI	General Visual Inspection
HERG	Herring Gulls
H_2S	Hydrogen Sulphide

hr	Hour
ID	Identification
km	Kilometre
KP	Kilometre Point
L	Litre(s)
LC49	Bioassay acute toxicity analysis
LAT	Lowest Astronomical Tide
m	metre(s)
mg	milligram(s)
mm	millimetre(s)
mol	Mole (unit)
MOPU	Mobile Offshore Production Unit
M&NP	Maritimes & Northeast Pipeline
MV	Motor Vessel
N	North
NA	Not tested for
NEB	National Energy Board
NOx	Nitrogen Oxides
NSERC	Natural Sciences and Engineering Research Council of Canada
O_3	Ozone
OWTG	Offshore Waste Treatment Guidelines
OTN	Ocean Tracking Network
PAH	Polynuclear Aromatic Hydrocarbons
PEI	Prince Edward Island
PFC	Production Field Centre
PPMW	Parts per million by weight
PSU	Practical Salinity Units
RADAR	Radio Detection and Ranging
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

SARA	Species at Risk Act
SBM	Single Buoy Moorings Inc.
SE	South East
SO_2	Sulphur Dioxide
SOEP	Sable Offshore Energy Project
SSIV	Subsea Isolation Valve
SW	South West
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
VECs	Valued Environmental Components
VHF	Very High Frequency
VIV	Vortex Induced Vibration
VOCs	Volatile Organic Compounds
WBM	Water-based Mud
WGS84	World Geodetic System 1984
WHPS	Wellhead Protection Structure

1 INTRODUCTION

McGregor GeoScience Ltd. (McGregor) was contracted in 2011 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 Offshore Production Environmental Effects Monitoring Plan (EEMP) (Encana, 2011: DMEN-X00-RP-EH-90-0003). This 2013 report represents the third yearly report submitted to Encana.

The 2013 EEM project team consists of:

- McGregor GeoScience Ltd. for subsea video data analysis and project reporting;
- SBM/Encana personnel from PFC and supply/standby vessels MV Atlantic Condor, MV Ryan Leet and MV Intrepid for marine mammal, sea turtles and bird observation, and for flare plume analysis;
- Acadia University for bird monitoring research;
- Zoe Lucas Consulting for Sable Island beached bird survey;
- Kingfisher Environmental Health Consultants for Sable Island air quality monitoring; and
- Ocean Tracking Network for acoustic survey of tagged species.

Table 1.1 provides an overview of the 2013 EEM program including relevant environmental effects monitoring (EEM) components and survey timing. No produced water, water quality or sediment sampling took place in 2013, as First Gas occurred in December 2013 (see section 1.1). These monitoring components including fish health assessment will resume in the 2014 sampling program.

Table 1.1 Overview of 2013 EEM Program

EEM Component(s)	2013 EEM Program	Survey Timing
Fish Habitat Alteration Section 6.4 of EEMP	Inspection of ROV video data to determine development of benthic communities at the wellheads, wellhead protection structures, PFC legs and pipelines.	July to September 2013
PFC Marine Wildlife Observations Section 6.6 of EEMP	Summarize PFC and vessels observations, including stranded birds.	Continuous
Assessment of bird-human interactions at offshore installations Section 6.6 of EEMP	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.	Between May and December 2013.
Oiled Bird Study conducted on Sable Island Section 6.6 of EEMP	Ten surveys for beached seabirds were conducted on Sable Island. Species identification, corpse condition and extent of oiling were recorded for seabird specimens.	Between January 1 and October 1, 2013
OTN tagged species survey Section 6.6 of EEMP	Acoustic receivers on offshore oil and gas infrastructure complementing existing receivers to monitor tagged animals including 20 Blue sharks.	Between July 2013 and December 2013
Air Quality Mark Gibson Section 6.7 of EEMP	Monitoring of air emissions with air quality monitoring instruments deployed on Sable Island	Continuous
Flare Plume observations Section 6.7 of EEMP	No systematic smoke data was compiled in 2013, but the flare was monitored continuously by cameras and visually. Systematic flare smoke monitoring was initiated in 2014 using the Ringelmann smoke chart.	Continuous camera and visual observations. Smoke monitoring twice a day initiated in February 2014.

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 1.1a**).

The project involves offshore production, processing and transport via a nominal 559mm (22 inch) 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 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 (H-08, M-79A, F-70, and D-41) (**Figure 1.1b and 1.1c**), a disposal well (E-70) and associated subsea flowlines and control umbilicals, and a gas export pipeline to shore.

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.

Significant project's milestones achieved in 2013 are as follows:

- June 3: start of flaring (nitrogen and buy-back natural gas);
- August 7: first well opened, start of acid gas flaring;
- August 11: export gas to market; and
- December 17: Production Acceptance Notice ('First Gas') and start of steady-state production with production capability reaching approximately 300 million cubic feet per day.

The general project location of the Deep Panuke EEMP is shown in **Figure 1.1a**. Rendering of the production platform and the wellheads are shown in **Figure 1.1b** and schematic of the Deep Panuke subsea production structures referenced in this report can be seen on **Figure 1.1c**.

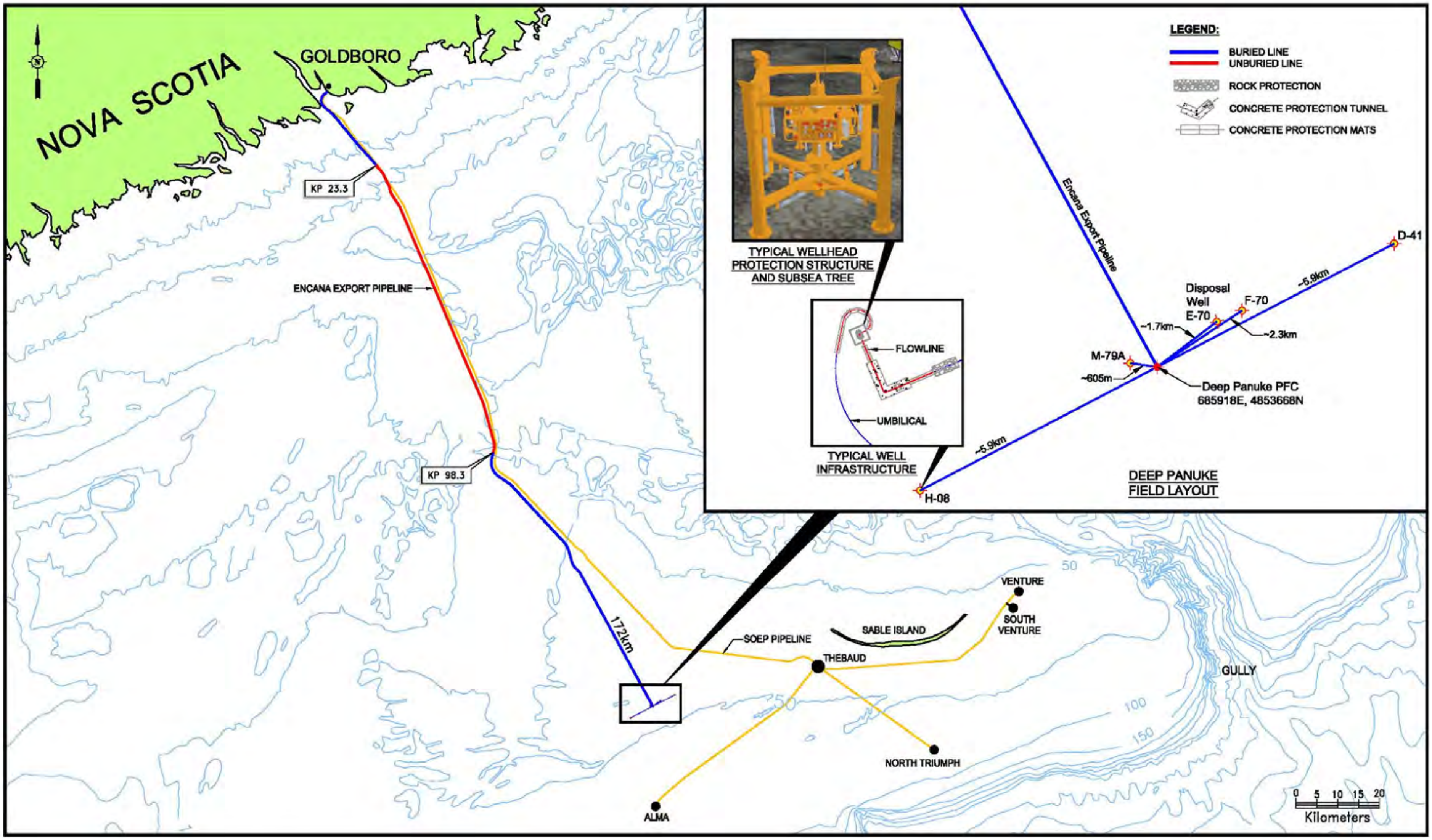


Figure 1.1a Deep Panuke Subsea Production Structures - General Overview (From Offshore Production EEMP - May 21 2011)

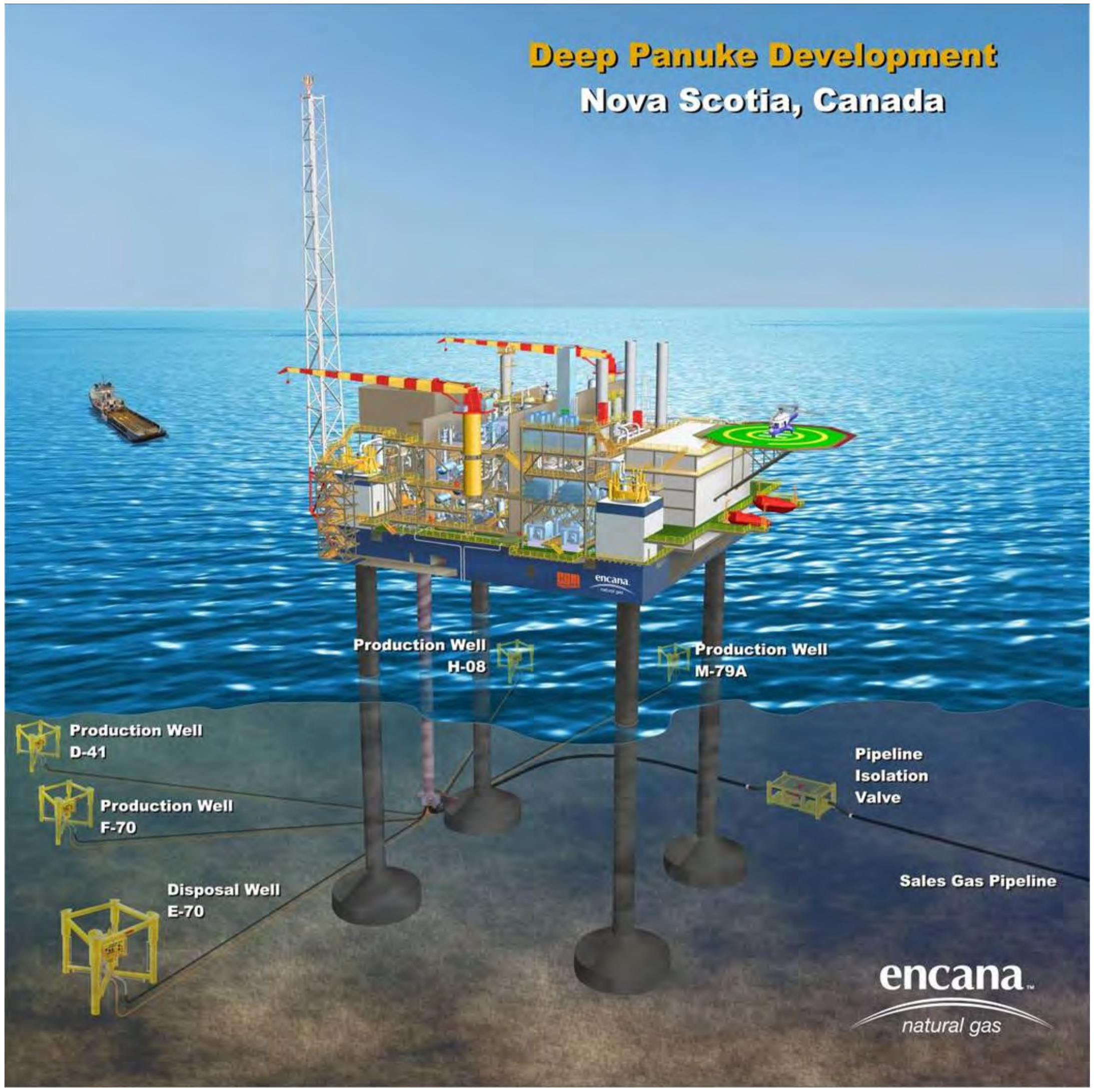


Figure 1.1b Deep Panuke Production Field Centre Rendering (From Offshore Production EEMP - May 21 2011)

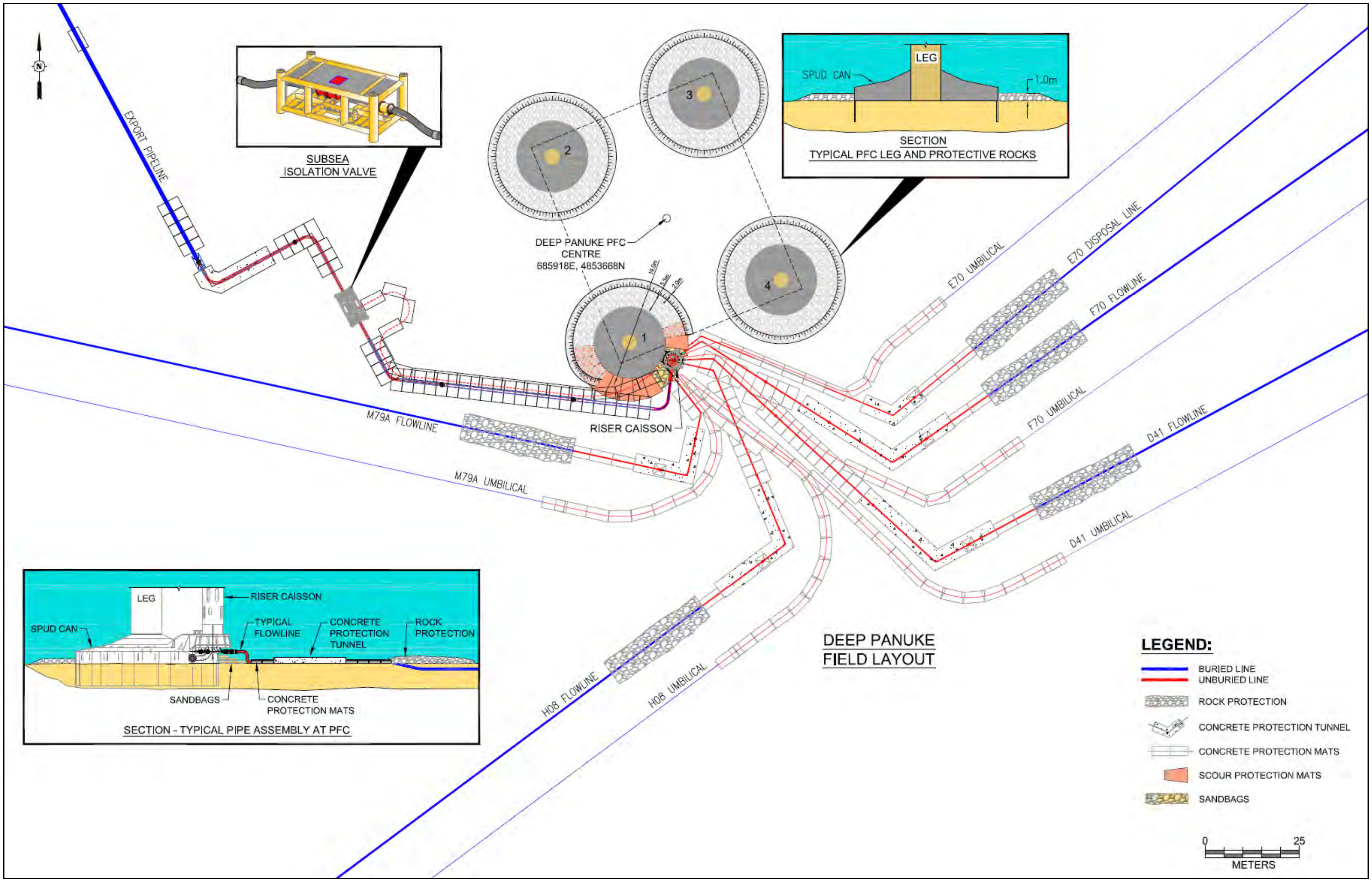


Figure 1.1c Deep Panuke Subsea Production Structures - PFC Area (From Offshore Production EEMP - May 21 2011)

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 & 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, 1992).

There is 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.

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 30 mg/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 25 mg/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.

Formation water was not produced in 2013. However, water of condensation is present in the gas and drops out during gas processing. This water was discharged through the produced water system starting on September 8, 2013, mostly as batch releases. Produced water quality and toxicity monitoring will start in 2014.

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 goes down the seawater discharge caisson located in the PFC SE leg and is 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.

It should be noted that the Offshore Production EEMP included the following areas of collaborative research with DFO COOGER under the Marine Water Quality Monitoring and Fish Health Assessment components:

- apply contaminant dispersion/risk assessment models (DREAM/EIF) using sampling results and physical oceanographic data to research environmental risk from produced water discharge and to identify the major components of concern;
- run in situ (lab) biodegradation studies to research persistence of contaminants of concern; and
- refine assay methodology to research fish egg fertilization success and development using produced water from the Deep Panuke PFC.

In 2013, COOGER have advised that with the recent changes in COOGER structure/mandate, they are not able to collaborate on the EEM work previously discussed. They are no longer using the DREAM model or conducting research on biological effects of contaminants. These research collaboration initiatives were put forward in the EEMP because of COOGER's active engagement in produced water research activities at the time, including collaboration with other local operators. In this context, Encana volunteered to contribute to this work. Because COOGER is no longer conducting this research, Encana will not pursue a collaborative research agreement in these areas. However, Encana will be conducting the monitoring components from the EEMP to verify environmental impact assessment predictions related to water quality and fish health, including water quality sampling and mussel and fish testing. This approach was approved by the CNSOPB in December 2013.

2.2.2 EEMP Goal

- To validate predictions regarding water quality dispersion made in the 2006 Deep Panuke 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 in seawater samples collected at sites in the vicinity of the PFC.

2.2.4 Sampling

No sampling took place in 2013 since start of production was postponed and resulting produced water discharges didn't start until September 2013, mostly as batch discharges. This limited discharge history is not expected to result in detectable levels of contaminants in the environment. The Water Quality Monitoring Program will resume in 2014.

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 1,000 m 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 250 m, 500 m and 1,000 m) 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 2013, since start of production was postponed and resulting produced water discharges didn't start until September 2013, mostly as batch discharges. This limited discharge history is not expected to result in detectable levels of contaminants in the environment. The Sediment Chemistry Monitoring Program will resume in 2014. Section 6.3.5 from the EEMP indicates that sampling at the wellhead locations may be discontinued after one year if the results show no signs of contamination from drilling and completion activities. The 2011 chemistry and toxicity survey (no samples were collected in 2012 or 2013 because of production delay) clearly concluded that all metal, non-metal, hydrocarbon and nutrient concentrations were found to fall below threshold levels as defined by the Canadian EQG and that all collected sediments were non-toxic. Therefore, sampling at the wellhead locations will be discontinued for the 2014 sediment chemistry and toxicity survey. The program will focus on the sampling locations downstream and upstream of the PFC site (i.e. 4 near-field sites at 250, 500, 1,000 and 2,000 m downstream of PFC along prevalent current direction (SW) and 2 far-field reference sites at 5,000 m upstream and downstream).

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 2013 since start of production was postponed and resulting produced water discharges didn't start until September 2013, mostly as batch discharges. This limited discharge history is not expected to result in detectable levels of contaminants in the environment. The Sediment Toxicity Monitoring Program will resume in 2014. Sampling at the wellhead locations will be discontinued in 2014 and the program will focus on the sampling locations downstream and upstream of the PFC site (i.e. 4 near-field and 2 far-field reference sites) (see section 2.3.4).

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 cunners), and occasionally by crustaceans (*e.g.* Jonah crabs). Sea stars, sea anemones and hydroids 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 main commercial-sized crustacean species commonly observed near/on exposed sections of the SOEP subsea pipeline to shore. Cunners and pollock were the 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 1,000 m of drill sites, most commonly within the 50 m to 500 m 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 20 m from the drill site for subsea release of cuttings and with a base radius of between 30 m – 160 m 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 well sites. 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. Compare species found and coverage of structures to previous years.

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 2013) and of the PFC area (summer 2013) 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 general visual inspection (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. 2013 data was compared to the 2012 video data (spring and fall 2012 for the wellheads and fall 2012 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 (winter 2013) 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.

2.5.5.3 GEP and Flowlines

Videos of the export pipeline subsea inspection survey (August and September 2013) 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 ~250 to ~500 m each from KP 23 to 98 (exposed GEP) from the 2013 survey data (same locations as surveyed in 2011 and 2012) 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. Colonial species were also given abundance values (*e.g.* encrusting algae and encrusting sponges) as they are not able to be quantified.

Video was sub-sampled 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 and 2012 surveys.

Areas of the GEP and flowlines that were outside the sub-sampled area of exposed GEP from KP 23 to KP 98 were also reviewed. Remaining pipe from KP 10 to KP 22, KP 126 to KP 137 and KP 166 to KP 168, and flowlines (coming from wellheads H-08, M-79A, E-70, F-70 and D-41) were reviewed and divided into exposed and buried pipe, and bottom types for the buried sections (*e.g.* covered in sand or rock). Abundance values were then given for each segment (SACFOR scale; Joint Nature Conservation Committee, 2011) and summarized into characterizing species for each bottom type.

2.5.6 Analysis QA/QC

All identifications were agreed upon by two taxonomists and compared to species from the 2011 and 2012 reports for reference. All structures shown in the video were identified using the commentary (if present - no commentary was available for WHPS D-41) on the video for validation.

2.5.7 Results

2.5.7.1 Subsea Structures

- Abundances and species present were comparable to the 2012 survey of the WHPS at each location. Common species observed include the dominant blue mussel *Mytilus edulis*, the hydroid *Tubularia* spp., the orange-footed sea cucumber *Cucumaria frondosa*, the frilled anemone *Metridium senile*, and the sea star *Asterias vulgaris*.
- Zonation was observed occurring on each WHPS in different locations. The bottom zone was mainly colonized by mussel (*Mytilus edulis),* sea cucumbers (*Cucumaria frondosa*) and hydroids (*Tubularia* spp.) in varying densities, and the top zone was colonized mainly by blue mussels (*Mytilus edulis*) and frilled anemone (*Metridium senile)* (**Tables 2.2 and 2.3; Figure 2.1a-e**). Dense mussels extended from 0.5-4.0 metres above the seafloor to the top of the structure. Total fouling of the WHPS was estimated to be between 85% to 95% for all structures. Significantly higher abundances of *Mytilus edulis* and *Metridium*

senile were observed, and less *Tubularia* was found, in 2013 than in 2012 (**Tables 2.2 and 2.3**).

- Sculpin (*Myoxocephalus* sp.) was the only fish species that lives on the sea bottom on the WHPS.
- In the summer 2013 survey of PFC legs, dense mussels (*Mytilus edulis*) and hydroids (*Tubularia* spp.) were observed over entire legs, whereas high abundances of *Cucumaria frondosa* and *Asterias vulgaris* were found on the sea bed around the legs (**Table 2.4**).

Table 2.2 Spring 2013 Survey of GVI of WHPS

Wellhead Site	Structure	Fauna	2012 Abundance	2013 Abundance	2013 Number	Description
E-70	WHPS (May)	*Mytilus edulis*	A	S	-	Mussels begin at 3.0 m on legs and covering inside of structure
		Asterias vulgaris	O	O	-	
		Metridium senile	F	A	-	Poor visibility
		Cucumaria frondosa	R	C	-	
		Tubularia? spp.	A	C	-	
F-70	WHPS (Mar)	*Mytilus edulis*	A	S	-	Mussels begin at 0.5 m on legs and covering inside of structure
		Asterias vulgaris	F	F	-	
		Metridium senile	C	A	-	
		Tubularia? spp.	A	F	-	
D-41	WHPS (May)	*Mytilus edulis*	C	S	-	Mussels begin at ~ 4 m on legs
		Asterias vulgaris	C	F	-	
		Metridium senile	C	A	-	
		Cucumaria frondosa	C	C	-	
		Tubularia? spp.	A	R	-	
	Subsea tree (May)	*Mytilus edulis*	-	F	-	Mussel coverage on an anode
		Asterias vulgaris	-	O	3	Little coverage, appeared to have been cleaned
		Metridium senile	A	F	-	
		Cucumaria frondosa	-	O	-	
		Tubularia? spp.	F	-	-	

* 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

Wellhead Site	Structure	Fauna	2012 Abundance	2013 Abundance	2013 Number	Description
H-08	WHPS	*Mytilus edulis*	S	S	-	Cunner are congregating at higher level of structure, pollock are around lower level. Mussels begin at 0.5 m on legs, inside and outside.
		Tautogolabrus adspersus	~70	A	~100	
		Metridium senile	C	A	-	
		Asterias vulgaris	R	F	-	
		Cucumaria frondosa	-	R	-	
		Tubularia? spp.	A	F	-	
		Myoxocephalus sp.	3	C	4	
		Polachius sp.	~100	A	~100	
M-79A	WHPS	*Mytilus edulis*	A	S	-	Cunner are congregating at higher level of structure, pollock are around lower level . Mussels begin at 2.0 m on legs
		Tautogolabrus adspersus	~150	A	~80	
		Metridium senile	C	A	-	
		Asterias vulgaris	C	F	-	
		Cucumaria frondosa	C	C	-	
		Tubularia? spp.	A	C	-	
		Campanulariidae? sp.	-	R	-	
		Myoxocephalus sp.	1	O	1	
		Polachius sp.	~100	A	~50	

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

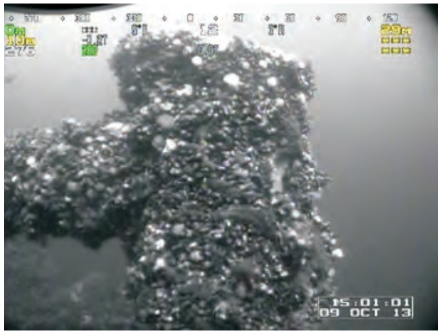
Table 2.4 Summer 2013 Survey of GVI of PFC legs (No 2012 data for comparison)

Wellhead Site	Structure	Fauna	2013 Abundance	2013 Number	Description
PFC Legs	VTS_12 (Jul)	*Cucumaria frondosa*	F	-	Few marine growth on concrete base and structure on it, with hydroid on pipes Sea stars and cucumbers in patches on the base
		Asterias vulgaris	C	-	
		Tubularia? spp.	A	-	Dense mussels covering entire leg
		Mytilus edulis	S	-	
		Metridium senile	F	-	High abundance of *Cucumaria frondosa* and *Asterias vulgaris* on sea bed
	VTS_13 (Jul)	*Cucumaria frondosa*	R	-	Poor visibility Few marine growth on concrete base and structure on it, with hydroid on pipes
		Asterias vulgaris	C	-	
		Tubularia? spp.	A	-	Dense mussels covering entire leg
		Mytilus edulis	S	-	
		Metridium senile	F	-	High abundance of *Cucumaria frondosa* and *Asterias vulgaris* on sea bed
		Myoxocephalus sp.	O	2	
	VTS_14 (Jul)	*Cucumaria frondosa*	R	-	Poor visibility Few marine growth on concrete base and structure on it, with hydroid on pipes
		Asterias vulgaris	C	-	
		Tubularia? spp.	A	-	Dense mussels covering entire leg
		Mytilus edulis	S	-	
		Metridium senile	F	-	High abundance of *Cucumaria frondosa* and *Asterias vulgaris* on sea bed
	VTS_15 (Jul)	*Cucumaria frondosa*	R	-	A few hydroids and sea starson concrete base and structure on it
		Asterias vulgaris	C	-	Dense mussels covering entire leg
		Tubularia? spp.	A	-	

Wellhead Site	Structure	Fauna	2013 Abundance	2013 Number	Description
		Mytilus edulis	S	-	High abundance of *Cucumaria frondosa* and *Asterias vulgaris* on sea bed
		Metridium senile	F	-	
		Myoxocephalus sp.	O	2	
	VTS_16 (Jul)	*Cucumaria frondosa*	R	-	Poor visibility
		Asterias vulgaris	C	-	Few marine growth on concrete base and structure on it, with hydroid on pipes
		Tubularia? spp.	A	-	Dense mussels covering entire leg
		Mytilus edulis	S	-	
		Metridium senile	F	-	High abundance of *Cucumaria frondosa* and *Asterias vulgaris* on sea bed
SSIV	SSIV (Jul)	*Cucumaria frondosa*	C	-	Abundant A*sterias vulgaris* on sea floor
		Asterias vulgaris	F	-	Dense hydroids covering entire structure
		Tubularia? spp.	S	-	
		Campanulariidae? sp.	C	-	
		Mytilus edulis	A	-	
		Myoxocephalus sp.	C	2	
		Tautogolabrus adspersus	A	~10	

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

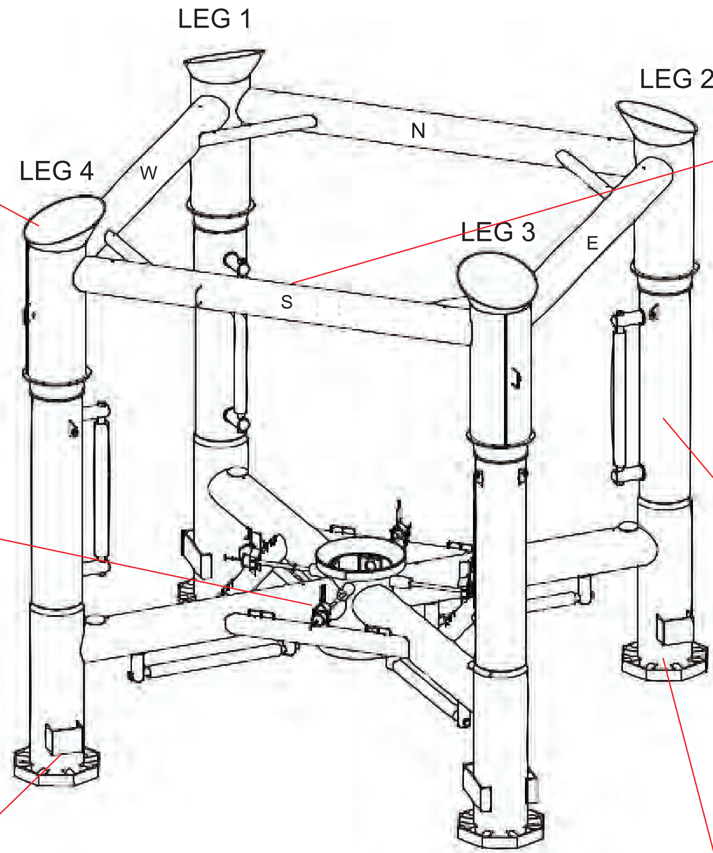
Station H-08



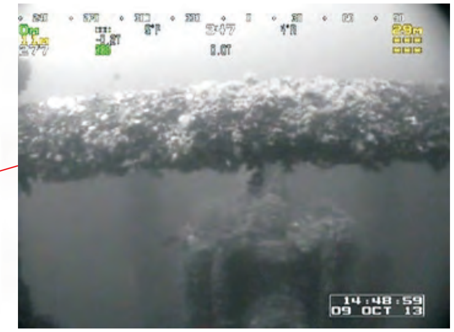
Dense coverage of blue mussels, sea anemones and hydroids at the top of Leg 4

Dense blue mussel coverage on the inside of the WHPS

Dense coverage of blue mussel with some sea anemones at the base of Leg 4



Wellhead Protection Structure



South horizontal brace densely colonized by blue mussels and sea anemones.

Leg 2 densely covered in blue mussel

Blue mussel and sea anemone coverage at the base of Leg 2, HB01-2 and AN02

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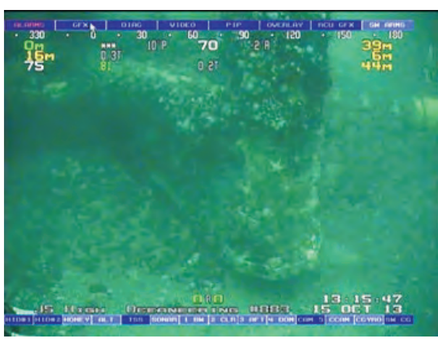
Figure 2.1a Wellhead Protection Structures and Associated Fauna at H-08

Figure 2.1a

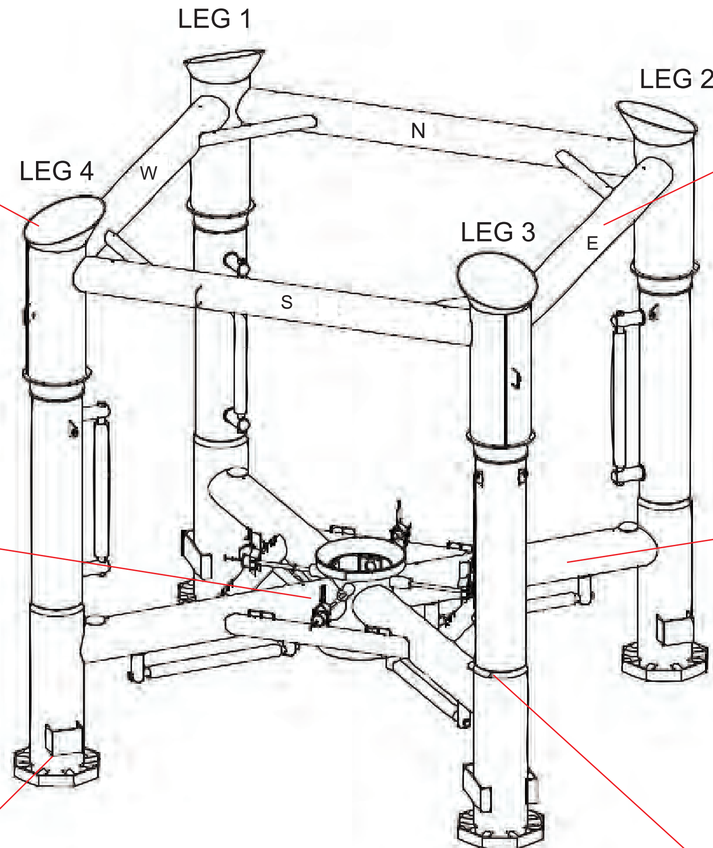
Station M-79A

Blue mussel, sea stars, sea anemones and hydroids colonizing the top of Leg 4

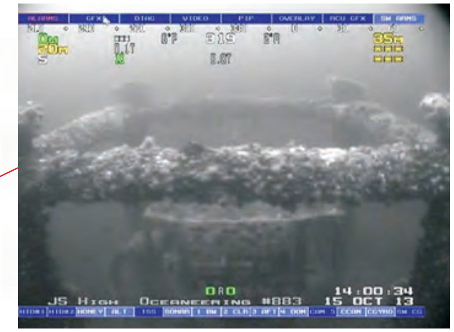
Blue mussels and sea cucumber at the base of the Subsea Tree



Blue mussels, sea stars and sea anemones at the base of Leg 4



Wellhead Protection Structure



East horizontal bracket with blue mussels and hydroids

Horizontal bracket HB01-2 with hydroids and blue mussel

Sparse marine growth, consisting of sea stars and sea cucumbers at the base of Leg 3

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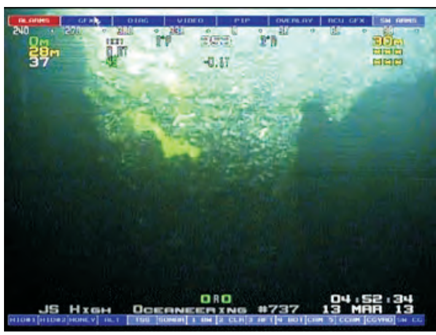
Figure 2.1b Wellhead Protection Structures and Associated Fauna at M-79A

Figure 2.1b

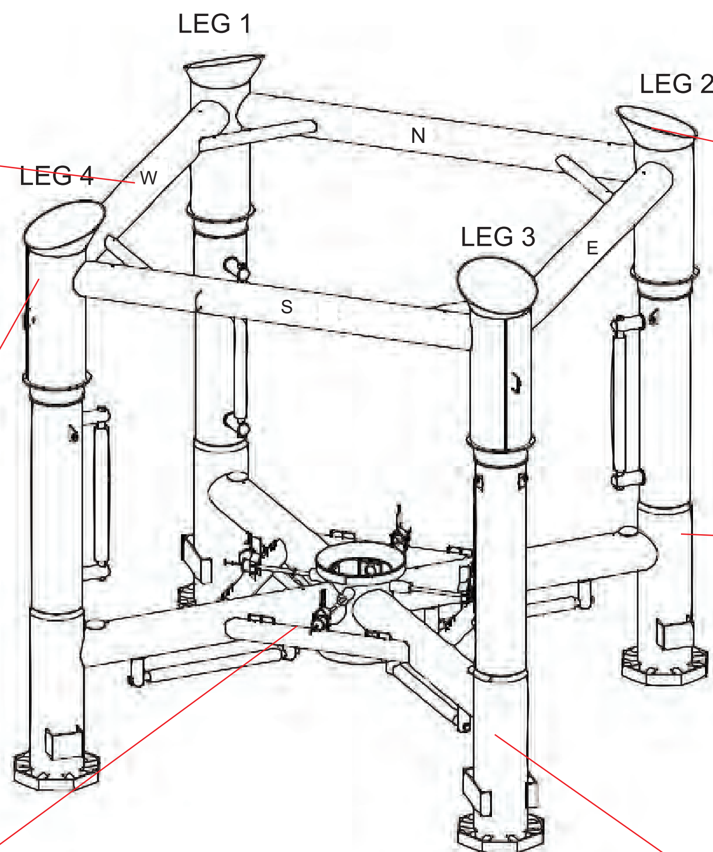
Station F-70

West horizontal bracket densely colonized by blue mussels with sea stars and anemone.



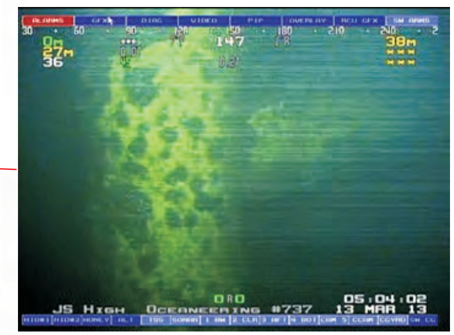
The top of Leg 4, colonized predominantly by blue mussel

Dense blue mussel coverage, with sea stars on base of Leg 4

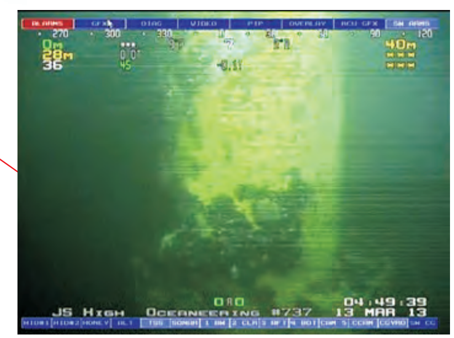


Wellhead Protection Structure

Dense blue mussels, hydroids, sea stars and sea anemones at the top of Leg 4



Patches of blue mussel near the base of Leg 4



Sparse marine growth at the Base of Leg 3. Some patched of blue mussels and sea cucumbers.

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

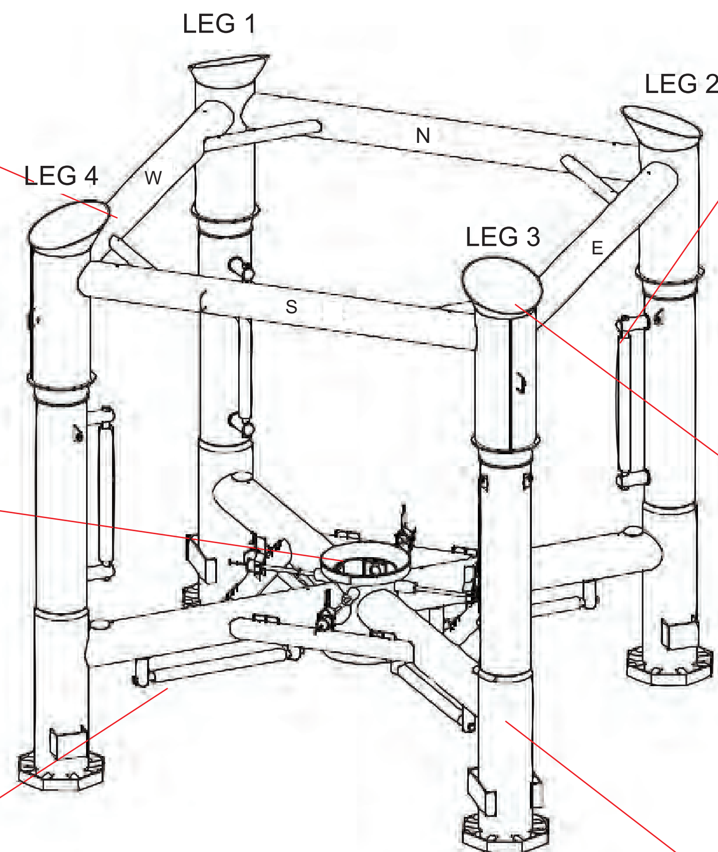
Figure 2.1c

Station D-41

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

Inside of WHPS with large patches of sea anemones

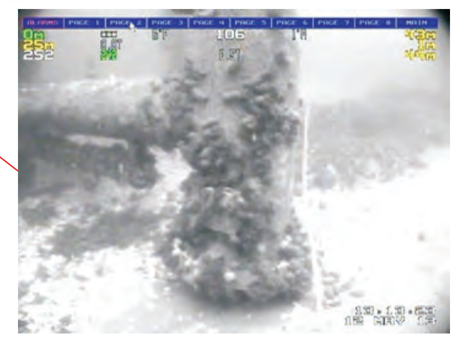
Dense blue mussel coverage on an anode



Wellhead Protection Structure

Blue mussel, sea stars and sea anemones on the upper portion of a leg

Patches of blue mussel and sea anemones at the top of a leg



Sea cucumbers on the base of a leg

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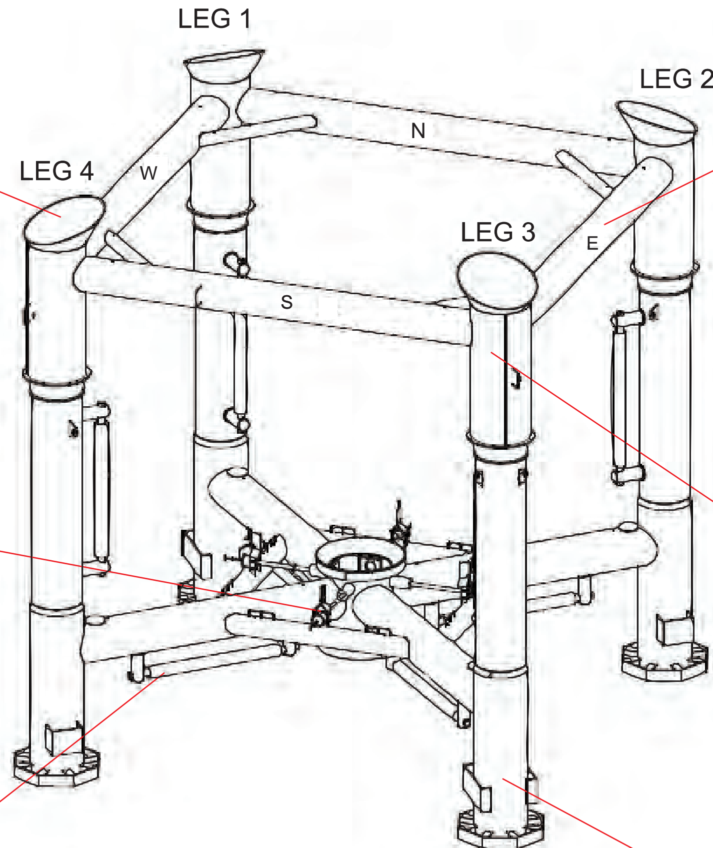
Figure 2.1d Wellhead Protection Structures and Associated Fauna at D-41

Station E-70

Patches of blue mussels and sea anemones, with the occasional sea star at the top of Leg 4

Blue mussel and sea anemones near the base of the Subsea Tree

Blue mussel colonizing anode AN04



Wellhead Protection Structure

Abundant blue mussel growth with hydroids on the East horizontal bracket

Patches of blue mussel with hydroids and anemones at the top of Leg 3

Patches of blue mussels with a few sea anemones near the base of Leg 3

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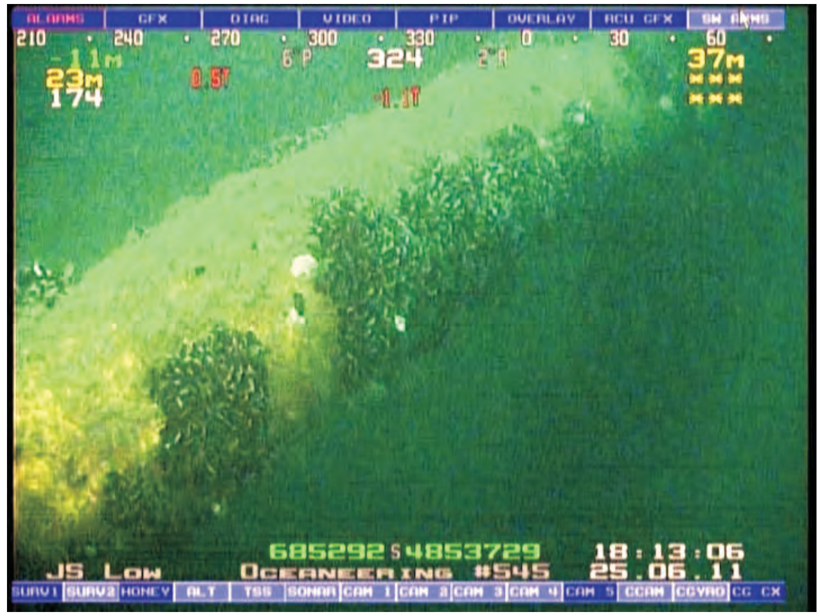
Figure 2.1e Wellhead Protection Structures and Associated Fauna at E-70

2011 Survey

Moderate marine growth on East horizontal bracket at WHPS M-79A in 2011 survey



2012 Survey

Significant growth of marine fauna on East horizontal bracket at WHPS M-79A in 2012

2013 Survey

Significant growth and ~100% coverage of marine fauna on the East Horizontal brackets at WHPS M-79A in 2013

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2011 Survey

Blue mussel growth starting at 4 metres above the seafloor on Leg 2 at WHPS F-70 in 2011 survey

2012 Survey

Similar growth on Leg 2 in 2012 survey

2013 Survey

More dense blue mussel growth and coverage on Leg 2 at WHPS F-70 in the 2013 survey.

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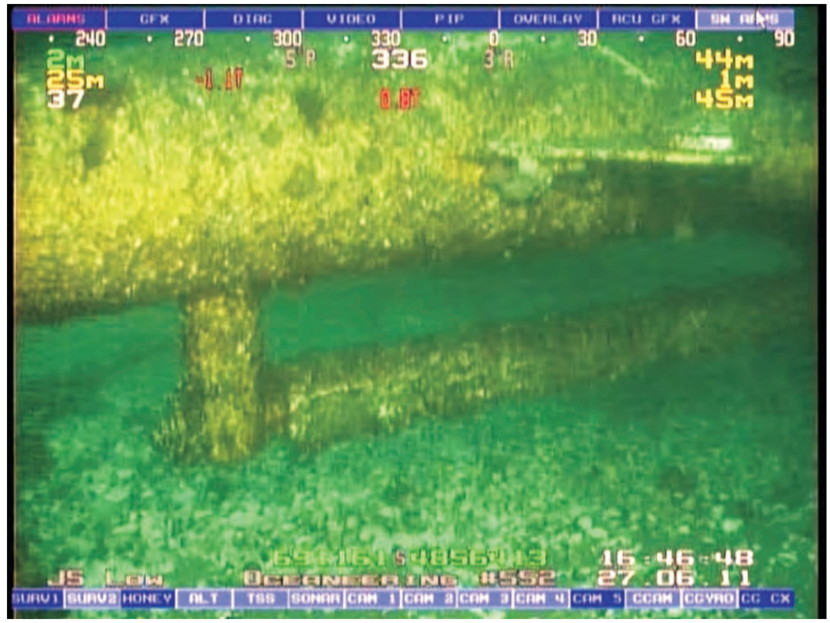
 Comparison of 2011, 2012 and 2013 Surveys at WHPS F-70 Figure 2.2

2011 Survey

Little marine growth at base of Leg 4 and HB01-4 at WHPS D-41 in 2011 survey



2012 Survey

Similar sparse marine growth at D-41 in 2012

2013 Survey

Similar sparse marine growth at a the base of a leg of WHPS D-41. Possible cleaning may have taken place as evidence by the organisms on the surrounding sea floor.

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Figure 2.2 Comparison of 2011, 2012 and 2013 Surveys at WHPS D-41

2.5.7.2 Cuprotect Coated Structures

- No mussels were observed in fall 2012 survey, but the mussel species *Mytilus edulis* was the most dominant species on PFC structures in winter 2013 (**Table 2.5**).
- Dense mussels and hydroids covered most part of PFC structure. On Cuprotect coated structure, however, mussels and hydroids covered only straps of Cuprotect coated structure, and little marine growth was observed on insulation covers with Cuprotect coating. One exception was growth on the flowline of D-41 where a hydroid was colonizing on a Cuprotect covered area in the 2012 survey and continues to colonize there with mussel in the 2013 survey (**Figures 2.3 and 2.4**).
- Sculpin were found in 2013 but not in 2012.

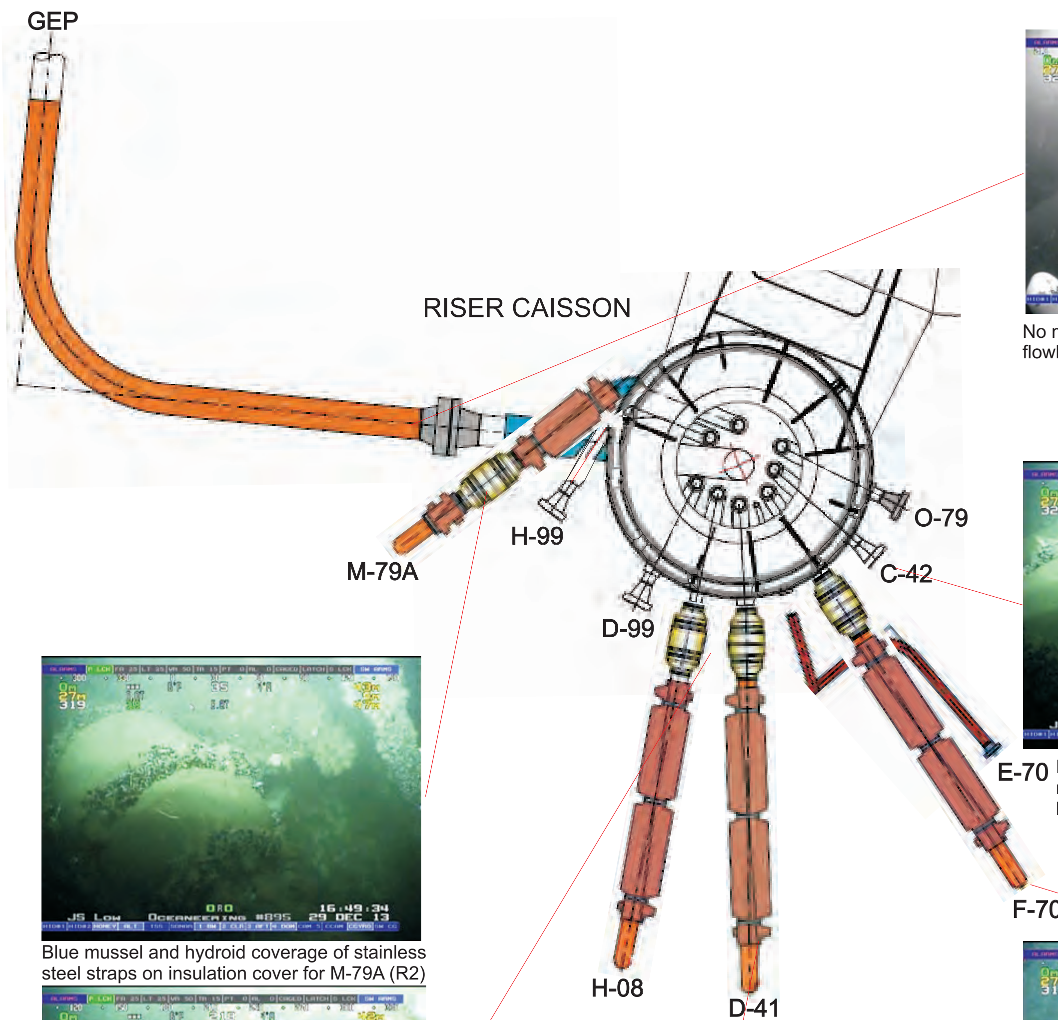
Table 2.5 Cuprotect Coated Structures Winter 2013

Wellhead Site	Structure	Fauna	2012 Fall Abundance	2013 Abundance	2013 Number	Description
PFC	Closing Spools (Dec)	*Cucumaria frondosa*	C	F	-	Poor visibility Dense mussels and hydroids covering entire upper structure
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	O	C	-	
		Myoxocephalus sp.	-	A	10	
		Pollock	-	-	-	
	Cuprotect Coated structure	*Cucumaria frondosa*	R	-	-	Dense mussels and hydroids only on straps, and little marine growth on insulation covers with cuprotect coating
		Tubularia? spp.	C	A	-	
		Mytilus edulis	-	S	-	
		Myoxocephalus sp.	–	C	2	
	Base of rising caisson	*Cucumaria frondosa*	O	-	-	Dense mussels and hydroid over entire structure
		Tubularia? spp.	A	A	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	O	O	-	
		Polachius sp.	85	-	-	
	Protection Tunnel (M-79A)	*Cucumaria frondosa*	C	-	-	Dense mussels and hydroids start at 1.0 m on the tunnel Less patches on the bottom part of the tunnel
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Cancer sp.	-	O	1	
		Myoxocephalus sp.	-	O	2	
		Unid. Fish	2	-	-	

Wellhead Site	Structure	Fauna	2012 Fall Abundance	2013 Abundance	2013 Number	Description
	Protection Tunnel (H-08)	*Cucumaria frondosa*	C	-	-	Mussels and hydroids in dense patches
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	R	-	-	
		Unid. Fish	1	-	-	
	Protection Tunnel (D-41)	*Cucumaria frondosa*	C	-	-	Mussels and hydroid in dense patches
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	-	O	-	
	Protection Tunnel (F-70)	*Cucumaria frondosa*	C	-	-	Mussels and hydroids in dense patches
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Myoxocephalus sp.	-	O	1	
		Unid. Fish	2	-	-	
	Protection Tunnel (E-70)	*Cucumaria frondosa*	C	-	-	Mussels and hydroids in dense patches
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Unid. Fish	1	-	-	

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

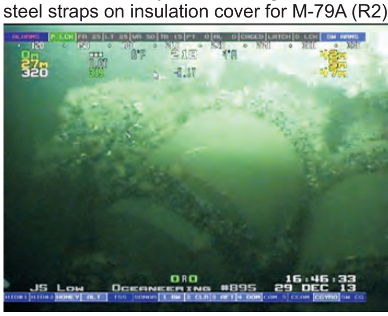
PFC Subsea Riser Caisson



No marine growth on Cuprotect coating of GEP flowline

Future flange cap (right) covered in marine growth (blue mussels and hydroids)

Blue mussel and 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)

Blue mussel and hydroids on the straps of the suppression strakes and insulation cover at D-41 (R6)

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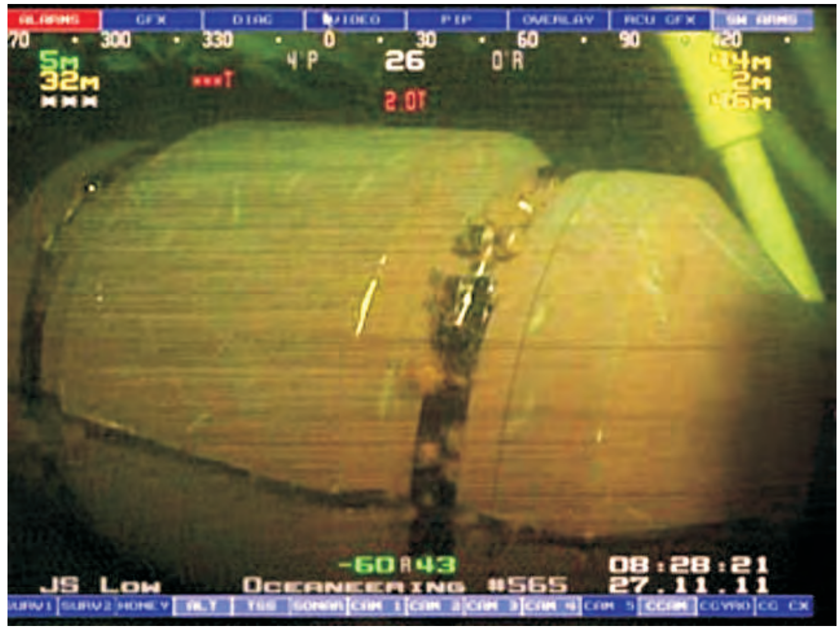
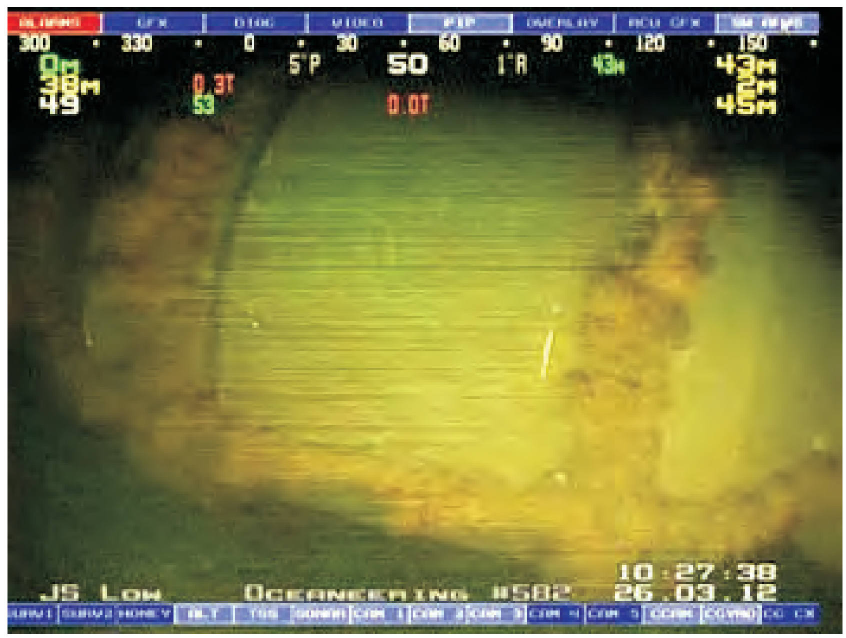
2011 Survey

Tubularian hydroids sparsely colonizing straps of insulation cover of flowline M-79A in the 2011 survey



2012 Survey

Significantly greater colonization of Tubularian hydroids on straps of insulation cover M-79A flowline in 2012



2013 Survey

Similar coverage for colonization on the straps of the insulation cover for the M-79 flowline in 2013. The organisms colonising have changed from hydroids to primarily blue mussel.

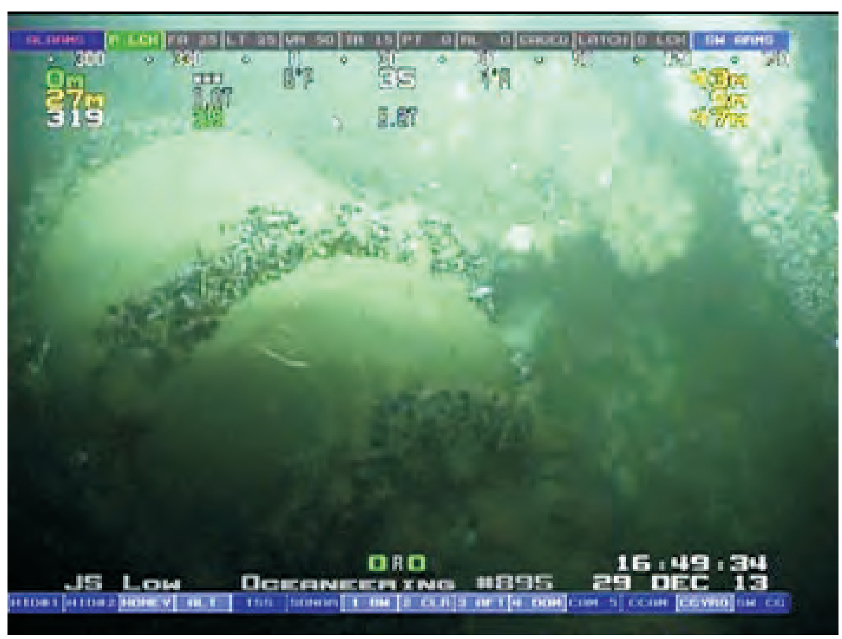


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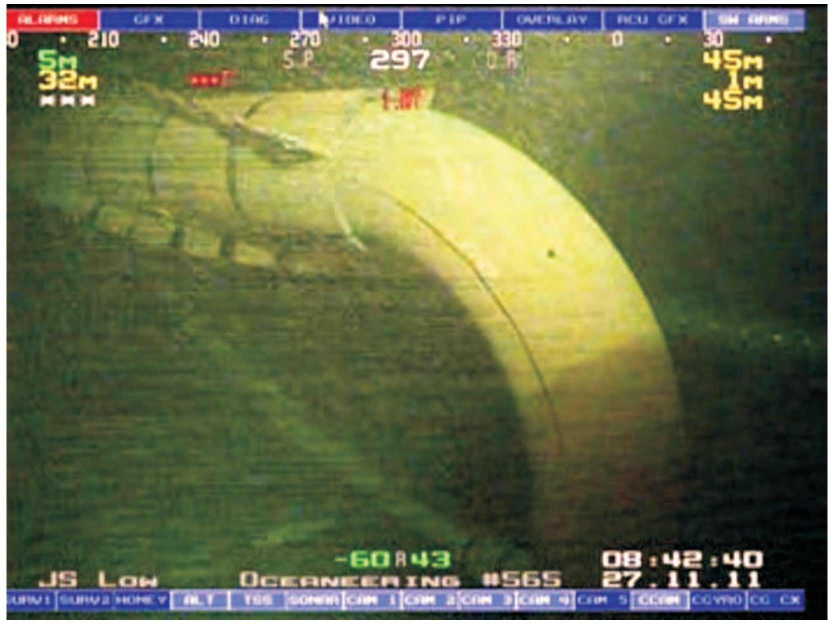
Figure 2.4 Comparison of Cuprotect Coated Structures between 2011, 2012 and 2013 Surveys Figure 2.4

2011 Survey

Absence of Tubularian hydroids on suppression strakes of D-41 in 2011 survey

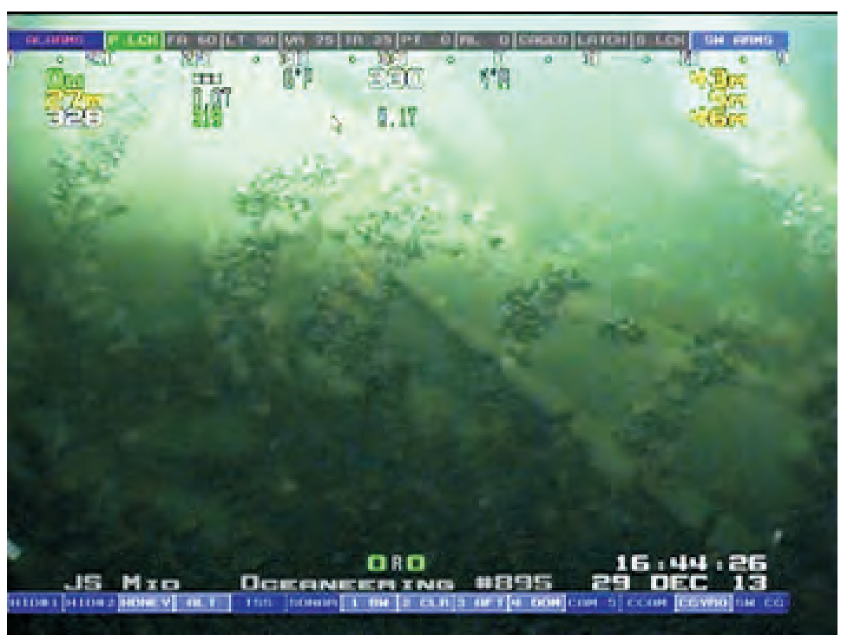


2012 Survey

Colonization of Tubularian hydroids on 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

2013 Survey

Colonization of blue mussel and hydroids on the suppression strakes of D-41 in the 2013 survey. The majority of colonization is on the straps, but some hydroids starting to colonize inbetween



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2011 Survey

Moderate coverage of future flange cap R-8 by hydroids in 2011

2012 Survey

Increases coverage of future flange caps R-8 and R-9 by hydroids in 2012 survey

2013 Survey

100% coverage of a future flange cap. Increased blue mussel colonization with hydroids interspersed in the 2013 survey

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Figure 2.4   Comparison of Cuprotect Coated Structures between 2011, 2012 and 2013 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 2.11**);
- Redfish showed an increase in numbers from the 2012 to 2013 survey (10914 in 2012; 14178 in 2012) throughout the stretch of exposed pipeline from KP 23 to KP 98. These fish were commonly found wherever the pipeline created a hollow pocket in the seafloor (**Figure 2.7**); it should also be noted that redfish numbers are likely higher than reported, as they are primarily found at the base of the pipe where a shadow is created, depending on how the lights are adjusted on the ROV. At times the base of the pipe was not visible on video because of the shadow, making fish and other species difficult to see.
- Numbers of Atlantic cod (**Figure 2.7**) showed an increase in numbers from 502 individuals in 2012 to 612 individuals in 2013. This may be due to the migrational nature of the Atlantic cod population on the Scotian Shelf, as the video was recorded in July/August of 2012 and August/September of 2013. Similar to redfish, cod are primarily found at the base of the pipe, and the same lighting issues may be a factor in the number observed. It is also notable that it is often difficult to distinguish gadoids (the family Gadidae which includes cod, haddock and pollock) on video.
- No flatfish (Pleuronectidae) were found in the 2013 survey. Based on numbers from the 2011 and 2012 surveys (62 individuals in 2011 and 10 individuals in 2012), this shows a decline in flatfish near the pipeline.
- A single Atlantic torpedo ray (*Torpedo nobiliana*) was found in the 2013 survey, ~2 KP from where the Atlantic torpedo ray was found in the 2012 survey (**Figure 2.7**).
- Snow crab (*Chionoecetes opilio*) were observed in 28 of 36 videos analyzed, totalling 1023 individuals sighted, which is similar to the 2012 survey which had 941 individuals appearing in 25 of the 36 videos. Jonah crab (*Cancer borealis*) were less abundant in 2013, with 1063 total individuals observed compared to 1367 total individuals in 2012. Hermit crab (*Pagurus sp.*) numbers decreased by close to 40% from 53 in 2012 to 32 in 2013, however, this may be due to video quality, as many hermit crabs are small in size. Northern Stone crab (*Lithodes*

maja) numbers increased by over 50%, having 47 individuals in 2012 and 102 in 2013.

- Like past survey years, crustaceans (**Figure 2.8**) were observed on video sitting on top of the pipe and climbing on it. However, an American lobster was found this year and not observed on top of, or climbing the pipe. Based on the video it is unclear whether the pipeline acted as a physical barrier for this individual (**Figure 2.11**).
- Commonly observed sea stars (*Asterias* sp. and *Henricia* sp.) were shown to decrease in total numbers by 35% in 2013. The small size of many of the sea stars inhabiting the pipeline makes it difficult to obtain exact numbers. Superior video quality in 2012 may be a factor in difference in numbers. As mentioned in the 2012 survey report, common sea star numbers went up by almost 150% compared to 2011, possibly due to video quality, making comparison between the annual surveys difficult to interpret;
- Comparison of faunal diversity by major group between the 2011, 2012 and 2013 surveys are shown in **Figure 2.6**. The graphs indicate a similar abundance of organisms for many species groups across the 8 transects selected. Notable differences are the decrease in echinoderm numbers at KP 93, 83 and 63, mentioned in the previous point, and an increase in fish numbers at KP 73 and 83. Additionally, Anthozoa (mainly sea anemones) increased at KP 83, and crustaceans decreased at KP 93.
- A notable event from the stretch of exposed pipe from KP 23 to 98 surveys was the presence of a basking shark carcass. The basking shark was found at KP 40.75 on September 13, 2013. The basking shark (*Cetorhinus maximus*) (considered as Endangered under SARA and COSEWIC) carcass appeared to be tangled in a rope of ~1cm diametre likely used for fishing, and resting on top of the pipe (**Figure 2.9**). This observation was reported to the CNSOPB, DFO and the Marine Animal Response Society (MARS) upon discovery.
- Flowlines from the PFC to the wellheads are mostly buried, either with rock or sand. (**Figure 2.10**). Species were consistent across all five flowlines and common species included sea cucumber (*Cucumaria frondosa*), *Cancer sp*., sculpin/sea raven and sea stars. In the rocky areas, sea cucumbers were the most prevalent species, usually being super abundant. In sandy areas the most dominant species were sea stars, being frequent to abundant. The majority of the

video for the flowlines was of poor quality, so it was difficult to identify to a species or genus level.

- 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 on most exposed sections. Sea stars were commonly found on exposed areas of the GEP as well. Sea urchins and brittle stars were also common in some sections of exposed pipe. (**Figure 2.10)**;
- Buried sections of the GEP and flowlines were covered by either sand or rock (**Table 2.6**). The main epifauna found on sandy sections of the buried flowlines and GEP were sea stars, and the occasional Jonah crab (*Cancer borealis*) and sculpin or sea raven. Epifauna on the rocky sections of the GEP and flowlines were mainly sea cucumbers and sea stars, with the occasional fish, Jonah crab and snow crab. On exposed sections of the flowlines, as well as concrete protection mattresses, sea cucumbers were super abundant, with common sea stars and occasional crabs (*Cancer sp.*)(**Figure 2.10**).
- Notable species found in the sections of GEP from KP 1 to 23 and KP 98 to 168 were American lobster (*Homarus americanus*), Atlantic wolffish (*Anarhichas lupus*) and the solitary hydroid *Corymorpha sp.* None of these three species were found in the 36 video clips analyzed from the stretch of exposed pipeline from KP 23 to 98. The Atlantic wolffish is notable, as it is considered a species of special concern under the Species at Risk Act. In both wolffish sightings from the video they appeared to have a burrow at the base of the pipe (**Figure 2.11**)

Table: 2.6 Species abundances along flowlines by substrate type – Summer 2013

Flowline	Substrate	Species	Abundance
H-08	Rock	Sea star	C
		Sea cucumber	S
		Cancer sp.	F
		Unid. Fish	O
		Redfish	O
		Sculpin/Sea raven	F
	Sand	Sea star	C
		Unid. Fish	R
		Sculpin/Sea raven	O
		Cancer sp.	F
	Exposed Pipe	Sea cucumber	A
		Sea star	C

Flowline	Substrate	Species	Abundance
M-79A	Rock	Sea cucumber	S
		Sea star	C
		Cancer sp.	C
		Sculpin/Sea raven	F
	Sand	Sea cucumber	R
		Sea star	A
		Cancer sp.	O
		Sculpin/Sea raven	R
	Exposed pipe	Sea cucumber	S
		Sea star	F
F-70	Rock	Sea cucumber	S
		Cancer sp.	F
		Sculpin/Sea raven	O
		Sea star	C
	Sand	Sea star	C
		Cancer sp.	O
		Sculpin/Sea raven	O
		Sea cucumber	R
	Exposed pipe	Sea cucumber	S
		Unid. Fish	C
	Concrete mattress	Sea star	C
		Sea cucumber	A
		Cancer sp.	F
D-41	Rock	Sea cucumber	S
		Sea star	F
		Cancer sp	F
		Sculpin/Sea raven	O
	Sand	Sea cucumber	O
		Sea star	F
		Cancer sp	O
		Sculpin/Sea raven	O
	Concrete mattress	Sea cucumber	S
		Sea star	C
		Cancer sp.	F
E-70	Rock	Sea cucumber	S
		Sea star	F
		Cancer sp.	O
		Sculpin/Sea raven	O
	Sand	Sea star	F
		Unid. Fish	O
		Sea cucumber	F
		Cancer sp.	O
		Sculpin/Sea raven	O
	Concrete mattress	Sea cucumber	S
		Sea star	O
		Unid. Fish	F

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

2.5.8 Summary and Conclusions

2.5.8.1 Subsea Structures

- Epifauna colonization of WHPS at all well site locations observed varied little from the 2012 survey. Species composition was homogenous across all wellhead sites;
- Seasonal differences in the timing or surveys could account for differences in fish species at the WHPS and base of the riser caisson. In the fall 2012 survey pollock were observed at the base of the riser caisson , whereas the winter 2013 survey showed no pollock present.
- Wellheads and protective structures appear to continue to act as an artificial reef/refuge as evidenced by the continued 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

- The main colonizing species of epifauna on non-Cuprotect coated structures has changed from the hydroid *Tubularia sp.* in 2012 to the blue mussel *Mytilis edulis* in the 2013 survey. Non-Cuprotect coated structures around the base of the riser caisson include the future flange caps, sandbags and concrete protection mats, and the Inconel 625 steel straps which hold insulation covers in place; and,
- Structures with Cuprotect coating continue to be free of epifaunal growth, except possible hydroid colonization between suppression strakes on flowlines, notably D-41 (**Figure 2.4**).

2.5.8.3 GEP and Flowlines

- The GEP continues to act as an artificial reef to provide shelter and protection for many species of fish (*i.e.* Redfish and Atlantic cod) and invertebrates;
- Commercial fish species recorded from the video analysis were Atlantic cod, pollock, haddock, hake, herring, and redfish (**Figure 2.5, 2.7**);

- Commercial crustaceans observed in the analyzed video were snow crabs, Jonah crabs and American lobsters (snow crab being the most abundant) (**Figure 2.8**);
- Other commercial invertebrates observed include the orange-footed sea cucumber; and
- Like past survey years, crustaceans were observed on video sitting on top of the pipe and climbing on it. However, one American lobster was found next to the pipeline and it was not clear whether the pipeline acted as a physical barrier for this individual.

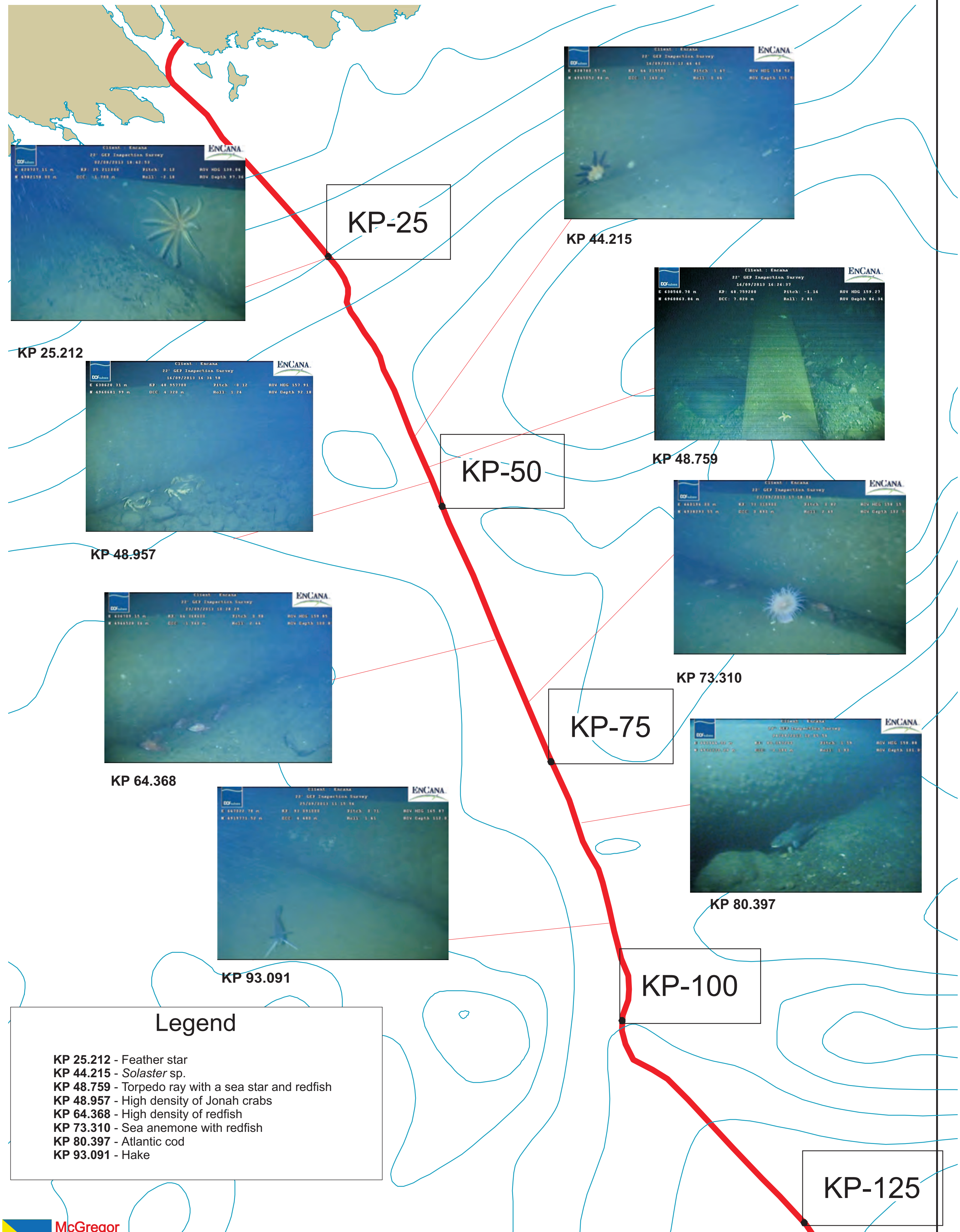

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Figure 2.5 Representative Stills from ROV Footage Along GEP Figure 2.5

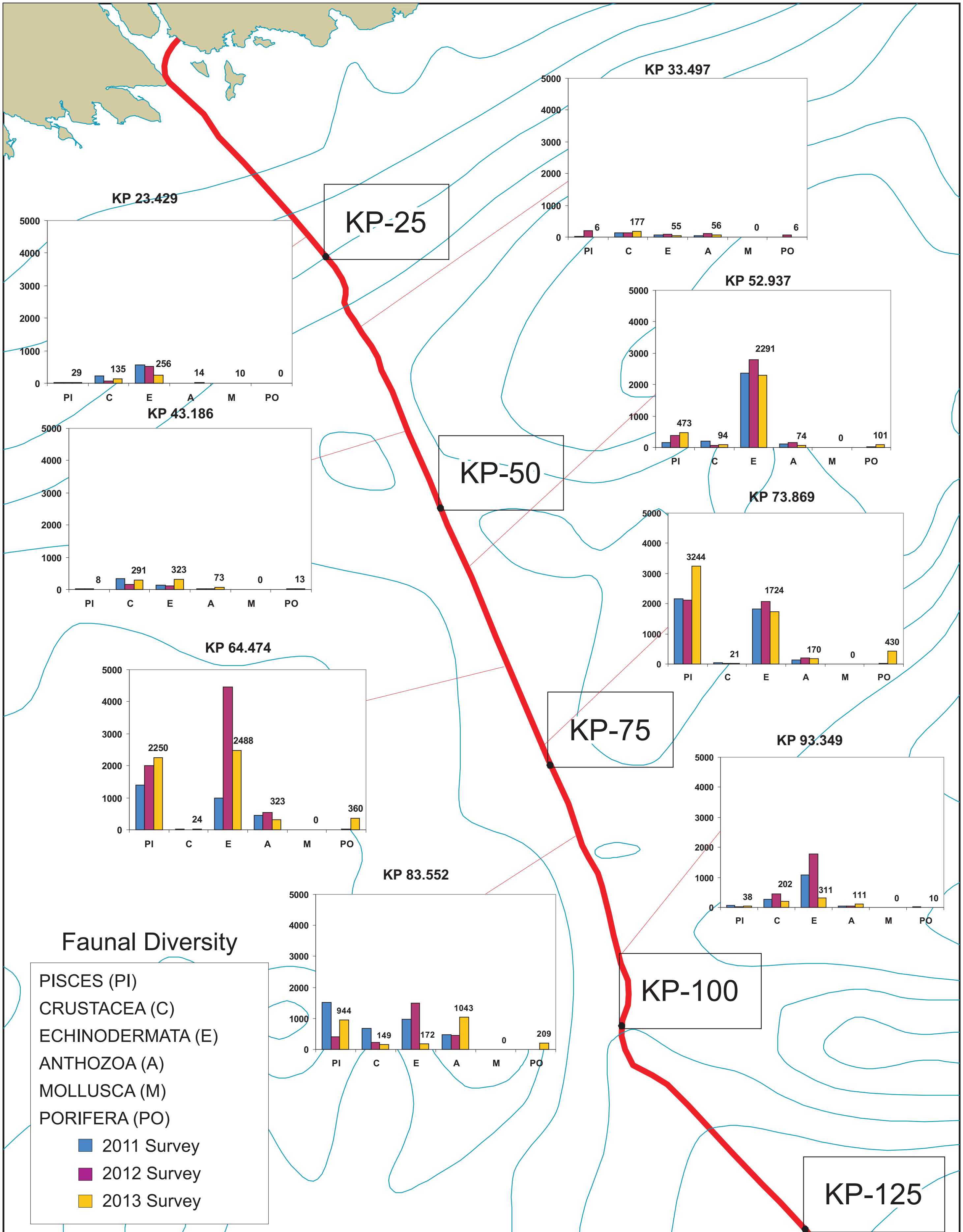

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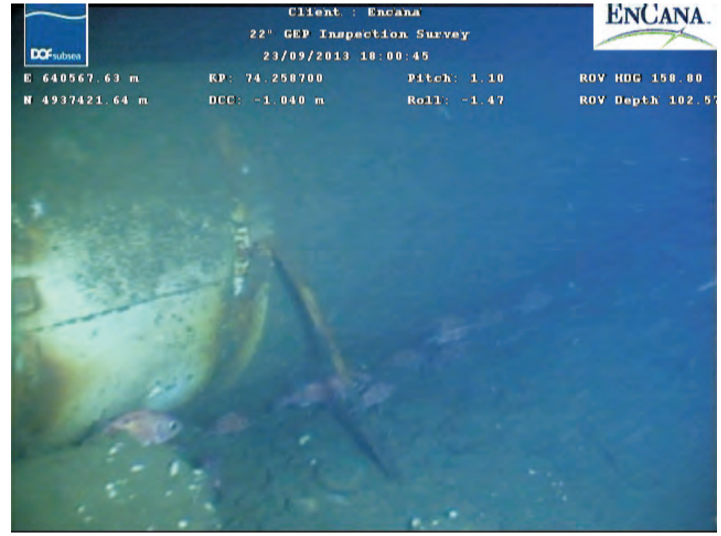
Figure 2.6 Standardized Faunal Composition of Exposed GEP at 10 km Intervals from 2011, 2012 and 2013 Surveys Figure 2.6

Atlantic cod at KP 44



High density of redfish at KP 74

Atlantic torpedo ray at KP 48 at a depth of 159 m

A cunner at the WHPS for M-79A

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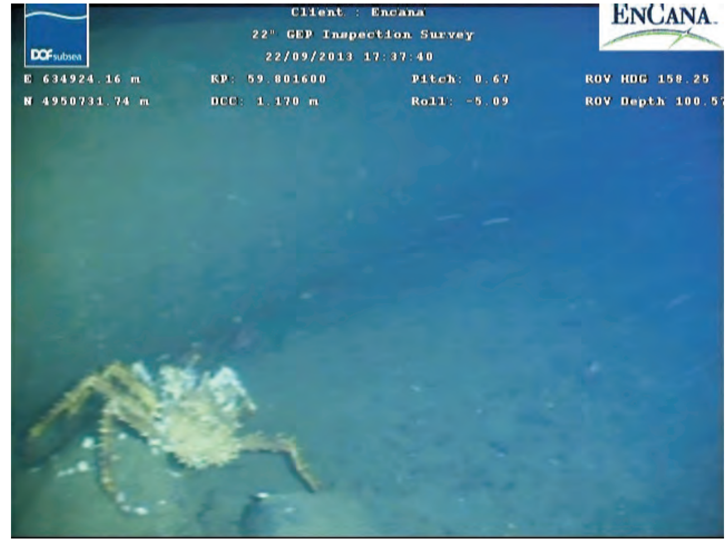
GeoScience
Limited

Figure 2.7 Fish diversity along the GEP pipeline and WHPS

Figure 2.7

A snow crab along the GEP at KP 46.525



A Northern Stone crab along the GEP at KP 59.801

A hermit crab along the GEP at KP 92.884

Jonah crabs along the GEP at KP 48.957

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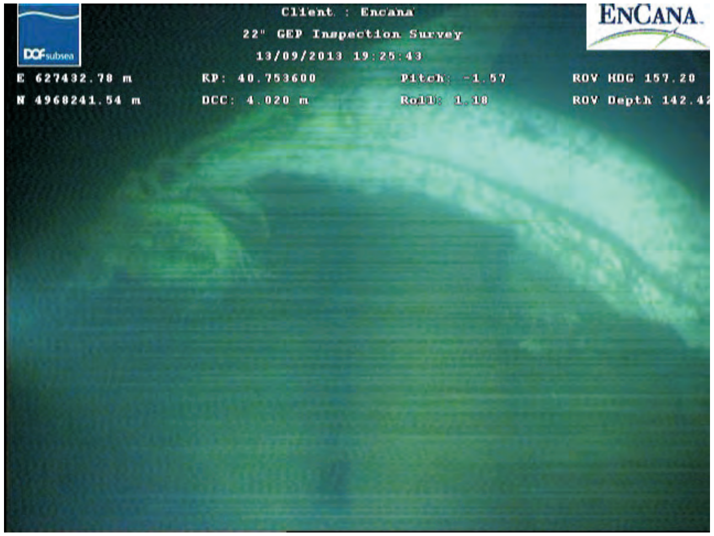
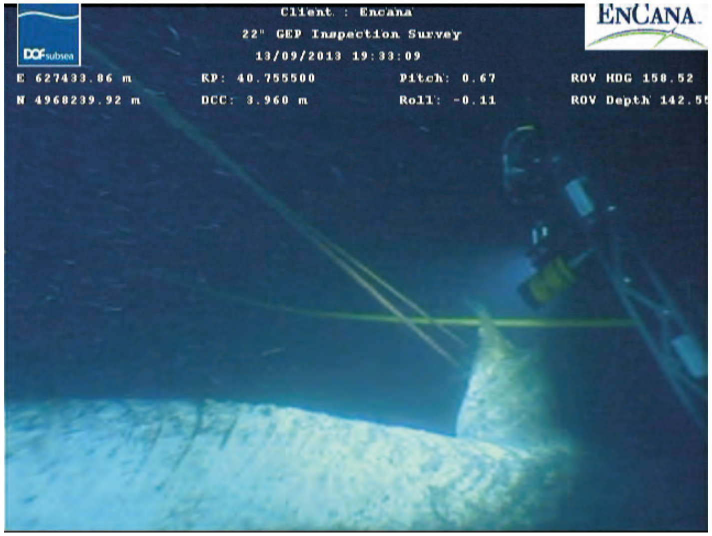
Figure 2.8 Crustacean diversity along the GEP

Figure 2.8

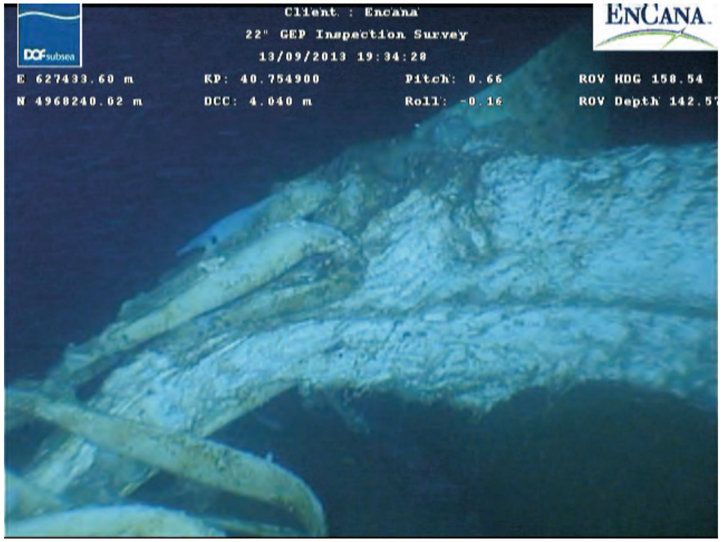


Approaching the basking shark carcass along the GEP at KP 40.753

A snow crab near the basking shark carcass. There were increased numbers of snow crab and Jonah crab in the vicinity



The line entangling the basking shark. It a appears to be a rope ~1cm in diameter



A close up of the decaying backing shark carcass

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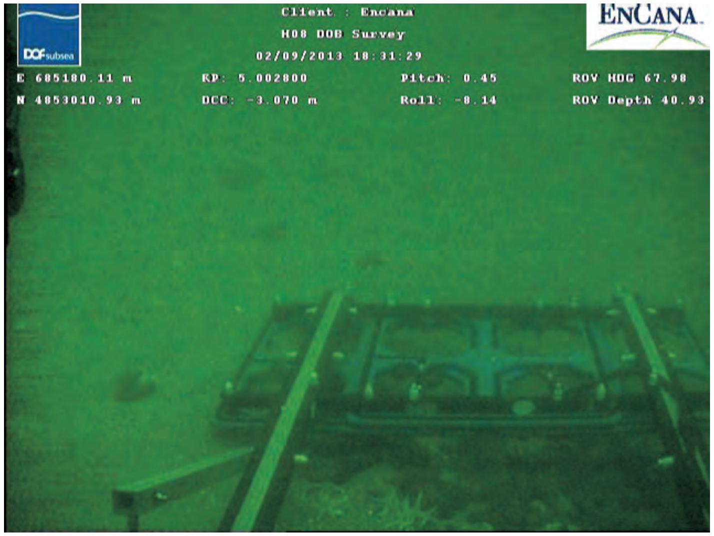
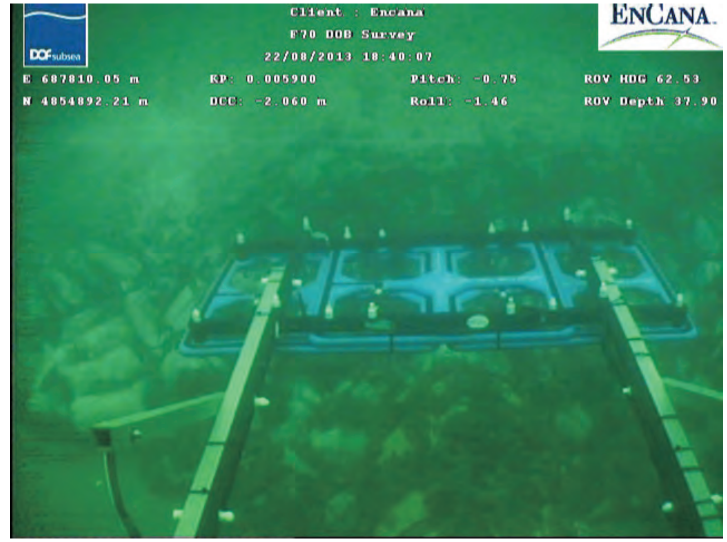
Figure 2.9 Photographs of an Entangled Basking Shark Carcass Resting on the GEP at KP 40

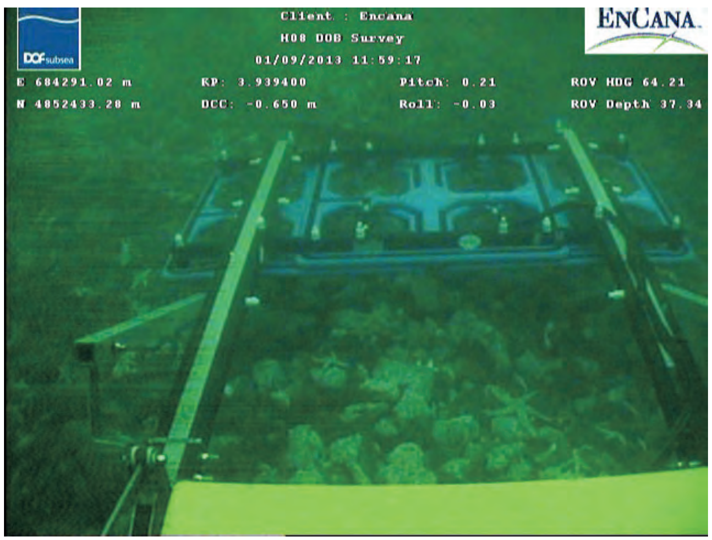
Figure 2.9



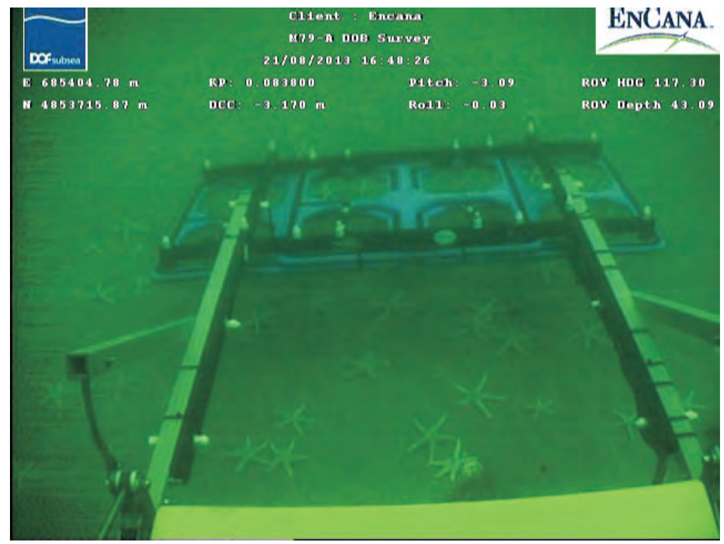
The end of a rock dump and buried flowline to wellhead H-08 with sandy sea floor with patches of the sea cucumber *Cucumaria frondosa*



Exposed flowline to wellhead F-70, with dense sea cucumber coverage



Rock dump covering flowline to wellhead D-41, with sea stars and sea cucumbers



Sandy seafloor with dense sea stars covering flowline to wellhead M79-A

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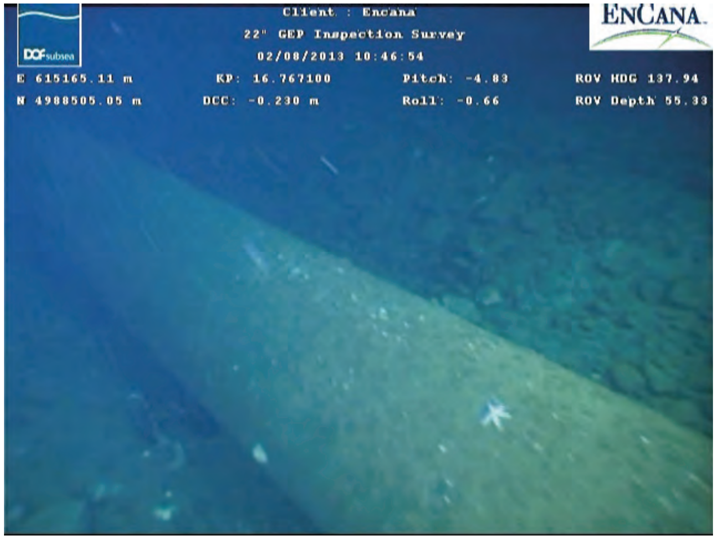
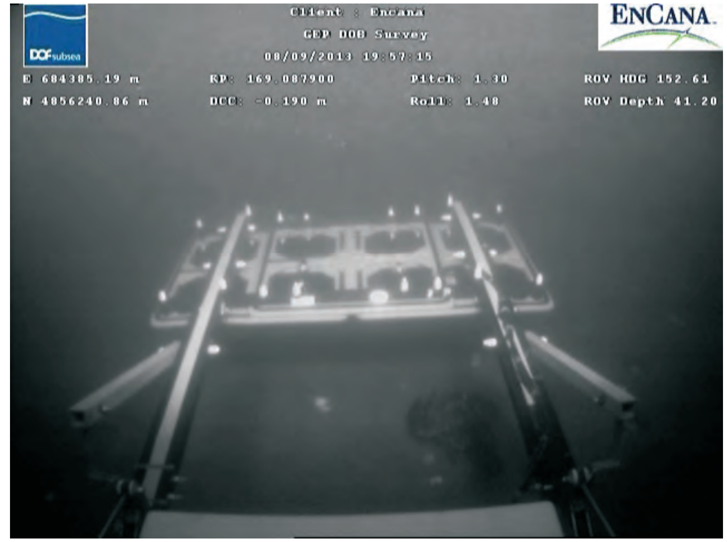
Figure 2.10 Buried and Exposed Wellhead Flowlines with Associated Fauna

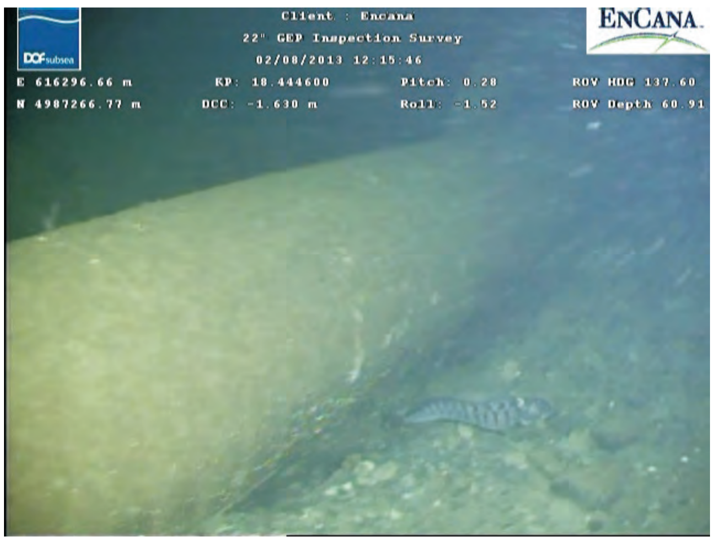
Figure 2.10



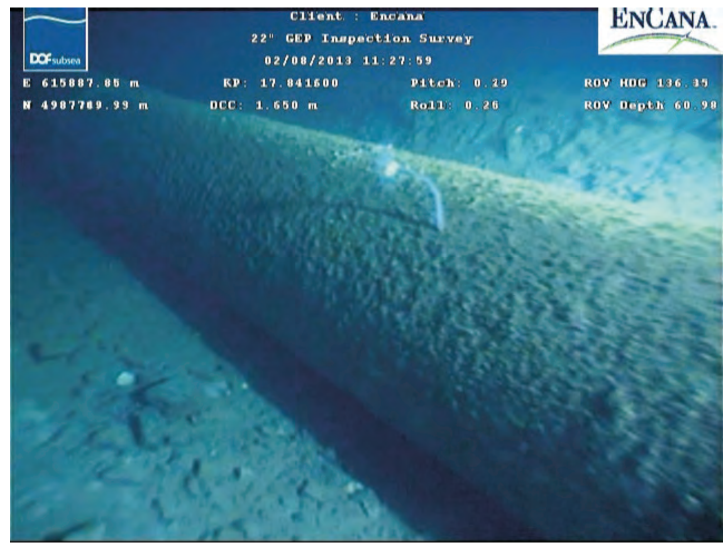
An American lobster (bottom left corner of the image) at the base of the GEP



A second American lobster, found on a sandy section of buried pipeline



An Atlantic wolffish (a species of special concern under the Species at Risk Act) emerging from a burrow at the base of the GEP



A solitary hydroid (likely *Corymorpha sp.*) attached to the GEP

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Figure 2.11 Notable species from KP 10-23, 126-137, and 167-168

Figure 2.11

2.6 MARINE WILDLIFE OBSERVATIONS

2.6.1 Background

Stranded Birds Handling

In 2012 and early 2013, Encana worked with ExxonMobil and the CNSOPB to improve stranded bird handling procedures and strengthen awareness of these procedures on offshore platforms and vessels. As a result, Encana/ExxonMobil have jointly developed a draft bird monitoring and handling protocol to ensure consistent measures are implemented on offshore platforms and vessels in Nova Scotia. These measures include dedicated personnel responsible for implementing the protocol, directions on how to handle different types of stranded birds, offshore personnel awareness/training, reference material, performance review, etc. This draft protocol was submitted to the CNSOPB and Environment Canada for review along with specific questions on bird handling procedures. Environment Canada has not yet provided comments on this protocol as they are in the process of writing their own offshore bird handling protocol, expected to be issued in the second quarter of 2014. Once Environment Canada's protocol is issued, Encana will finalize its own bird handling protocol, incorporate it into its Production EPCMP and roll it out to the PFC and vessels, including training of relevant personnel and provision of reference material.

Visual Monitoring of Wildlife around the PFC / Vessels

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 behaviour 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.

Acadia Bird Monitoring Research Study

Studies have shown that birds are attracted to offshore platforms, drilling rigs, and support vessels for roosting sites and foraging opportunities (**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 satellite tagging, 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. Additional study sites in Cape Breton/Canso were added to the study and the study was extended by an additional year.

Seasonal Densities of Seabirds (Transects)

Between 2006 and 2011 a transect-gradient study was completed involving systematic observations of seabirds by Canadian Wildlife Service (CWS) biologists along supply vessel transits to and from SOEP offshore platforms (between one and three transects were surveyed each year). This approach allows changes in the density of seabirds with respect to distance from offshore platforms to be monitored and provides an opportunity to evaluate whether the platform provides birds with additional foraging or refuge opportunities. However, this program is not designed to fully address the effects of offshore platforms on seabird behaviour. As mentioned in the approved Deep Panuke 2011 EEM Report (DMMG-X00-RP-EH-90-0001.03U; Section 4, Recommended EEM Programs for 2012) instead of conducting transect surveys, seasonal bird movements and potential bird-platform interactions were studied as part of the large-scale instrument-based Acadia research study in 2012. This study (which was extended into

2013) will provide more comprehensive data and analysis than could be obtained from limited transect observations.

Sable Island Beached Bird Surveys

Seabird mortality due to chronic oiling in proximity to the PFC was also monitored during 2013. 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.)

Ocean Tracking Network

In 2013, Encana was approached by the Ocean Tracking Network (OTN) to deploy some hydrophones on O&G infrastructure to feed into the OTN network. Encana agreed to deploy hydrophones of its wave buoy mooring and its ROV used for the 2013 subsea asset survey.

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

- Record any stranded (live or dead) birds on the Deep Panuke PFC and vessels;
- Record the behaviour of any birds, marine mammals and sea turtles observed in the vicinity of the Deep Panuke PFC and vessels;
- 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;

- Estimate seasonal densities of seabirds in the vicinity of the PFC;
- Identify the oil type/source on feathers of beached seabirds found on Sable Island; and
- Monitor tagged animals (*e.g.* blue sharks) in the vicinity of the PFC or pipeline.

2.6.4 Sampling

- Record any stranded (live or dead) birds on the Deep Panuke PFC and vessels;
- Record the behaviour of any birds, marine mammals and sea turtles observed in the vicinity of the Deep Panuke PFC and vessels;
- 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;
- Estimate seasonal densities of seabirds in the vicinity of the PFC;
- Identify the oil type/source on feathers of beached seabirds found on Sable Island; and
- Monitor tagged animals by OTN (*e.g.* blue sharks) with acoustic receivers near the Deep Panuke PFC and gas export pipeline.

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 Acadia University – Mid-year Report, Year 3; January 2014 **Appendix B**).
- Oil types observed on feathers from beached seabirds collected on Sable Island were monitored (**Appendix C**);
- Tagged animals were monitored by OTN with acoustic receivers on the Encana wave buoy and ROV (**Appendix E**).

2.6.6 Parameters Analyzed

Table 2.7 Marine Wildlife Observations in 2013

	Sampling		Analysis	
Location	**Type/Method**	**Frequency/Duration**	**Type/Method**	**Parameters**
PFC / vessels	Implementation of Encana's EPCMP stranded bird protocol	As required	Yearly bird salvage report submitted to CWS	Species; condition; action taken; fate of bird
PFC / vessels	Visual monitoring of seabirds, marine mammals and sea turtles around PFC / vessels	Opportunistic observations from PFC / vessels	Direct observation	Species, counts and behavioural observations (*e.g.* any congregation of wildlife will be reported)
PFC area, Sable, Country and Bon Portage Islands, and NE Nova Scotia (Acadia research study)	Bird monitoring with radio and satellite transmitters	2011 to 2013 research study	Analysis of VHF and satellite transmitters data	Quantify patterns of individual and population level bird activities in relation to offshore installations
Sable Island	Beach bird surveys	Approx. 10 surveys/year	Based on CWS protocol	Oiling rate (standardized approach)
PFC / vessels	Blue shark and other tagged species monitoring via acoustic tags and receivers	Continuous, with data downloads periodically	Use acoustic receivers to record tagged animals. Report submitted by OTN.	Acoustic receivers track if there is activity of tagged animals near PFC/pipeline

2.6.7 Results

2.6.7.1 Marine Wildlife Observations

Stranded Seabird Summary

- A bird matching the description of an Ipswich Sparrow was observed on April 23, 2013 near the supply vessel Atlantic Condor, looking for a place to perch. The following morning on April 24, the bird was found dead aboard the supply vessel and discarded overboard.
- On May 9, 2013 a Thick-billed Murre was found on the construction vessel MV Intrepid (conducting flowline maintenance activities) with damage to its foot webbing (later to be determined as an older injury that did not occur on the MV Intrepid). The bird was put in a box and brought back to shore and later released by Environment Canada at the mouth of the Halifax Harbour.
- A stranded bird, a Common Nighthawk (a Threatened Species under SARA), was found on the PFC on Oct. 1, 2013, and remained in the same area for three days until Oct. 3, 2013. The bird was caught, placed in a box and was to be transferred to Hope for Wildlife for rehabilitation as advised by Environment Canada. The bird died overnight before 6 am on Oct. 4, 2013. The bird was preserved in a freezer aboard the support vessel Ryan Leet and given to the Atlantic Veterinary College in Charlottetown, PEI for a necropsy. The necropsy confirmed that the bird died of emaciation / starvation.
- A storm petrel was found on the PFC on Oct. 26, 2013 with an oily substance on it. The bird was washed and dried off, put in a box, and then released later that night.

For complete description of these stranded birds events, refer to Report of “2013 Stranded Bird Report”, **Appendix D1**. For details on the necropsy of the Common Nighthawk, refer to " Common Nighthawk Wildlife Diagnostic Report (March 2014)
", **Appendix D2**.

Visual Monitoring of Wildlife around the PFC / Vessels Summary

- Both the supply vessels the Condor and the Ryan Leet reported wildlife sightings in 2013.

- The Condor observed three mike whales and one fin whale in May of 2013, a seal in June and a whale in August, along with various untagged gulls year round.
- The Ryan Leet observed two pilot whales, a minke whale, approximately 10 porpoises and a grey seal in May of 2013.
- Two snowy owls were observed in December of 2013 on the PFC.

For complete details on marine wildlife observed from the supply vessels and PFC, refer to **Appendix F** "2013 Observations from Supply Vessels and PFC of Marine Wildlife".

Acadia Bird Monitoring Research Study Summary

Field studies were conducted between May and December 2013 on Sable Island, Country Island and Bon Portage Island, Conrad's Beach, and north-eastern Nova Scotia. This resulted in:

1) VHF tag deployments on 588 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 and GPS-logger tag deployments on 9 HERG and 11 GBBG;
3) Geolocator tag deployments on 67 Leach's Storm-petrels;
4) Colour wing- and leg-banding of 60 HERG (adults) and 164 GBBG (mixed chicks, immatures, and adults); and
5) VHF receivers were run at three breeding colonies, more than a dozen coastal sites, and four offshore platform supply vessels, resulting in ~1000 receiver tracking-days, including >300 days from supply vessels, in 2012, and even more from supply vessels, in 2013.

- In 2013 vessel-based VHF receivers were active during the entire tagging period and birds were effectively detected without interference from VHF "noise", as in previous years. In that year, 42% and 28% of VHF-tagged Herring Gulls and Great Black-backed Gulls, respectively, were detected at least once by platform supply vessel; continued analysis will investigate the timing, frequency and duration of these interaction events. No storm-petrels or Blackpoll Warblers were detected from vessels in 2013, and only a few detections of Ipswich Sparrows and terns were recorded.

- VHF tags and colour wing-bands showed that gulls typically 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 5 of 9 individual Herring Gulls tracked. For those individuals, the percentage of locations occurring within 200 m of platforms ranged from 0.5 to 9.0% which varied among individuals and years. Those individuals interacting with platforms in 2012 also interacted with platforms in 2013, suggesting individual specialization on platforms. Most of the locations within 200 m of platforms occurred around Thebaud (69%) and Deep Panuke (26%), with fewer detections near Alma (5%) or Venture, South Venture, and North Triumph (< 1% combined). Most interactions occurred during chick-rearing and post-breeding phases, between July and November, primarily by 3 of the 9 tagged individuals.
- During breeding, terns on Sable Island made regular foraging trips of 3 to 6 h and continued analysis will examine sources of variation in foraging activity patterns among species and colonies. Stable isotope analysis revealed dietary differences between the two tern species suggesting the species forage in distinct areas or specialize on different prey types. In 2013, a network of receivers established across Sable showed movements along the island with 12% of individuals detected at least once at the island tips, and 40% traveling distances greater than 20 km at least once during the breeding season. This suggests the potential for terns to travel long distances to foraging areas along the length of the island. In 2013, only two individuals (on one occasion each) were detected by receivers on supply vessels suggesting limited offshore foraging and low potential for interactions with platforms or supply vessels. In both years, most VHF-tracked individuals departed their colonies during the last week of July, and nearly all had departed by mid-August.
- Foraging trips by Leach's Storm-petrels from Bon Portage Island and Country Island typically lasted 3 to 5 days during incubation phases and 2 to 3 days during chick-rearing phases. GLS-tracking data indicated that they may travel as much as 1000 km offshore during these trips. The foraging areas of Country Island storm-petrels overlapped with the platform area around Sable, but tracks from Bon Portage Island did not. Colony-based VHF-tracking data also indicate that Bon Portage Island birds departed south on foraging trips, thus limiting potential platform interactions, whereas Country Island petrels departed on easterly trajectories which may bring them in proximity to platforms in the Sable area.

- During 2012 and 2013, Ipswich Sparrows tagged in August undertook migratory departures from Sable Island between September and November; juveniles departed earlier than adults. In 2012, about half (61%) of sparrows detected on the mainland were first detected at the northerly stations (Taylor's Head and Country Island) which suggests a north-westerly migration path for these individuals. A larger sample size and more extensive receiver network in 2013 suggests that adults and juveniles appear to differ in their route choice, with adults displaying a more easterly or southerly route than juveniles. If juvenile 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. The more easterly route observed by adult Ipswich to southern Nova Scotia, or a possible direct route to the east coast of the USA, would be more likely to cross the Deep Panuke and Thebaud platform areas. No tagged individuals were detected from platform supply vessels during autumn migration in either year. During the 2013 spring migration, Ipswich Sparrows tagged on the Nova Scotia mainland showed over water migration initiated immediately following sunset, most departures occurring in central portions of Nova Scotia between Conrad's Beach and Clam Harbour, and 10 of 21 individuals successfully migrating to Sable Island. Two individuals were detected by offshore supply-vessels, one passing by the vessel near the Deep Panuke platform (successfully arriving on Sable) and one detected for 5.5 h approximately 110 km west of Sable Island when the vessel was in transit towards Sable (unsuccessful migration).
- In 2012, 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). 34 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. In 2013, 48 individuals were tagged at Glasgow Head (Canso Peninsula); none of these were detected flying over Sable Island, or by supply vessels. Many individuals were detected

moving SW along the coastline of NS, and it is suspected that most of the individuals tagged likely departed from locations that would not have put them in proximity to offshore platforms. More analysis is required of these data.

- In March 2012, a scope of work document was completed which outlined the plans for equipment installations on the Deep Panuke platform, including VHF receivers and use of existing platform radar signals. In March 2013, the revised goal was to have a VHF receiver/antennas installed prior to spring field studies (April 2013) and access to platform radar signal in June 2013. Due to delays in the hook up and commissioning of the platform, bird monitoring equipment was not installed on the platform in 2013. Deep Panuke First Gas was achieved in December 2013 and the installation of bird monitoring equipment is now scheduled for the spring of 2014.

For complete details on the Acadia bird study, refer to **Appendix B** " Assessment of bird-human interactions at offshore installations Acadia University – Mid-year Report, Year 3; January 2014".

Sable Island Beached Bird Surveys Summary

- Between January 1 and October 1, 2013, ten surveys for beached seabirds were conducted on Sable Island, with no surveys during November and December.
- During 2013, the corpses and fragments of 461 beached seabird corpses were collected on Sable Island. Fulmars and shearwaters accounted for 25.8% of total corpses recovered, and alcids comprised 55.5%. Of the 461 corpses, 217 (47.1%) were complete (i.e. with >70% of body intact).
- Seasonal occurrence of *clean* complete corpses varied by bird group and species. More Larus gulls and alcids occurred in winter (61.9% and 74.0%, respectively). Most Northern Fulmars (81.3%) and all Northern Gannets and all shearwaters occurred in summer.
- The overall oiling rate for all species combined (based on complete corpses) was <0.5% — a single bird (one of 16 Northern Fulmar corpses). The corpse had traces of oil on one wing and the tail (an oil sample was not collected because the corpse was decomposed and the oil highly weathered).

- The 2013 oiling rate for alcids (all species combined) was markedly lower than that observed in 2012 (i.e. 0% compared with 40.4%). This is the first time in 21 years (since beginning the beached seabird survey program in 1993) that the annual oiling rate for alcids was 0%.

For complete details on the Sable Island Beached Seabird study, refer to **Appendix C** "2013 Beached Seabird Survey on Sable Island ".

Ocean Tracking Network Report Summary

- Twenty juvenile female blue sharks were tagged by the OTN in July/August of 2013 by surgically implanting an acoustic tags.
- All twenty blue sharks were picked up on acoustic receivers in the region after being released, meaning that all sharks survived the surgical procedure.
- The acoustic tags have a six year battery life, so these twenty sharks can be monitored up to a six year period (assuming a significant portion of tagged sharks survive over this time), documenting changes in behaviours as the sharks mature
- None of the twenty tagged female sharks were picked up on the receivers (data downloaded on December 1, 2013) on the Encana wave buoy or the Encana ROV. All detections were on receivers already deployed in the area by OTN, mainly on the inner Halifax line.
- A grey seal, originally tagged on Sable Island on 30 June 2013 was detected on by the Encana wave buoy (coordinates- 43.81200, -60.66500) on 6 July 2013, and again on 10 Aug 2013.
- Possible noise from the Encana ROV could have impaired ability to detect coded tags and OTN will reattempt this mission in 2014 with a broad spectrum sounds sensor, with permission from Encana.

For complete details on the OTN blue shark tagging study, refer to **Appendix E** " OTN Report – Acoustic Tracking of Marine Species near N.S. Offshore Oil and Gas Platforms, First Field Season (January 2014)".

2.6.8 Summary and Conclusions

- Four birds were stranded in 2013. The storm petrel found of the PFC and the Murre found on the MV Intrepid were later released unharmed. The Common Nighthawk found on the PFC and the Ipswich Sparrow found on the Atlantic Condor both died.
- The 2013 Acadia Bird Study resulted in VHF deployments on 299 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 and GPS-logger tag deployments 3 HERG and 11 GBBG and geolocator tag deployments on 30 Leach's Storm-petrels. In 2013, vessel based VHF receivers were active throughout the entire tagging period. Preliminary results are presented in Appendix B and 2013 data is still being analyzed.
- Beached seabirds - A total of 461 seabird corpses were collected on Sable Island over 10 beached bird surveys during the time between January 1 and October 1, 2013. Fulmars and shearwaters accounted for 25.8% of total corpses recovered, and alcids comprised 55.5%. The overall oiling rate for all species combined was <0.5%, which was due to a single corpse of a Northern Fulmar with a small amount of oil on the wing and tail. A sample was not collected, as the corpse was decomposed and the oil highly weathered.
- Twenty juvenile blue sharks were tagged in July/August of 2013 by the Ocean Tracking Network. 2013 data from acoustic receivers on Encana platforms and the Encana ROV showed no detection of any of the twenty blue sharks tagged but detected a grey seal, originally tagged on Sable Island, by the Encana wave buoy in July and August 2013. All twenty blue sharks were recorded on other receivers in the region. It is unclear whether sharks are in the vicinity of Deep Panuke, as the time period was from July to December only, and tagged animals; only included juvenile females. ROV noise could have impaired ability to pick up tags, so the project will be reattempted in 2014 with a broad spectrum sensor.

2.7 AIR QUALITY MONITORING

2.7.1 Background

Sable Island is uniquely located in the Atlantic Ocean off the east coast of North America. Despite its remote location, Sable Island receives significant trans-boundary pollutant flows from industrial and urban areas along the Great Lakes and US eastern seaboard. The local air-shed around Sable Island also receives contributions of contaminants from local sources of emissions on Sable Island itself, passing marine traffic, and from activities associated with nearby offshore hydrocarbon developments.

The Sable Island Air Monitoring Station, which has been operating since mid-2003, was installed to provide baseline information on the ambient air quality on Sable Island and to monitor trends in air quality as development of the Nova Scotia offshore oil and gas exploration expanded. Data collected serves as a basis for a comprehensive air quality management system to identify and address any potential impacts attributable to contaminant emissions from offshore activities. Monitoring is targeted at potential pollutants that could be associated with offshore oil and gas activity such as nitrogen oxides (NOx), sulphur dioxide (SO_2), fine particulate matter ($PM_{2.5}$), hydrogen sulphide (H_2S) and greenhouse gases (GHG) such as methane (CH_4), carbon monoxide (CO), and carbon dioxide (CO_2). If the station detects a pollution event such as from a smoky flare on an offshore gas production platform, researchers are able to generate a back-trajectory indicating the origin of the pollutant based on flare characteristics and analysis of meteorological conditions at the time of the event.

A new study focusing on gaseous pollutants (in particular VOCs) and particulate speciation (for fine and ultra-fine particles) associated with the offshore oil and gas industry and marine emissions has been carried out by Dr. Mark Gibson, Dalhousie University, Department of Community Health and Epidemiology on Sable Island since 2011. The study is funded principally by the Environmental Studies Research Fund (ESRF) with in-kind logistical and technical support from various government agencies, stakeholder groups and offshore oil and gas companies.

Starting in 2013, Mark Gibson has been contracted by Encana and ExxonMobil through Kingfisher Environmental Health Consultants to conduct Sable Island air contaminant spike monitoring as well as data analysis of air quality and meteorological data to identify potential correlation with O&G operations.

2.7.2 EEMP Goal

- More fully understand the nature of the Sable Island air-shed;
- Provide a basis for understanding environmental impacts (if any) observed on Sable Island that may be attributable to contaminant emissions from offshore petroleum production activities, and in particular the Deep Panuke project [EA predictions #14 & 15 in **Table 3.1**]; and
- Provide feedback for continuous improvement in reducing flare and other emissions from the Deep Panuke project [EA prediction #14 in **Table 3.1**].

2.7.3 Objectives

- Provide baseline information on the air quality on Sable Island;
- Monitor trends in air quality on Sable Island as the Deep Panuke development comes on-stream; and
- Investigate the possible relationship of anomalies (spikes of contaminants) in air quality measurements on Sable Island with flaring patterns on the PFC during production operations.

2.7.4 Sampling

Flare smoke monitoring:

- No systematic flare smoke monitoring took place in 2013. The flare was monitored continuously by one camera at the PFC Central Control Room (CCR). Technicians looked into potential causes when there was an occurrence of a dirty flare.
- Systematic flare smoke monitoring has started in February of 2014 and the flare smoke shade will be monitored twice daily, assessing it using the Ringelmann smoke chart.

For more details about the flare smoke monitoring, refer to **Appendix G** "2013 Flare Plume Observations".

Sable island air quality:

- Continuously measured nitric oxide (NO), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), fine particulate matter with a median aerodynamic diameter less than or equal to, 2.5 microns ($PM_{2.5}$), total volatile organic compound (VOC), methane (CH_4) and non-methane hydrocarbons (NMHC) on Sable Island.

For more details about Sable island air quality monitoring, refer to **Appendix H** "2013 Sable Island Air Quality Monitoring".

2.7.5 Analysis

- No formal analysis for flare smoke took place in 2013. Daily monitoring of the flare smoke is occurring of 2014, which will provide data for analysis.
- Investigation of possible relationship of air quality anomalies on Sable Island to offshore production activities by analyzing breaches of selected air emission 1-hour 'spike' thresholds, as well as air quality daily concentrations above background. Analysis includes back-trajectory modeling.

2.7.6 Results

- The most important feature of the air pollution data acquired in the 2013 year was one event where the NOx emissions 'spike' threshold (1-hr period) was exceeded and likely not a result of O&G operations. The back trajectory analysis revealed that it came from the Westerly/North Westerly direction, which eliminates O&G operations as the source. The NOx spike was likely due to continental outflow.
- There were three H_2S spikes investigated which were likely due to instrument drift rather than O&G operations.
- Elevated daily average concentrations that rose above three standard deviations above the mean were found for all pollutant data sets except for O_3, CH_4 and total VOC. The 1st highest daily average $PM_{2.5}$ concentration of 22.79 µg/m^3 on November 28, 2013, had a back trajectory to the South, which is in line with the North Triumph platform. Elevated $PM_{2.5}$ concentrations may also be a consequence of sea salt spray and further investigations of the $PM_{2.5}$ chemistry and/or O&G operations would need to be conducted to confirm this.
- There were no breaches of the National Air Quality Standards, Canada Ambient Air Quality Objectives (CAAQO) or Canada Wide Standard for any of the air pollution metrics.

2.7.7 Summary and Conclusions

- The following air quality parameters were measured on Sable Island in 2013: NO, NO_2, NO_x, SO_2, H_2S, $PM_{2.5}$, VOC, CH_4 and NMHC.
- Hourly spikes above selected thresholds and elevated daily concentrations of air contaminants were analyzed for possible relationship with offshore production activities.
- There was one NOx spike which was likely not a result of O&G operations.
- There were three H_2S spikes which were likely due to instrument drift rather than O&G operations.
- There were no breaches of the National Air Quality Standards, Canada Ambient Air Quality Objectives (CAAQO) or Canada Wide Standard for any of the air pollution metrics.

For more details about Sable island air quality monitoring, refer to **Appendix H** "2013 Sable Island Air Quality Monitoring".

3 ENVIRONMENTAL ASSESSMENT (EA) PREDICTIONS

Table 3.1 EEM Related Environment Assessment (EA) Predictions and 2013 Results

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2013 Plan	2013 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 not to commence until third quarter of 2013. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	N/A - Produced water discharge did not commence until third quarter of 2013, mostly as batch discharges. PFC and WHPS had similar species composition and slightly more marine growth coverage than 2012. Video surveys spanned times before and after first gas and produced water discharge.
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 2013 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" effects 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℃. The temperature anomaly will be a maximum of a 2.5℃ upon contact with the seafloor. Beyond 130 m, the temperature anomaly will be less than that 1℃ and will fall below 0.4℃ 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	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 2013. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	N/A - Produced water discharge did not commence until third quarter of 2013, mostly as batch discharges. PFC and WHPS had similar species composition and slightly more marine growth coverage than 2012. Video surveys spanned times before and after first gas and produced water discharge.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2013 Plan	2013 Results
	temperatures and the predicted 2.5℃ 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 2013. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	N/A - Produced water discharge did not commence until third quarter of 2013, mostly as batch discharges. PFC and WHPS had similar species composition and slightly more marine growth coverage than 2012. Video surveys spanned times before and after first gas and produced water discharge.
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 2013. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	N/A - Produced water discharge did not commence until third quarter of 2013, mostly as batch discharges. PFC and WHPS had similar species composition and slightly more marine growth coverage than 2012. Video surveys spanned times before and after first gas and produced water discharge.
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	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 2013. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	N/A - Produced water discharge did not commence until third quarter of 2013, mostly as batch discharges. PFC and WHPS had similar species composition and slightly more marine growth coverage than 2012. Video surveys spanned times before and after first gas and produced water discharge.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2013 Plan	2013 Results
	Alkylatedphenols that are unlikely to elicit measurable 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 2013. Discontinue E-70 cuttings pile monitoring.	N/A - Sediment sampling at wellsite locations to be discontinued in 2014 based on results from 2011 chemistry and toxicity survey (no surveys conducted in 2012 and 2013) which concluded that all metal, non-metal, hydrocarbon and nutrient concentrations were below Canadian EQG threshold levels and that all collected sediments were non-toxic ("therefore, there is negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of the ecosystem and the designated resource uses they support"). – EA prediction no longer applicable. The sediment chemistry and toxicity program will focus on the sampling locations downstream and upstream of the PFC site (i.e. 4 near-field and 2 far-field reference sites)..
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. Dense epifaunal colonization continued to be observed on many of the subsea structures. Cuprotect coated surfaces appeared to have colonization of marine life in

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2013 Plan	2013 Results
						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 constitute a significant concern as a physical barrier to crustacean movement.	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 communities along the pipeline. Continue observation of crustaceans, particularly American lobster if present.	The subsea pipeline does not constitute a physical barrier to crustacean movement as evidenced by multiple species of crabs on top and on the sides of the exposed structure. EA prediction has been confirmed for all types of crabs found along the GEP. It is unclear if the GEP acted as a physical barrier to a lobster observed near the pipeline.
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 2013. OTN tracking and tagging of blue sharks new for 2013.	- No attraction of wildlife has been observed at the PFC through indirect observations. Tagged animals were not picked up on supply vessel or PFC receivers.
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. - In 2013, vessel based VHF receivers were active throughout the entire tagging period. In 2013 42% of VHF tagged Herring Gulls and 28% of VHF tagged Great Black-backed Gulls were detected once by a platform supply vessel. No storm-petrels or Blackpoll Warblers were detected from vessels, and a few detections of Ipswich Sparrows and terns occurred.
13	The potential for oiling of birds and/or contamination of their	8.2.4 8.6.4	- Marine Water - Quality	- Marine Water Quality - Monitoring	Summarize observations and findings from Sable Island Beach	<0.5% oiling for all species of beached birds found on Sable

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2013 Plan	2013 Results
	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.		- Marine Related - Birds	- Marine Wildlife Observations	Surveys.	Island (a single bird, Northern Fulmar, which had traces of oil on one wing and the tail). An oil sample was not collected because the corpse was decomposed and the oil highly weathered.
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 described in 2012 EEM report. . Expected to start in 2013.	One NOx spike and three H_2S spikes, none of them likely a result of O&G operations. No breaches of National Air Quality Standards, CAAQO or Canada Wide Standard for any of the air pollution metrics.
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 described in 2012 EEM report.. Expected to start in 2013.	One NOx spike and three H_2S spikes, none of them likely a result of O&G operations. No breaches of National Air Quality Standards, CAAQO or Canada Wide Standard for any of the air pollution metrics.

4 RECOMMENDED EEM PROGRAM FOR 2014

Table 4.1 Summary of Deep Panuke 2013 Offshore EEMP Sampling Activities, Analysis, and 2014 Recommendations

EEMP Component	2013 Sampling			2013 Analysis		2014 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
Produced Water Chemistry and Toxicity **No 2013 data**	PFC (prior to mixing with seawater system discharge) **No Sampling Conducted in 2013**	Niskin Bottle **No Sampling Conducted in 2013**	Twice annually after First Gas **No Sampling Conducted in 2013**	Water quality composition **No Analysis Conducted in 2013**	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters **No Analysis Conducted in 2013**	Start produced water sampling in 2014; to be collected and analyzed twice a year.
			Annually after First Gas **No Sampling Conducted in 2013**	LC49 bioassay acute toxicity analysis **No Analysis Conducted in 2013**		Start LC49 bioassay in 2014.
Marine Water Quality Monitoring **No 2013 data**	Triplicate seawater samples at 5 near-field downstream sites and 2 upstream sites along tide direction **No Sampling Conducted in 2013**	Niskin Bottle **No Sampling Conducted in 2013**	In 2011 (prior to First Gas), then annually for the three following years **No Sampling Conducted in 2013**	Water quality composition **No Analysis Conducted in 2013**	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters **No Analysis Conducted in 2013**	Conduct next water sampling program in 2014.
Sediment Chemistry and Toxicity **No 2013 data**	9 near-field benthic sampling locations and 2 far-field reference sites **No Sampling Conducted in 2013**	Grab Sample **No Sampling Conducted in 2013**	In 2011 (prior to First Gas and post 2010 drilling and completion activities), then annually for the following three years **No Sampling Conducted in 2013**	Chemical composition **No Analysis Conducted in 2013**	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 2013**	Conduct next sampling program in 2014. Discontinue 5 wellsite locations and focus on sampling locations downstream and upstream from PFC site (4 near-field sites 250, 500, 1,000 and 2,000 m downstream (SW) and 2 far-field sites 5,000 m upstream and downstream)
				LC49 bioassay acute toxicity analysis **No Analysis Conducted in 2013**	Suitable marine amphipod species such as *Rhepoxynius abronius* or *Eohaustoriux estuaries* **No Analysis Conducted**	Conduct LC49 bioassay in 2014. . Discontinue 5 wellsite locations and focus on sampling locations downstream and upstream from PFC site (4 near-field sites 250, 500, 1,000

EEMP Component	2013 Sampling			2013 Analysis		2014 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
					in 2013	and 2,000 m downstream (SW) and 2 far-field sites 5,000 m upstream and downstream)
Fish Habitat	Subsea production structures	ROV video- camera survey	Annually (using planned activities, *e.g.* routine inspection and storm scour surveys)	Video analysis	Subsea production structures: evaluate the extent of marine colonization and compare to previous years.	Continue fish habitat analysis near subsea production structures into 2014 with annual ROV footage of wellsites, PFC and pipeline.
Fish Health Assessment **No 2013 data**	Mussels: PFC SW leg Fish: immediate vicinity of PFC and suitable far-field reference sites **No Sampling Conducted in 2013**	Mussels: scraping Fish: angling **No Sampling Conducted in 2013**	Mussels: annually after First Gas Fish: every 3 years after First Gas **No Sampling Conducted in 2013**	Mussels: body burden Fish: enzyme induction, pathology **No Analysis Conducted in 2013**	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) **No Analysis Conducted in 2013**.	Start mussel health assessment in 2014 as first gas and full production occurred in late 2013. (Fish health assessment to start three years after First Gas)
Marine Wildlife Observations	PFC / vessels	Implementation of Williams and Chardine protocol for stranded birds Visual monitoring of seabirds, marine mammals and sea turtles around PFC	As required Opportunistic observations from PFC / vessels	Yearly bird salvage report to be 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)	Continue into 2014; updated stranded bird handling protocol to be finalized and implemented once regulatory feedback has been received Continue into 2014; conduct in conjunction with daily deck sweeps for stranded birds once updated stranded bird handling protocol has been implemented

EEMP Component	2013 Sampling			2013 Analysis		2014 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
	Sable, Country and Bon Portage Islands, NE Nova Scotia, PFC area (Acadia bird monitoring research study)	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 2014 with data analysis and potential focused study of specific species based on study's results.
	Transects between PFC and shoreline	Visual monitoring of seabird distributions using CWS ECSAS protocol	Seasonal bird movements and potential bird-platform interactions were monitored as part of large-scale instrument-based Acadia study in 2013			Seasonal bird movements and potential bird-platform interactions studied as part of Acadia study
	Sable Island	Beached bird surveys	Approx. 10 surveys/year	Based on CWS protocol	Oiling rate (standardized approach)	Continue into 2014.
Air Quality Monitoring	Sable Island Air Quality Monitoring Station	Air quality monitoring instrumentation	Continuous	Compare Sable Island air contaminant spikes with O&G production activities using meteorological records	$PM_{2.5}$; VOCs, SO_2; H_2S; NO; NO_2; NOx; O_3; CH_4; and NMHC; flare smoke shades	Continue Sable Island air quality monitoring in 2014
	PFC	Visual observations of flare plume	Continuous during walk-arounds on deck and from video camera looking at the flare			Twice daily visual flare plume monitoring using Ringelmann smoke chart started in February of 2014. Continue monitoring through 2014.

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.

JNCC (2011). *SACFOR abundance scale*. Available at: http://jncc.defra.gov.uk/page-2684

Lee, K., & Neff, J. (2011). *Produced water - environmental risks and advances in mitigation technologies.* New York, NY: Springer Science + Business Media.

Martec Ltd., CEF Consultants Ltd., DRDC Atlantic, St. Francis Xavier University (2004). *Effects of pipelines/gathering lines on snow crab and lobster.* Halifax, NS. Retrieved from: http://www.esrfunds.org/pdf/150.pdf

Stephenson, M.T. (1992). *A survey of produced water studies*. New York, NY: Plenum Press.

APPENDICES

APPENDIX A

Fish Habitat Alteration Video Assessments 2013

		Start KP											
Fauna	**Fauna (Latin name)**	**23.222**	**24.235**	**25.873**	**27.495**	**29.211**	**31.134**	**32.984**	**35.072**	**36.864**	**38.646**	**40.627**	**42.787**
Sculpin	*Myoxocephalus sp.*	1				6						1	
Redfish	*Sebastes sp.*	4	3	20	4	4	30	1				1	1
Atlantic Cod	*Gadus morhua*												
Gadoid	Gadidae		1	4		2	2						
Eelpout/Ocean pout?	Zoarcidae												
Atlantic Hagfish	*Mixine glutinosa*										2		
Blenny	*Lumpenus sp.*												
Hake	*Urophycis sp.*												
Atlantic Herring	*Clupea harengus*												
Torpedo ray	*Torpedo nobiliana*												
Basking shark (dead)	*Cetorhinus maximus*											1	
Unid. Fish		1			2	1		2		2		1	2
Hermit crab	*Pagurus sp.*						3	3	3	1	11	5	
Toad crab	*Hyas sp.*												
Snow crab	*Chionoecetes opilio*	28	75	48	20	178	62	88	12	16	70	80	108
Northern Stone Crab	*Lithodes maja*												
Jonah crab	*Cancer borealis*			2						7	19	24	8
Cancer sp.	*Cancer sp.*												
Shrimp	Pandalidae											A	
Sea urchin	*Strongylocentrotus sp.*	3	190	1992	484	19	7	3					
Feather star	Crinoidea						1						
Basket star	*Gorgoncephalus sp.*	34	19		1	3		3	1		1	5	1
Solaster	*Solaster sp.*	4	6	2	5	3	1	1	1	5	3	7	22
Crossaster	*Crossaster sp.*	2	5			1						8	4
Hippasteria sp	*Hippasteria sp.*		1			1		8	8	7	6	1	9
Ceramaster	*Ceremaster sp.*												
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	5	1	1	15	46	30	13	16	42	64	27	92
Sand dollar	*Echinarachnius parma*												
Sea cucumber	*Cucumaria frondosa*	5	3										1
Sea anemone	Actinaria	3	75	5	12	68	25	26	118	163	42	25	29
*Cerianthus sp**	*Cerianthus sp.*												
Soft Coral*	Alcyonacea							3	1				
Hydrozoa	Hydrozoa	F	R	R	R			R	R				
Gastropod	Gastroppoda												
Neptunea sp.	*Neptunea sp.*	1											
Buccinum sp.	*Buccinum sp.*	1		1	1	1							
Brachiopod	*Terebratulina sp.*					F	F	F	O	O			
Sponge*	Porifera					6	3	3	7	24	3		3
Polymastia	*Polymastia sp.*									1			2
Encrusting sponge	Porifera												
Tunicate	Tunicata												
Sea potato	*Boltenia ovifera*												
		23.429	**24.573**	**26.317**	**27.893**	**29.869**	**31.517**	**33.497**	**35.450**	**37.354**	**39.101**	**41.140**	**43.186**
*Observed around pipeline		**Start KP**											
		F = Frequent taxa, O = Occasional Taxa, R = Rare taxa											

		Start KP											
Fauna	**Fauna (Latin name)**	**44.807**	**46.370**	**48.567**	**50.746**	**52.480**	**54.717**	**56.772**	**59.236**	**61.669**	**63.882**	**66.430**	**68.353**
Sculpin	*Myoxocephalus sp.*									1			
Redfish	*Sebastes sp.*	26	90	581	42	187	282	659	851	550	1273	1001	780
Atlantic Cod	*Gadus morhua*	1	12	5	4	27	65	59	33	72	59	29	31
Gadoid	Gadidae												
Eelpout/Ocean pout?	Zoarcidae									2			
Atlantic Hagfish	*Mixine glutinosa*					2		1					
Blenny	*Lumpenus sp.*												
Hake	*Urophycis sp.*												
Atlantic Herring	*Clupea harengus*											1	1
Torpedo ray	*Torpedo nobiliana*			1									
Basking shark (dead)	*Cetorhinus maximus*												
Unid. Fish		1					1	6					
Hermit crab	*Pagurus sp.*												
Toad crab	*Hyas sp.*												
Snow crab	*Chionoecetes opilio*	38	49	3	4		5	1		2	4	1	4
Northern Stone Crab	*Lithodes maja*							1		1		1	
Jonah crab	*Cancer borealis*	1	4	50	37	43	6	5	8	1	10	2	4
Cancer sp.	*Cancer sp.*												
Shrimp	Pandalidae												
Sea urchin	*Strongylocentrotus sp.*	1042	771	70	1313	383	3		26	36	2		1
Feather star	Crinoidea		3	4	1						1		
Basket star	*Gorgoncephalus sp.*	2											
Solaster	*Solaster sp.*	44	9	4	8	8	1	11	8	5	16	4	19
Crossaster	*Crossaster sp.*	16	6		1	2		2		1			
Hippasteria sp	*Hippasteria sp.*	15	5	2	1	1	8	24	5	19	7	4	10
Ceramaster	*Ceremaster sp.*							2					
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	38	217	119	113	634	775	1286	642	1284	1435	1163	1876
Sand dollar	*Echinarachnius parma*	44								2	3		
Sea cucumber	*Cucumaria frondosa*	3	4	6	28	19	2	4	5	6	9	6	8
Sea anemone	Actinaria	63	152	82	60	34	38	65	139	221	191	84	279
*Cerianthus sp**	*Cerianthus sp.*												
Soft Coral*	Alcyonacea												
Hydrozoa	Hydrozoa			C									
Gastropod	Gastroppoda												
Neptunea sp.	*Neptunea sp.*												
Buccinum sp.	*Buccinum sp.*		6						1			1	1
Brachiopod	*Terebratulina sp.*			S									
Sponge*	Porifera	10	51	S	30	31	29	22	67	98	189	166	122
Polymastia	*Polymastia sp.*		18	62	33	15	9	1	10	14	24	12	149
Encrusting sponge	Porifera			S					R				
Tunicate	Tunicata						S	S	S	S	A	C	C
Sea potato	*Boltenia ovifera*			4									
		45.175	**46.864**	**49.013**	**51.175**	**52.937**	**55.190**	**57.295**	**59.795**	**62.170**	**64.474**	**66.852**	**68.952**
*Observed around pipeline		**Start KP**											
		S = Superabundant taxa, A = Abundant taxa, C = Common taxa											

		Start KP											
Fauna	**Fauna (Latin name)**	**70.947**	**73.297**	**75.587**	**78.183**	**80.354**	**83.016**	**85.448**	**88.109**	**90.347**	**92.825**	**95.361**	**97.378**
Sculpin	*Myoxocephalus sp.*					1			1	1			
Redfish	*Sebastes sp.*	981	1790	760	653	1130	497	904	592	425	9	44	3
Atlantic Cod	*Gadus morhua*	27	66	34	26	31	9	12	4	4	2		
Gadoid	Gadidae												
Eelpout/Ocean pout?	Zoarcidae												
Atlantic Hagfish	*Mixine glutinosa*					1		3				2	
Blenny	*Lumpenus sp.*							1	1			2	2
Hake	*Urophycis sp.*										3	8	1
Atlantic Herring	*Clupea harengus*								1		6	3	
Torpedo ray	*Torpedo nobiliana*												
Basking shark (dead)	*Cetorhinus maximus*												
Unid. Fish								1				2	4
Hermit crab	*Pagurus sp.*						1				5		
Toad crab	*Hyas sp.*												
Snow crab	*Chionoecetes opilio*	1							1	3	9	11	102
Northern Stone Crab	*Lithodes maja*	1		1	4	5	20	16	8	14	6	18	6
Jonah crab	*Cancer borealis*	5	12	47	52	50	59	72	132	100	86	87	130
Cancer sp.	*Cancer sp.*	1											
Shrimp	Pandalidae												
Sea urchin	*Strongylocentrotus sp.*	5		1	1								
Feather star	Crinoidea										1		
Basket star	*Gorgoncephalus sp.*										1		1
Solaster	*Solaster sp.*	11	9	14	6	6	3	3	3	15	1		1
Crossaster	*Crossaster sp.*												
Hippasteria sp	*Hippasteria sp.*	1	5	29	12	15	4	9	12	18	39	11	39
Ceramaster	*Ceremaster sp.*				2					3		1	
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	752	969	2067	323	218	75	55	50	312	112	20	53
Sand dollar	*Echinarachnius parma*												
Sea cucumber	*Cucumaria frondosa*	5	3	6	6	8	10	4	1		9	6	4
Sea anemone	Actinaria	215	41	37	10	12	6	2	3	4	14	6	43
*Cerianthus sp**	*Cerianthus sp.*		56	318	333	905	553	870	800	1168	44	617	6
Soft Coral*	Alcyonacea												
Hydrozoa	Hydrozoa												
Gastropod	Gastroppoda												
Neptunea sp.	*Neptunea sp.*												
Buccinum sp.	*Buccinum sp.*												
Brachiopod	*Terebratulina sp.*												
Sponge*	Porifera	77	111	109	45	65	108	37	161	55	5	133	13
Polymastia	*Polymastia sp.*	456	135	2		7	4	6	3	21		2	3
Encrusting sponge	Porifera												
Tunicate	Tunicata	C	C	C	A	A	A			A			
Sea potato	*Boltenia ovifera*												
		71.478	**73.869**	**76.202**	**78.538**	**80.941**	**83.552**	**86.019**	**88.662**	**90.865**	**93.349**	**95.808**	**97.890**
*Observed around pipeline		**End KP**											
		A = Abundant Taxa, C = Common taxa											

APPENDIX B

Assessment of bird-human interactions at offshore installations

Acadia University – Mid-year Report, Year 3; January 2014

Assessment of bird-human interactions at offshore installations

Mid-year Report, Year 3 – January 2014

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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 by the Bird Banding Office (permits 10480-S, 10851, 10273-AH**,** 10695, 10273). Parks Canada Research and Collection Permit (SI-2012-0001) was issued 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) was obtained.

Acronyms

Bird species:
ARTE – Arctic Tern
BLPW – Blackpoll Warbler
COTE – Common Tern
GBBG – Great Black-backed Gull
HERG – Herring Gull
IPSP – Ipswich Sparrow
LHSP – Leach's Storm-petrel

Study Sites:
BP – Bon Portage Island
CI – Country Island
SI – Sable Island

Other:
GPS – Global Positioning System
GLS – Global Location Sensing tags
PFC – Production Field Centre
VHF – Very High Frequency

1. Executive Summary

Difficulties associated with direct observations from offshore platforms and the episodic nature of bird-platform interactions mean 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 of field and lab work conducted during the period from June 2011 to December 2013.

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. Receivers were developed in 2011/2012, were lab and field tested at multiple mainland, island and vessel locations in early 2012, and implemented throughout our studies in 2012 and 2013.

Bird movements **–** Field studies were conducted between May and December of each year on Sable Island, Country Island, Bon Portage Island, Conrad's Beach (spring 2013), south-eastern Cape Breton (autumn 2012), and north-eastern Nova Scotia (autumn 2013). This resulted in:

1) VHF tag deployments on 588 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 and GPS-logger tag deployments on 9 HERG and 11 GBBG;
3) geolocator tag deployments on 67 Leach's Storm-petrels;
4) colour wing- and leg-banding of 60 HERG (adults) and 164 GBBG (mixed chicks, immatures, and adults); and
5) VHF receivers were run at three breeding colonies, more than a dozen coastal sites, and four offshore platform supply vessels, resulting in ~1200 receiver tracking-days, including 400 days from supply vessels, in 2012, and >5000 receiver tracking-days, including nearly 1000 days from supply vessels, in 2013/2014

VHF receivers were deployed on platform supply vessels to quantify bird-platform interactions in offshore platform areas. Deployments in 2011 demonstrated the feasibility of this approach but results were inconclusive due to excessive VHF noise recorded from commercially available receivers; this problem precipitated the development of custom built receivers and software in 2012. In 2012, supply vessels equipped with VHF receivers recorded 14 interaction events with gulls, but no detections of tagged petrels, terns, sparrows, or warblers. However, in 2012, the ability to detect most species from vessel receivers was limited by the timing of receiver deployments, equipment failures, and a bug in the receiver software which exacerbated VHF noise (all issues were fixed in 2013). Nonetheless, the 14 recorded gull-vessel interaction events suggest that most interactions are short in duration, occur at night, are more frequent for Herring Gulls, and are limited to a small portion of the Sable Island gull population. In 2013 vessel-based VHF receivers were active during the entire tagging period and birds were effectively detected without interference from VHF "noise". In that year, 42% and 28% of VHF-tagged Herring Gulls and Great Black-backed Gulls, respectively, were detected at least once by platform supply vessel; continued analysis will investigate the timing, frequency and duration of these interaction events. No storm-petrels or Blackpoll Warblers were detected from vessels in 2013, and only a few detections of Ipswich Sparrows and terns were recorded (these are described below).

VHF tags and colour wing-bands showed that gulls typically 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 5 of 9 individual Herring Gulls tracked. For those individuals, the percentage of locations occurring within 200 m of platforms ranged from 0.5 to 9.0% which varied among individuals and years. Those individuals interacting with platforms in 2012 also interacted with platforms in 2013, suggesting individual specialization on platforms. Most of the locations within 200 m of platforms occurred around Thebaud (69%) and Deep Panuke (26%), with fewer detections near Alma (5%) or Venture, South Venture, and North Triumph (< 1% combined). Most interactions occurred during chick-rearing and post-breeding phases, between July and November, primarily by 3 of the 9 tagged individuals.

During breeding, terns on Sable Island made regular foraging trips of 3 to 6 h and continued analysis will examine sources of variation in foraging activity patterns among species and colonies. Stable isotope analysis revealed dietary differences between the two tern species suggesting the species forage in distinct areas or specialize on different prey types. In 2013, a network of receivers established across Sable showed movements along the island with 12% of individuals detected at least once at the island tips, and 40% traveling distances greater than 20 km at least once during the breeding season. This suggests the potential for terns to travel long distances to foraging areas along the length of the island. In 2013, only two individuals (on one occasion each) were detected by receivers on supply vessels suggesting limited offshore foraging and low potential for interactions with platforms or supply vessels. In both years, most VHF-tracked individuals departed their colonies during the last week of July, and nearly all had departed by mid-August.

Foraging trips by Leach's Storm-petrels from Bon Portage Island and Country Island typically lasted 3 to 5 days during incubation phases and 2 to 3 days during chick-rearing phases. GLS-tracking data indicated that they may travel as much as 1000 km offshore during these trips. The foraging areas of Country Island storm-petrels overlapped with the platform area around Sable, but tracks from Bon Portage Island did not. Colony-based VHF-tracking data also indicate that Bon Portage Island birds departed south on foraging trips, thus limiting potential platform interactions, whereas Country Island petrels departed on easterly trajectories which may bring them in proximity to platforms in the Sable area.

During 2012 and 2013, Ipswich Sparrows tagged in August undertook migratory departures from Sable Island between September and November; juveniles departed earlier than adults. In 2012, about half (61%) of sparrows detected on the mainland were first detected at the northerly stations (Taylor's Head and Country Island) which suggests a north-westerly migration path for these individuals. A larger sample size and more extensive receiver network in 2013 suggests that adults and juveniles appear to differ in their route choice, with adults displaying a more easterly or southerly route than juveniles. If juvenile 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. The more easterly route observed by adult Ipswich to southern Nova Scotia, or a possible direct route to the east coast of the USA, would be more likely to cross the Deep Panuke and Thebaud platform areas. No tagged individuals were detected from platform supply vessels during autumn migration in either year. During the 2013 spring migration, Ipswich Sparrows tagged on the Nova Scotia mainland showed over water migration initiated immediately following sunset, most departures occurring in central portions of Nova Scotia between Conrad's Beach and Clam Harbour, and 10 of 21 individuals successfully migrating to Sable Island. Two individuals were detected by offshore supply-vessels, one passing by the vessel near the Deep Panuke platform (successfully arriving on Sable) and one detected for 5.5 h approximately 110 km west of Sable Island when the vessel was in transit towards Sable (unsuccessful migration).

In 2012, 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). 34 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. In 2013, 48 individuals were tagged at Glasgow Head (Canso Peninsula); none of these were detected flying over Sable Island, or by supply vessels. Many individuals were detected moving SW along the coastline of NS, and it is suspected that most of the individuals tagged likely departed from locations that would not have put them in proximity to offshore platforms. More analysis is required of these data.

Platform Sensors Deployment – In March 2012, a scope of work document was completed which outlined the plans for equipment installations on the Deep Panuke platform, including VHF receivers and use of existing platform radar signals. In March 2013, our revised goal was to have a VHF receiver/antennas installed prior to spring field studies (April 2013) and access to platform radar signal in June 2013. Due to continued delays in the hook up and commissioning of the platform, bird monitoring equipment was not installed on the platform in 2013. Deep Panuke First Gas was achieved in December 2013 and the installation of bird monitoring equipment is now scheduled for the spring of 2014.

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 from Sable Island and Leach's Storm-petrels from two mainland colonies (Country and Bon Portage islands) 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 supply-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, allowed us to expand the initial project and conduct two additional years of field studies. In 2012 and 2013, the project was continued and expanded in three 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 VHF-receiver based on commercially available off-the-shelf components. These receivers allow us much more control over tag recording and detection, which overcame problems associated with the significant VHF noise issues encountered in

2011. Second, we expanded the scope of our study to include three additional seabird species (Common Tern, Arctic Tern, and Great Black-backed Gull) and two passerine species (Blackpoll Warbler and Ipswich Sparrow), and an additional study site in Cape Breton. Finally, in 2013 the study was additionally expanded to include spring tagging of Ipswich Sparrows on the mainland Nova Scotia to investigate the spring migrations of this species to Sable Island. This report summarizes the preliminary results of colour-banding, VHF-tracking, and other telemetry approaches used for all species during our field studies from 2011 to 2013.

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 December of 2011 to 2013, field studies were conducted on Sable Island, Country Island, Bon Portage Island, south-eastern Cape Breton Island (autumn 2012), Conrad's Beach (spring 2013), and north-eastern Nova Scotia (Canso, autumn 2013; Figure 4.1-1). At each site birds were equipped with various combinations of colour-bands and/or telemetry devices 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 and colour bands on birds (4.4).

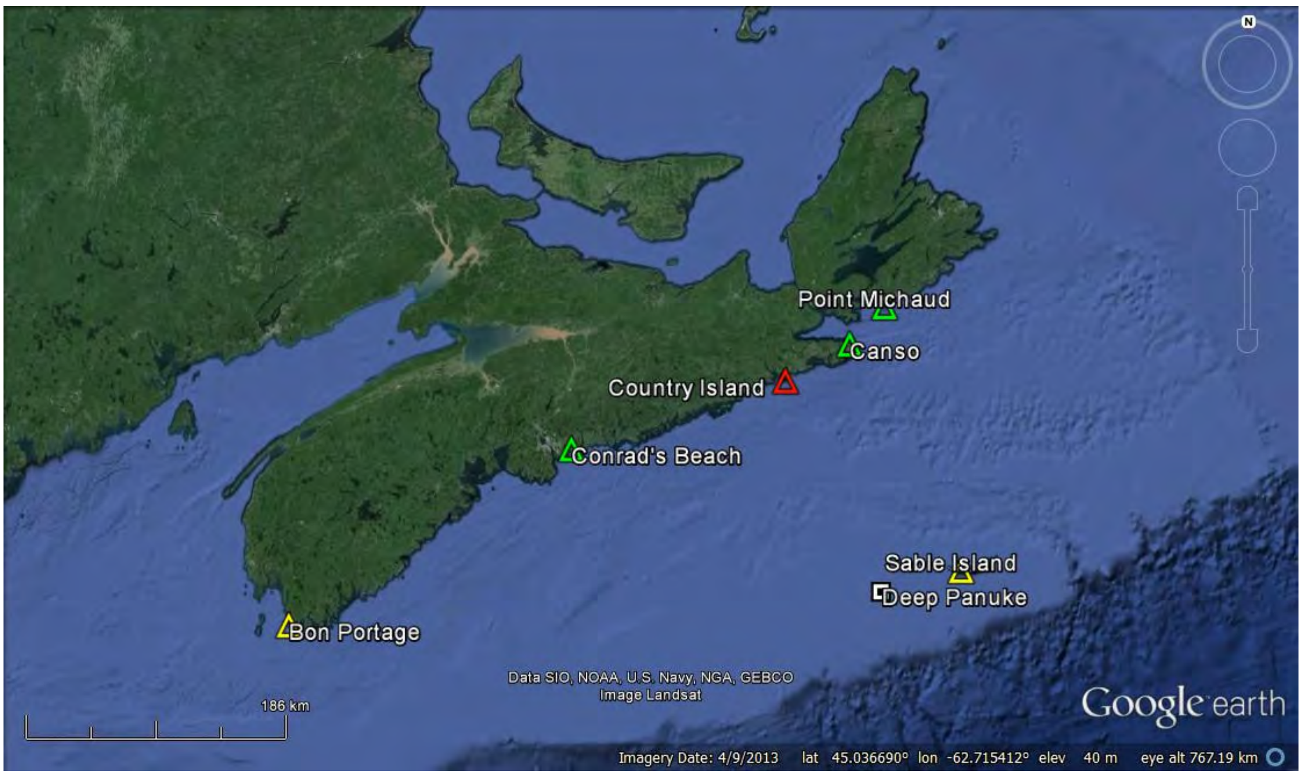


Figure 4.1-1 – Location of study sites relative to the Deep Panuke platform. Tags were deployed on seabirds (red sites), songbirds (green), or both (yellow). Tags were deployed on gulls (Sable Island, 2011-2013), terns (Sable, 2012 & 2013; Country Islands, 2013), Leach's Storm-petrels (Bon Portage and Country Island, 2011-2013), Ipswich Sparrows (Conrad's Beach, spring 2013; Sable Island, late summer 2012 & 2013), and Blackpoll Warblers (Point Michaud, 2012; Canso, 2013; Bon Portage 2012 & 2013). See Section 4.4 for additional details on tag deployments by species and site.

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, First Gas achieved in December 2013). Situated approximately 200 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 years, SOEP platforms developed by ExxonMobil began extractions in 1999 (3 platforms), 2003 (1), and 2004 (1); Encana's Deep Panuke platform began 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. In 2013, additional receivers stations were deployed with 1 km of each of the tips of the 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 (ExxonMobil platforms) and date platform was installed offshore (Deep Panuke, production commenced in 2013). POB = Personnel On Board at all times. Distances are approximate.

						Distance (km)	
Platform	Operator	Latitude	Longitude	Year	POB	to Sable Island	to shelf edge
Thebaud	ExxonMobil	43.89188	-60.19989	1999	yes	9	48
Venture	ExxonMobil	44.03328	-59.58175	1999	no	7	44
North Triumph	ExxonMobil	43.69958	-59.85454	1999	no	25	18
Alma	ExxonMobil	43.59483	-60.682	2003	no	60	27
South Venture	ExxonMobil	43.9982	-59.6273	2004	no	6	42
Deep Panuke	Encana	43.8127	-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 – Sable Island supports about 750-950 breeding pairs of Herring Gulls and 400-500 breeding pairs of Great Black-backed Gulls (Ronconi unpubl. data) which have both declined since surveys in the 1970s (Lock 1973). In other parts of the world, gulls are commonly attracted to platforms and supply vessels for foraging and roosting (Baird 1990; Tasker et al. 1986) and, around Sable, 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). The diets of Sable's gulls were studied in the 1970s (Lock 1973) but nothing is known about their foraging ranges or habitat use.

Terns - Large colonies of Common and Arctic Terns nest on Sable Island, and Sable is one of only six 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.

Leach's Storm-petrels - The breeding population of Leach's Storm-petrels on Sable Island is very small and dispersed, known from occasional nests discovered around buildings and under debris, making it impractical to conduct studies on this species at this site. Instead, storm-petrels were tracked from mainland colonies at Country Island and Bon Portage Island (Figure 4.1), the two largest breeding colonies in Nova Scotia. 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. Storm-petrels are known to make foraging trips of 2 to 7 days while incubating and raising young at colonies, suggesting the potential to travel to the Sable Island area where interactions with platforms may occur. 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.

Sparrows - A sub-species of Savannah Sparrow, the Ipswich Sparrow is slightly larger, with paler plumage and is 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 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.

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 departing 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 at offshore platforms in the vicinity of Sable Island (CCWHC 2009). Their populations are declining in eastern Canada (Environment Canada 2010b).

4.2 VHF receiver development

Deployments of VHF receivers (SRX-600, Lotek Wireless Inc.) 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. These new receivers were used extensively during 2012 and 2013, demonstrating that the receivers and the associated tag extraction algorithm have enabled us to better detect tags in noisy environments.

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.sensorgnome.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 or intern SD cards. 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. During 2012, 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 enabled us to develop procedures for deployment setups that resulted in minimal down times in 2013.

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.

4.2.4 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. In 2013, this algorithm proved very effective at finding tag detections even in "noisy" environments. Nevertheless, we continue to explore alternate tag algorithms which may improve data extraction efficiency.

4.2.5 Wiki

We have created a wiki (www.sensorgnome.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 which enabled more effective VHF tracking networks to be established in the final year of the project. In 2013, Sensor Gnome and wiki users included project partners from New Brunswick, Maine, and Massachussetts who ran receiver stations capable of detecting birds tagged in our study.

4.3 Receiver deployments

A network of automated telemetry antennas and receivers (Figure 4.3-1, Appendix I) 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). In 2011, receivers were deployed in three colonies and six vessels, including three platform supply vessels, resulting in a total of nearly 600 receiver-tracking days (Table 1 in Appendix I). In 2012, 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 (Table 2 in Appendix I). A total of 1255 receiver-tracking-days were successfully obtained between 03-Jun and 25-Nov, 2012, including 628 days from seabird colonies, 224 days from coastal sites along mainland Nova Scotia, and 403 days from vessels around offshore platforms. In 2013, the receiver network included the three seabird colonies, four offshore supply vessels, and was expanded to include 17 coastal stations along the coast of Nova Scotia (Figure 4.3-1, Table 3 in Appendix I). On Sable we established additional stations as well with 9-element Yagi antennas at each of the lighthouses, 5-element antennas within 1 km of each of the island tips, and omni-directional antennas in each of the tern colonies (for a total of 6 receiver stations operational on Sable in 2013). A total of 5425 receiver-tracking-days were successfully obtained between 19 March 2013 and 13 Mach 2014, including 1214 days from seabird colonies, 3228 days from coastal sites along mainland Nova Scotia, and 983 days from vessels around offshore platforms (Table 3 in Appendix I). Data from 2013 are still being collated.

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).

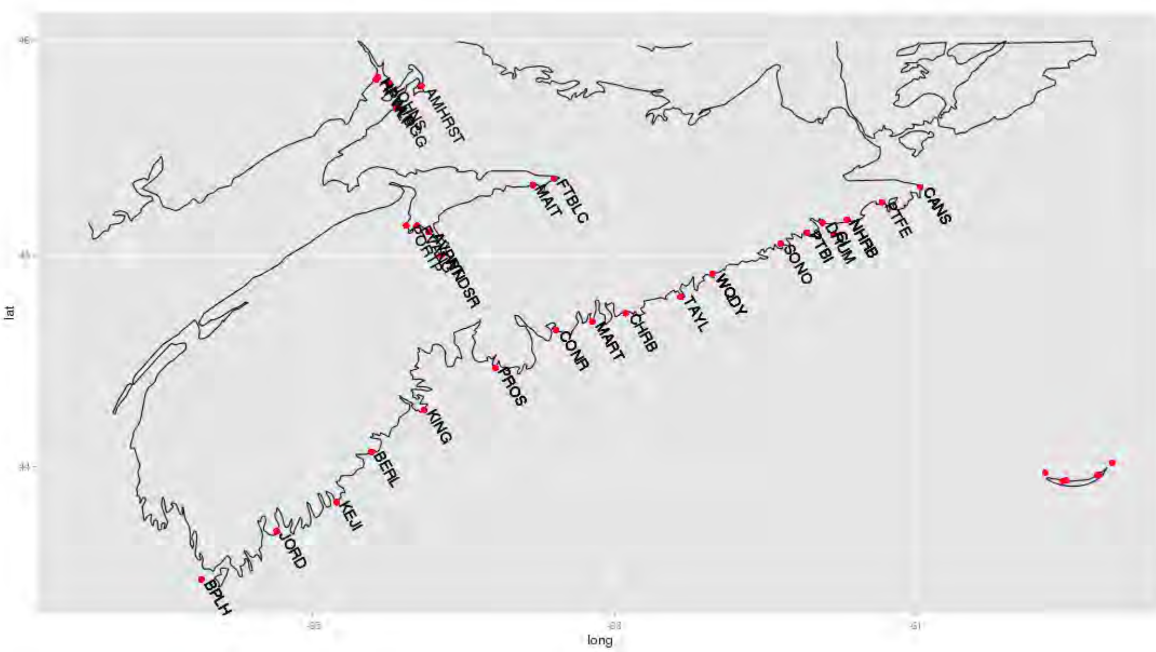


Figure 4.3-1 – Distribution of automated VHF receiver stations in Nova Scotia and New Brunswick during 2013. Site codes can be found in Table 3 of Appendix I. A subset of these stations were also used in 2011 and 2012 (see Appendix I for full details on receiver deployments in each year).

Vessel-based receivers were used to track the presence/absence of VHF-tagged birds near 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 a few kilometers of the platform, continuous VHF monitoring was conducted in the vicinity of manned platforms (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, 2012, to allow simultaneous monitoring of a second frequency (166.300 MHz) for tracking Blackpoll Warblers in that year. Antenna height was between 10 and 20 m above sea level.

Receivers at mainland sites and colonies had various antenna configurations (Appendix I) 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

Five types of electronic tags were used to track the movements of birds during this study. These included Very High Frequency (VHF) radio transmitters, Global Location Sensing (GLS) tags, GPS-logging tags, GPS-satellite tags, and PTT-satellite. Tag deployments are summarized in Table 4.4-1 and species specific details are provided in subsections below. Here we describe each tag type and their general purpose.

VHF radio telemetry tags (Lotek Wireless, avian nano-tags; www.lotek.com) were deployed on all study species. The small size of these tags (0.29 to 5 g) makes them ideal for deployment and tracking of a wide range of species, particularly small species that are not able to carry larger tags. VHF tags transmit signals at regular intervals (e.g. 5-10 seconds) which are then detected and recorded by receiver stations when birds are within detection range of antennas (see section 4.3 for summary of receiver station deployments). Automated receiver stations allow for continuous monitoring the presence/absence of VHF-tagged birds at receiver locations. 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 in 2012 and 166.380 for all other species and years). Deployments by species and locations are summarized in Table 4.4-1, and VHF tag model, programming, and attachment methods are summarized in Table 4.4-2.

Global Location Sensing (GLS) tags are small (<1g) data logging devices that were deployed on Leach's Storm-petrels to track their foraging trips from breeding colonies. The tags log ambient light levels throughout the day to provide estimates of sunrise and sunset times which are used to calculate daily latitude and longitude positions. Because these are archival tags, rather than transmitting, they must be recovered from the birds for data to be retrieved for analysis, thus, limiting their usage to birds that can easily be recaptured within the breeding season. The accuracy of locations obtained is relatively poor (± approximately 180 km), but is still useful for birds that travel long-distances to foraging areas and birds that are too small to carry other transmitters, such as storm-petrels.

GPS-logging tags coupled with automatic downloading base-station (Ecotone, Sterna 7 g, http://en.ecotone.com.pl) record GPS locations at pre-programmed schedules (e.g. every 15 min or 1 h). These tags store several thousand locations which are later uploaded to a base station when birds come within downloading range of the station (200-800 m). These tags provide high-accuracy locations but are limited to deployments on larger birds and during the breeding season when birds will predictably return to nest sites in proximity of the base station.

Satellite tags are considerably larger (typically in the 15 to 50 g range) which only allow deployments on larger species such as gulls. Two types of solar-powered satellite tags were used in this study: PTTs and GPS-satellite. Platform terminal transmitters (PTTs) turn on at a pre-determined schedules during which they transmit signals to earth orbiting satellites which determine their position on the surface of the earth (Argos satellite system, CLS America; www.clsamerica.com). GPS-satellite tags were programmed to obtain GPS locations at pre-determined intervals, store these data in internal memory, and transmit data through earth orbiting satellites every 4 to 5 days. Data are downloaded from the satellite service provider and decoded using software provided by the tag manufacturer (Microwave Telemetry Inc.). This allows us to track the movements of tagged animals anywhere they travel without the requirements of tag recovery (GLS) or a network of receiver stations (VHF).

Table 4.4-1 – Summary of telemetry devices deployed on birds in from 2011 to 2013. VHF = Lotek nano-tags. Sat = Microwave Telemetry 20g satellite linked GPS tags (Herring Gulls), Microwave Telemetry 20g solar PTT (Great Black-backed Gulls). GPS = Ecotone Sterna 7g GPS logger (Great Black-backed Gulls). GLS = Global Location Sensing (also known as geolocation tags).
** NE-Nova Scotia Blackpoll Warbler location: Point Michaud in 2012 and Canso in 2013*

Species	Location	Tag type	2011	2012	2013	TOTAL
Arctic Tern	Sable Island	VHF		15	22	**37**
	Country Island	VHF			16	**16**
Common Tern	Sable Island	VHF		20	28	**48**
	Country Island	VHF			15	**15**
Herring Gull	Sable Island	VHF	20	27	9	**56**
	Sable Island	Sat		6	3	**9**
Great Black-backed Gull	Sable Island	VHF		26	27	**53**
	Sable Island	Sat			11	**11**
Leach's Storm-petrel	Country Island	VHF	15	15	20	**50**
	Bon Portage Island	VHF	30	20	25	**75**
	Country Island	GLS		19	15	**34**
	Bon Portage Island	GLS		18	15	**33**
Ipswich Sparrow	Sable Island	VHF		44	64	**108**
	Conrad's Beach	VHF			21	**21**
Blackpoll Warbler	Bon Portage Island	VHF		53	2	**55**
	NE-Nova Scotia *	VHF		4	50	**54**
	TOTALS	**VHF**	**65**	**224**	**299**	**588**
		Sat/GPS	**0**	**6**	**14**	**20**
		GLS	**0**	**37**	**30**	**67**
		Overall	**65**	**267**	**343**	**675**

*Table 4.4-2 – Specifications of VHF tags deployed on seabirds and passerines in all years. 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 in 2012 (166.300). In 2013, tag model NTQB-6-2 was used on gulls with a weight of ~5 g and expected battery life of ~600 d.*

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

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 and satellite tag deployments. The goal was to investigate 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 for two species of gull: Herring and Great Black-backed. During May and June of each year, 2011-2013, adult gulls were captured during the breeding season 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. During August (2012 & 2013) and January (2012 & 2013), Great Black-backed Gulls of various ages were also caught by noose carpets set around seal carcasses.

Colour marking - 60 Herring Gulls (HERG) and 164 Great Black-backed Gulls (GBBG) from Sable Island were colour marked in 2011 through 2013 (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 leg (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. 2013) 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 also deployed on GBBG chicks in June of all years. 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 Sable Island. 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.

Year	Species	Age	Season (month)	Sample size: Colour Band	Sample size: 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
2013	HERG	adult	breeding (May/June)	12		na
	GBBG	AHY	winter (Jan)	12		na
	GBBG	AHY	breeding (May/June)	29		na
	GBBG	HY	breeding (May/June)	17		na
	GBBG	HY & AHY	post-breeding (Aug)	11		na
Totals	**HERG**			**26**	**34**	
	GBBG			**127**	**37**	

Information on bird movements from colour marking relies on reports from field observers. We 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 newsletters, handouts to Canadian Coast Guard and NOAA vessels, communication with the Canada Nova Scotia Offshore Petroleum Board's Fisheries Advisory Committee, and through a blog: http://sableislandgulls.wordpress.com/.

Radio tagging – In 2012, 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. In 2013, VHF tags (NTQB-6-2, ~4 g) were deployed on 44 gulls during May and June (n = 12 HERG, and n = 23 GBBG) and August (n = 9 GBBG). 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.

Satellite tagging – Platform terminal transmitting (PTT) satellite tags (Solar PTT-100, 18 g, Microwave Telemetry Inc., Columbia, MD, U.S.A.) were deployed on Great Black-backed Gulls in June, 2013 (n = 5 males & 1 female) - sex determined by DNA analysis. GPS-satellite tags (Solar Argos/GPS PTT-100, 22 g, Microwave Telemetry Inc.) were deployed on Herring Gulls in May, 2012 (n = 6 females) and June, 2013 (n = 2 males & 1 female). 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. PTT were programmed to turn on for 8 h daily. GPS-satellite 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; and
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.

To improve tag performance, the three tags deployed in 2013 were programed to receive 12 positions daily during spring/summer/fall, and 4 positions daily during winter.

4.4.2 Common and Arctic Terns

During June of two years, we deployed VHF tags on terns at two colonies on Sable Island (2012 and 2013) and one mainland colony at Country Island (2013 only). 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 provided information on differences in feeding preferences between the two species. Terns were caught on nests using walk-in Potter traps with drop-down doors or remotely activated bow nets (60 cm diameter).

Colonies and Receivers – Over two years, a total of 63 Common Terns and 53 Artic Terns were tagged between 9 and 17 June of each year. The period was chosen to be during mid to late incubation in order to minimize abandonment from handling in early incubation.

On Sable, study colonies 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 five 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 DFO (Department of Fisheries and Oceans) 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 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. In 2013, additional receivers were placed within East Colony, and the East and West Spits of Sable Island. An omnidirectional antenna was mounted in the East Colony to obtain fine-scale attendance data. Five-element antennas were mounted to the receivers on the East and West Spit to monitor movements of terns during breeding and post-breeding periods.

Country Island is located ~5 km off the coast of eastern Nova Scotia (45° 5" 58' N, -61° 32" 34' W) and contains a mixed colony of approximately 1300 pairs of Common and Arctic Terns. The island is approximately round and only ~500 m in diameter; nesting terns on the island are <100 m from the ocean. A yearly monitoring program (run by CWS) was active during the season and researchers on the island provided weather data, feeding observations and hatch success of tagged terns. To track tagged terns, receivers and directional antennas were mounted at the top of the Country Island lighthouse located in the center of the colony. Additional receivers were deployed onshore at nearby (<20 km) areas where terns have been previously observed. The locations were Drum Head, New Harbour, and Port Bickerton, Nova Scotia. Additional visual monitoring of the tagged terns was conducted at the Country Island colony which will be used to validate the presence/absence of VHF signals recorded from automated receiver stations. Observations were conducted from within wooden blinds located within 20 m of the nests of tagged birds.

Table 4.4-4 - Number of VHF tags deployed on terns at three colonies in June of 2012 and 2013.

Year	Colony	Common Terns	Arctic Terns	Total
2012	Sable, Main Station	10	10	20
	Sable, East Light	10	5	15
2013	Sable, Main Station	14	11	25
	Sable, East Light	14	11	25
	Country Island*	15	16	31
Total		**63**	**53**	**116**

* includes 2 tags that fell off and were redeployed on new birds

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. Common Terns tagged on Country Island during the 2013 season were given a black colour band with unique 3-letter code on their left leg – these facilitated individual identification for observations made from blinds.

VHF radio transmitters (NTQB-3-2, 1.4 g, braided antenna 14 cm long and 0.5 mm thick, with custom made end-tubes, 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.

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 (2011 to 2013), and deployment and recovery of geolocation tags (2012 and 2013). 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. Birds were captured by reaching into nesting burrows during late incubation and early chick-rearing stages.

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 and VHF tracking – During each study year, Leach's storm-petrels (LHSP) were captured for tagging during early July, on Country Island, and mid-July to mid-August on Bon

Portage Island (see Table 4.4-5 for samples sizes in each year). All birds were banded with a unique USFWS/CWS stainless steel leg bands, morphometric measurements were taken, blood and feather samples were collected for dietary analysis, and VHF tags were deployed. 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.

Patterns of colony attendance and information on departure directions were obtained from automated VHF receiver stations deployed on each island. On Country Island, the arrangement of antennas was modified slightly each year to improve detections. In 2011, two 9-element Yagi antennae facing 78° and 166° were connected to an SRX-DL situated at the top of the lighthouse for the entire season. In 2012 an omni-directional antenna connected to a Sensor Gnome was mounted to a pole close to the center of the colony (July 8 to 31) and four 9-element Yagi antennae facing 66°, 120°, 210°, and 246°situated at the top of the lighthouse (after July 31). In 2013, the four 9-element Yagi configuration was repeated for the entire season. On Bon Portage Island, in each year 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.

GLS Tagging: During 2012 and 2013, additional Leach's storm-petrels were captured for deployment of Global Location Sensing tags (GLS; Lotek Wireless, model MK5740, ~0.8 g, light sensor mounted on 5mm stalk) during early July, on Country Island, and mid-July to mid-August on Bon Portage Island (see Table 4.4-5 for samples sizes in each year). In 2012 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. On Bon Portage Island in 2012, all were deployed using the same technique as for the VHF tags. In 2013, all GLS tags were deployed using sub-dermal sutures, as per tern VHF-tag deployments.

Table 4.4-5 – Summary of tracking devices deployed on Leach's Storm-petrels between 2011 and 2013, on Country Island and Bon Portage Island. VHF = Very High Frequency (a.k.a. radio tags) and GLS = Global Location Sensing.

Year	Island	VHF	GLS
2011	Bon Portage	30	0
	Country Island	15	0
2012	Bon Portage	20	17
	Country Island	15	21
2013	Bon Portage	25	22
	Country Island	20	15
Total		**125**	**73**

Burrow monitoring: Each burrow was monitored at regular intervals (approximately weekly on Bon Portage and every 3 to 4 weeks on Country Island) 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. In 2013 VHF tag deployments were conducted during two periods, the first in mid-April at Conrad's Beach Nova Scotia, and the second in late August on Sable Island Nova Scotia. Migration tracking for these two deployments was from April through to July, and August through to December, respectively. The goal was to investigate differences in migration timing, differences in overwater migratory route, potential interactions with offshore platforms while in transit, and proportion of successful migrations between Sable and the mainland Nova Scotia for three groups (adult males, adult females, and juveniles)

***Spring Banding on Sable* -** Between 23 May and 23 June, 2012, 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 deployed 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.

Autumn Radio Tagging: In August of 2012 and 2013, Ipswich Sparrows were captured and banded with a unique USFWS/CWS aluminum band within 1 km of the West Light receiver on Sable Island, Nova Scotia. Adults were targeted by observing territorial individuals and flushing them into mist nets. Juveniles were caught incidentally while targeting adults. In 2012 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.

Birds 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. In 2012, 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. In 2013 birds with indeterminable sex were not tagged therefore no blood samples were taken.

Tag deployments for Ipswich sparrows are summarized in Table 4.4-6. Between 22 and 29 August 2012, 270 Ipswich Sparrows were captured, processed, and banded with a unique USFWS/CWS aluminum leg band. A total of 44 of these birds, 20 AHY and 24 HY from earlier broods, were radio tagged. Between 12 and 18 August 2013, 141 Ipswich Sparrows were captured, processed and banded with a unique USFWS/CWS aluminum leg band. A total of 64 of these birds, 31 AHY and 33 HY from earlier broods, were radio tagged.

Table 4.4-6 - *Total number VHF tags deployed on Ipswich Sparrows on during spring (Conrad's Beach, April 2013) and autumn (Sable Island, August 2012 and 2013)*

		Adult (AHY)		Juvenile (HY)	Total
		Male	Female		
2012	**Autumn**	7	13	24	44
2013	**Spring**	18	3	na	21
2013	**Autumn**	16	15	33	64
Totals	**Autumn**	**23**	**28**	**57**	**108**
	Overall	**41**	**31**	**57**	**129**

Spring Radio Tagging: Between 12 and 18 April, 2013, Ipswich Sparrows were captured, processed and banded with unique USFWS/CWS aluminum bands on Conrad's Beach, approximately 15km South East of Halifax, Nova Scotia. All captures were within 1.35 km of the Conrad's Beach telemetry receiver. Birds were caught while foraging using mistnets and radio tagged using a figure-8 leg-loop harness. Birds were aged based on moult patterns (Pyle 1997) and in one case from a recapture from 2012, as either after second year (ASY) or second year (SY): ASY birds had broad somewhat truncated retrices, while SY birds had extremely tapered outer retrices. Sexing was done by examining for presence of brood patch (present in females but not males) and when this was not possible blood was collected with capillary tubes, 0.1mL per bird from one wing and analyzed. A total of 21 birds (18 adult male, 3 adult female) were radio tagged using the same figure-8 leg-loop harness as in fall tagging (Table 4.4-6).

Manual Tracking on Sable Island: In addition to arrival detections by automated receiver stations at East and West Light, two island wide searches were conducted between 24 May and 10 June 2013 to locate radio tagged birds that had successfully migrated to Sable Island. Tracking was done with a handheld 5-element yagi antenna and an SRX-600. To detect as many birds as possible, tracking was done by climbing to the highest point at roughly 500 m intervals on both the North and South sides of Sable Island. At each point, the area was scanned in a minimum of 4 directions for approximately 30 seconds each. If a bird was detected it was located by sight and its GPS coordinates recorded.

Birds that were detected during manual tracking were subsequently monitored for 1 to 6 hours in an attempt to locate nests and quantify vegetation types within territories. Each individual's territory was mapped with a handheld GPS unit after observing flight and song patterns and territorial disputes with neighbouring sparrows. Territory assessments were made in the centre of the territory as well as at 3 locations 100 m away from territory center at 0, 120, and 240 to serve as proxies for adjacent territories. Territory assessments included: vegetation classification (dense heath, sparse heath, dense grass, sparse grass, sand), aspect, topography (flat, hummocky, hills, dunes), distance to nearest freshwater pond edge, uniformity, weather, time, interaction with other birds, and bird behaviour (foraging, singing, chirping). At bordering territories vegetation was classified, topography, aspect, bird presence or absence in a 10 x 10 m area.

Manual Tracking and searching on mainland Nova Scotia: In 2012, 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 2012 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 and 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.

Due to the lack of detections, the time costly nature of manual tracking, and success of automated digital detections, this methodology was not repeated in 2013.

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:

2012: 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 to 28 Sept, and on Bon Portage Island, mist nets were operated from 19 Sept to 25 Oct.

2013: BLPW were captured in mist nets and radio-tagged at two locations in Nova Scotia: Canso Peninsula (45° 19 ' 7.45"N, 60°58' 6.05" W) and Bon Portage Island (43°27'52.71"N, 65°44'45.17"W). The site at Canso was at the tip of the peninsula, about 175 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 Canso, mist nets were operated for most of Sept and early October. On Bon Portage Island we operated nets continuously between mid-August and the end of October.

Banding and radio tagging: Sample size by year and site is summarized in Table 4.4-7. In 2012, we radio-tagged 4 BLPW at Point Michaud and 59 at Bon Portage Island. Median tagging dates were 24 Sept 2012 at Point Michaud and 6 Oct 2012 on Bon Portage Island. In 2013, we radio-tagged 50 BLPW at Glasgow Head between 11 Sep and 11 Oct, and, after 9 consecutive days of not catching warblers, we relocated to Bon Portage Island where 2 individuals were tagged after 22 Oct. 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 (2012) and 166.380 MHz (2013) with a burst interval of 9.5-10.5 s, which had approximate lifetimes of 33 d. Tags weighed 0.29 g, which comprised 2.1 ± 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) in 2012.*

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
Total	**38**	**13**	**0**	**5**

Table 4.4-8 - *Summary of Blackpoll Warblers tagged by site, age, and fat score (*n = *53) in 2013.*

Site	Hatch-year		After-hatch-year	
	Fat < 4	Fat ≥ 4	Fat < 4	Fat ≥ 4
Canso Peninsula	39	6	3	2
Bon Portage Island	0	0	0	0
Total	**39**	**6**	**3**	**2**

Radio-telemetry: In 2012, local, stopover, and departure movements of tagged individuals were monitored using a pair of automated digital telemetry towers installed at the 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.

In 2013, departures of tagged individuals from the Canso peninsula (45.320°N, -60.968°W) were monitored by a pair of telemetry towers scanning a total of six antennas (3 per tower). Antennas were spaced in 60 degree intervals starting at 30 degrees. At Bon Portage Island, only one tower with 2 antennas was available, thus, limiting the quantification of departure directions but enabling the measurement of presence/absence at this site.

In both years, a broader array of telemetry towers monitored subsequent movements along the Atlantic coast of Nova Scotia and offshore areas around Sable (Appendix I; 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.

4.5 Tag detections in "noisy" environments

In 2012 we conducted the first deployments of Sensor Gnome receivers on vessels. Though there was a significant improvement over commercial receiver deployments in 2011, in 2012 a bug in the Sensor Gnome software exasperated "noise" from receivers on vessels (section 5.1) and, therefore, extra data processing procedures to eliminate potential false positive detections were conducted and are described in this section. The bug was fixed in 2013 deployments on vessels (sections 4.2.4 and 5.1), thus, procedures described below only apply to 2012 data.

The receivers deployed on vessels recorded all VHF pulses within the target frequency range of the VHF tags. These settings were optimized to detect tags but also recorded spurious pulses generated from various instruments aboard the vessels and in the surrounding areas. Post processing of these data searched for patterns of pulses which matched the pre-recorded VHF tag pulses based on inter-pulse intervals (milliseconds between sets of four pulses) and inter-burst intervals (time in seconds between sets of four pulses, typically 5-10 seconds depending on the tag programming). See sections 4.2.3 and 4.2.4 above for further details. This processing, however, may still generate false positive tag detections due to the excessive amounts "noise" generated by vessel-based instruments. Therefore, we used the following filtering criteria, separately for each vessel, to extract valid VHF tag detections (hereafter "hits") from the VHF noise. First we included only tag hits that had 2 or more hits in a run (run.len >1). A run is a series of consecutive tag hits for a given tag ID where all hits are separated by the known burst interval. Using run.len > 1 excludes tag hits that only had a single detection even, i.e. no runs. Second, we applied a spatial filter which omitted all hits when vessels were in port or approaches to the Halifax port (excluded detections of longitude < -62.5). During approaches to the Halifax port, vessels recorded excessive and often continuous hits, making true tag detections unreliable in this area. Finally, we applied a function which removed all hits when more than 5 tag IDs were detected within a 10 second period. This eliminates periods of excessive hits which were likely generated from periods of extensive VHF "noise" recorded sporadically from vessel-based receivers.

After filtering, we plotted the remaining hits for individual tag IDs to examine patterns of signal strength and detection rates across time, to determine plausible true detections of bird tags. We considered 4 or more hits within a 5 minute period to be plausible tag detections for further consideration. These hits were then compared with detections at mainland and colony-based receiver stations to examine if the timing and trajectory of movements between terrestrial and marine sites were still plausible. Series of consecutive detections from offshore vessels were then reclassified as "interaction events" to examine the timing, duration, location, and characteristics of each event.

5. Results

5.1 Receiver development

Early in the season of 2012, 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 2012 summer, and used extensively throughout all sites in 2013. 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 Appendix I for details on site specific receiver deployments).

On Sable Island, 2012, 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 of 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 Sable Island, 2013, there were only two notable receiver failures that resulted in data gaps. The first was at the East Light tern colony in the latter half of the breeding season (mid-July) when the grass grew tall and prevented the solar panel from charging the receiver battery. The second was at the West Spit when in late June horses snapped the antennas cables – this was repaired in mid-August. Additionally, in November and December when day length was short and unable to recharge batteries, some short gaps in receiver coverage also occurred at West Spit, East Light and East Spit, though most study species had departed by this time.

On Country Island and Bon Portage Island, receiver towers worked for the entire tracking period with no significant gaps in data collection during either 2012 or 2013. On the mainland sites in 2012, 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. On the mainland sites in 2013, a few receivers failed for short periods (typically < 5 d) but the larger array of receivers in the network and more frequent checks of the receivers mean that these gaps will have minimal consequences for tracking bird migrations.

Receivers were deployed on four offshore supply vessels operating around Sable. Table 5.1-1 summarizes deployment schedule by vessels outlining periods of active receivers and limitation of coverage in 2012 due to equipment malfunctions. 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. An early deployment on the Panuke Sea provided no useful data coverage because the vessel was conducting operations outside of the target study area (late July), and high amounts of VHF noise resulted in no coverage for October and November (see following paragraph on algorithm error). 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). In 2013, the vessel-based receivers worked continuously from April through to December except for one failure on the Ryan Leet (27-Sep to 13-Nov).

Table 5.1-1 Summary of receiver deployment schedule on four platform supply vessels in 2012 when monitoring periods were limited by "noise" and gaps in deployment periods. In 2013, the only significant gap occurred for the Ryan Leet between 27-Sep and 13-Nov.

Vessel	Platforms supported	Periods of receiver monitoring in 2012	Limitations
Venture Sea	SOEP platforms	14 Aug - 06 Dec	
Panuke Sea	SOEP platforms	23-31 Jul*, 13 Aug to 21 Nov	high noise in Oct and Nov
Ryan Leet	Deep Panuke	24-31 Jul, 19 Sep to 13 Nov	
Atlantic Condor	Deep Panuke	08 Aug to 25 Nov	

*operating outside of Sable natural gas field during this period

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 in 2012; this error was corrected for all deployments in 2013. We have refined the algorithms to extract tag detections from ambient VHF noise levels and are 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 for all receivers and software within the Sensor Gnome receivers (see also section 6.2 below). These fixes were extensively tested over the winter of 2012-2013, and most systems ran without problems in 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. Interpretation of these results and implications for monitoring bird-platform interactions are presented in section *6 Discussion* below.

5.2.1 Herring and Great Black-backed Gulls

Colour marking – Since initial deployments in 2011 through to December 2013, we have collected 94 resighting reports of wing-tagged and colour banded gulls. Data on mainland resightings are still being compiled but here we present some of the key results from sightings at platforms and platform supply vessels.

Wing-tags were deployed on 21 adult Herring Gulls in May and June 2011. Between 1 Jun and 31 Dec, 2011, we received 27 sighting reports and individual identification codes were confirmed on 59% (16/27) of these (Table 5.2-1). Sightings of 8 different individuals (38% of tagged birds) were confirmed by 3-letter codes, and most individuals were spotted on multiple occasions. More than half of the sightings and 5 of the confirmed individuals (24% of the total tagged population) were observed from supply vessels operating near the Deep Panuke platform between 21-July and 22-August. Four sightings from SOEP supply vessels confirm that Sable Island Herring Gulls also attended other offshore platforms and vessels.

Table 5.2-1 Resightings of wing-tagged Herring Gulls between July and December, 2011. % of sightings = percentage of all confirmed tag re-sighting reports (total of 27).

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

*Ryan Leet and Rolling Stone; **Panuke Sea

From 21 Herring Gulls tagged in 2011, eight 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 HERG and 25 GBBG in May and June 2012. Between 1 Jun and 31 Dec, 2012, we received 7 sighting reports of HERG and 13 reports of GBBG (Table 5.2-2). 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. In 2012, only 2 of 13 wing-tagged Herring Gulls (15%) and 1 of 25 wing-tagged Great Black-backed Gulls (4%) individuals were resighted at platforms or supply vessels. 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.

*Table 5.2-2 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**

No wing-tags were deployed in 2013, but colour leg bands were deployed on 12 HERG (adults) and 57 GBBG (various ages). Since 01 January 2013, 22 resightings were reported of colour bands and wing-tags deployed in this or previous years (Table 5.2-3), but only one sighting was associated with a platform: a leg-banded Herring Gull, marked in 2013, was reported from a supply vessel at Thebaud platform on 03 August. Without the deployment of wing-tags in 2013, we expected fewer resightings because leg-bands are more difficult to notice.

Table 5.2-3 Resightings of wing-tagged gulls between 1 January, 2013 and 25 March, 2014. HERG = Herring Gull, GBBG-S = Great Black-backed Gull banded in the spring, GBBG-W = Great Black-backed Gull banded in the winter.

Location	Species	No. sightings	% of sightings	Confirmed individuals (no. of sightings)	Dates
Sable Island					
summer	HERG	1	4.5	ACP (1)	21-Aug-13
spring	GBBG-W	1	4.5	turquoise tag (not identified)	20-Mar-13
spring	GBBG-S	1	4.5	yellow tag (not identified)	20-Mar-13
summer/fall	GBBG-S	3	13.6	AFP(1), AFK(1), one other	May/June & Nov-2013
Offshore					
Bay of Fundy	HERG	1	4.5	AFF(1)	14-May-13
Supply vessel - Thebaud platform	HERG	1	4.5	pink leg-band (not identified)	3-Aug-13
Gully Marine Protected Area	GBBG-S	1	4.5	green leg-band (not identified)	1-Sep-13
Mainland					
Montauk, NY	HERG	1	4.5	AFX(1)	1-Jan-13
Fitchburg, MA	HERG	1	4.5	AFF(1)	26-Feb-13
Cape Cod, MA	HERG	1	4.5	AFP(1)	18-May-13
Port-aux-Basques, NL	HERG	1	4.5	pink tag (not identified)	28-Jul-13
Cape Breton, NS	HERG	1	4.5	pink tag (not identified)	10-Sep-13
Glace Bay, NS	HERG	3	13.6	AAF(3)	10-Oct to 16-Nov-13
Montauk, NY	HERG	2	9.1	AFP (2)	15-27 Dec-13
Wilmington, DL	HERG	1	4.5	AAF(1)	8-Mar-14
Cape May, NJ	GBBG-S	1	4.5	AFM(1)	24-May-13
West Pubnico, NS	GBBG-S	1	4.5	AFJ(1)	12-Dec-13
Total - Herring Gulls		**14**	**63.6**	**4**	
Total - Great Black-backed Gulls		**8**	**36.4**	**7**	
Total - all gulls		**22**	**100**	**11**	**01-Jan-31-Dec**

Despite these limitations associated with non-systematic resightinging effort, resightings of wing-tags and colour bands provide evidence of general patterns interactions with platforms and post-breeding movements. First, birds begin attending offshore supply vessels and platforms after chick rearing is complete (mid-July) and peaks in August. Second, from the Sable population, a higher proportion of platform attendance occurs by Herring Gulls than by Great Black-backed Gulls. Third, migration to the mainland occurs between late August and early October. Finally, at least some individuals remain offshore to forage near supply vessels and platforms through September and October (24 October was the latest sighting in all years).

VHF tracking – VHF tags were deployed on Herring Gulls and Great Black-backed Gulls between May and June of 2011 (n = 20), 2012 (n = 53) and 2013 (n = 44), and colony based receivers monitored gull presence/absence during the breeding and post-breeding period, until December of each year (with a gap from 27 Aug to 4 October in 2012). In 2011 most tags (15/20) stopped being detected after 1 day to 3 weeks, limiting analysis in that year, 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 5.2-2), 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 from 2012 (Table 5.2-4), most gulls (58% of GBBG and 82% of HERG) departed Sable Island before 27 August, when the receiver failed. Mean departure dates during this period were 13-July (± 12.2 d) for GBBG and 26-Jul (± 17.7 d) for HERG. A two week receiver re-activation in early October showed that seven GBBG (41%) and three HERG (18%) remained in the Sable Island area until this time. 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.

Table 5.2-4 Summary of Herring Gull and Great Black-backed Gull departure dates from Sable Island inferred from VHF tags deployed on 53 gulls in 2012. Automated receiver stations at East Light and West Light on Sable Island were functional between 20 June to 27 August 2012, providing departure dates (i.e. date of last detection on the island) for 24 of 34 individuals during this period. The receiver was reactivated from 4-17 October, providing evidence of birds still present on the island during this period. Data were analyze for 34 gulls where complete data were available, thus, omitting tracks with "incomplete data" where tags were known to fall off, birds departed the colony immediately after tagging, or birds were tagged in section of the island where receivers failed (see text for details).

		departures occurring between 20-Jun and 27-Aug, 2012				
Species	**gulls tracked (n)**	**n**	**earliest**	**mean**	**SD (days)**	**number of gulls detected between 4-17 Oct 2012**
Great Black-backed Gull	17	10	25-Jun	13-Jul	12.8	7
Herring Gull	17	14	2-Jul	26-Jul	17.7	3

VHF receivers deployed on four supply vessels recorded 14 gull-vessel interaction events in 2012 (summarized in Table 5.2-5). Most events were from Herring Gulls (5 individuals, 12 events) and only one Great Black-backed Gull was recorded from supply vessels during two events. Most events occurred near Thebaud platform (10/14) at night in late August and early September, compared with two detections of the Great Black-backed Gull near the Deep Panuke platform during the day in late September. Two additional detections from the Ryan Leet occurred > 14 km away from any platform, likely while this vessel was in transit to Halifax. Most interaction events were brief: 11/14 were less than 30 minutes in duration, only three were more than one hour (longest event occurred over 3.7 h period in late August). These results should be treated with caution as numerous equipment failures and excessive VHF noise from vessels have limited the detection of VHF tags in 2012 (see Section 5.1 above); this summary of interaction events is likely an under-estimation of the true number of interaction events which occurred (see Section 6.6.1 of the *Discussion* below).

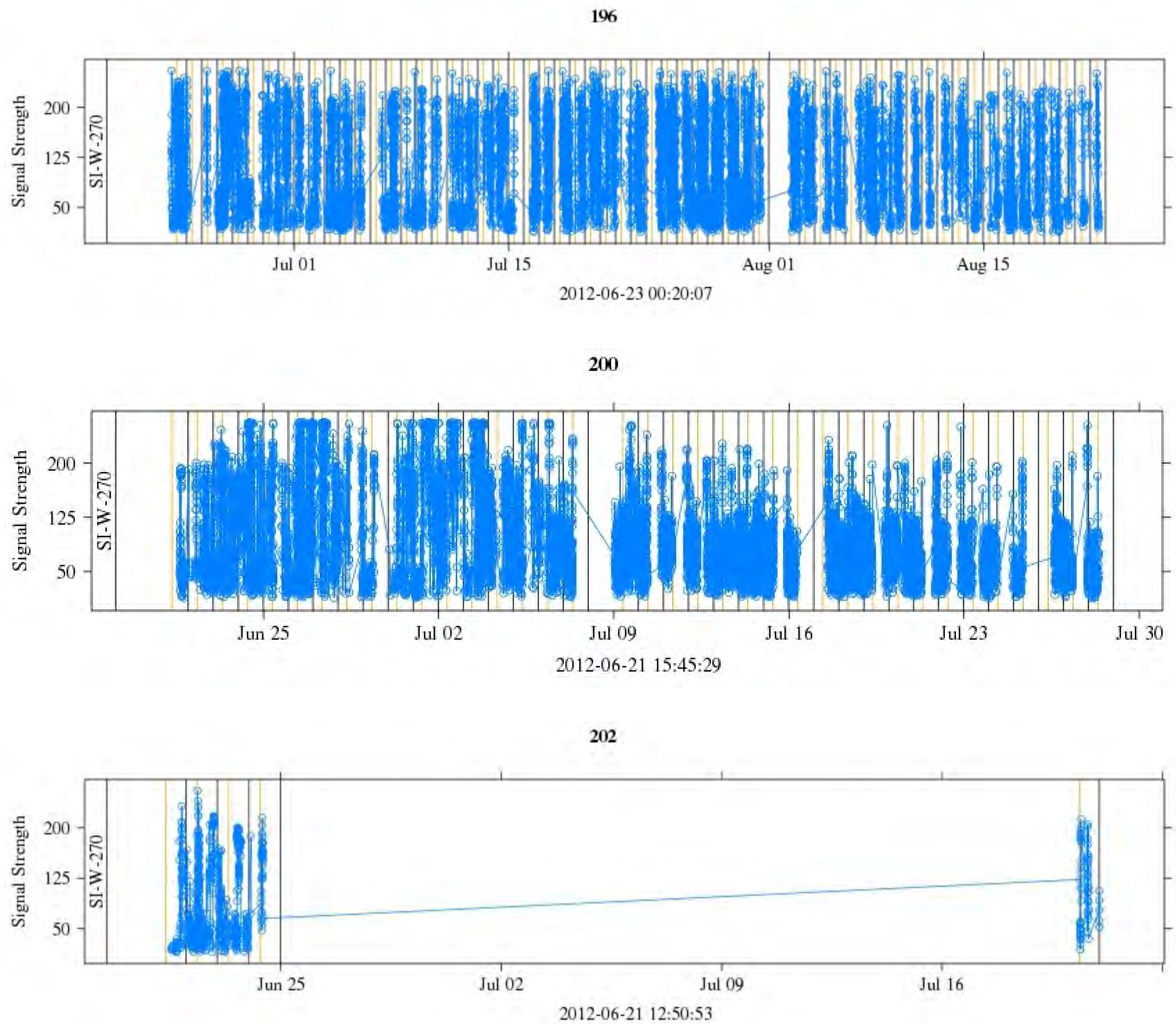


Figure 5.2-1 Example plots showing patterns of colony attendance by three Herring Gulls tagged on Sable Island. Individual gulls are identified by their tag ID number at the top of each plot. Each circle represents a VHF tag detection and blue lines connect detections in sequence. Gaps in detection periods 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.

Table 5.2-5 Summary of gull-vessel interaction events documented from four platform supply vessels in 2012. Interaction event is defined as 4 or more consecutive VHF tag detections. HERG = Herring Gull, GBBG = Great Black-backed Gull, RL = Ryan Leet, VS = Venture Sea, DP = Deep Panuke, T = Thebaud

				Nearest Platform		Interaction Event			Signal Strength (db)	
Date (2012)	Species	Bird ID	Vessel	Name	Distance (km)	Start time (UTC)	VHF detections (n)	Duration (min)	Mean	SD
26-Jul	HERG	27	RL	DP	14	19:13	4	9	-67.0	2.3
28-Jul	HERG	27	RL	DP	30	15:24	4	10	-52.1	1.9
24-Aug	HERG	196	VS	T	2.3	23:08	4	8	-75.6	1.2
25-Aug	HERG	205	VS	T	1 to 1.4	5:09	13	98	-65.8	5.6
25-Aug	HERG	195	VS	T	1 to 1.8	3:13	58	224	-70.4	4.2
29-Aug	HERG	185	VS	T	1.5 to 3	2:10	21	79	-66.6	5.7
31-Aug	HERG	195	VS	T	1.5 to 2	0:53	4	10	-66.5	3.8
31-Aug	HERG	185	VS	T	2.2	2:02	6	14	-65.3	4.2
1-Sep	HERG	185	VS	T	4.5 to 6	5:53	5	26	-66.3	2.8
4-Sep	HERG	205	VS	T	2.1 to 2.7	2:54	6	14	-70.7	5.9
8-Sep	HERG	205	VS	T	1.7	23:49	5	14	-65.0	5.4
9-Sep	HERG	205	VS	T	2.8	4:03	13	19	-62.8	4.1
29-Sep	GBBG	188	RL	DP	3.4	18:39	15	3	-63.9	2.7
29-Sep	GBBG	188	RL	DP	2.1	21:05	22	5	-63.2	4.9

In 2013, platform supply vessels detected 42% and 28% of VHF tagged Herring and Great Black-backed Gulls at least once (Table 5.2-6). These data are roughly consistent with 2012 showing higher proportions of Herring Gulls attending platform areas than Great Black-backed Gulls and most of these interactions occurring post-breeding. Subsequent analysis will look at timing and duration of platform interaction events for both 2012 and 2013 combined.

Table 5.2-6 – Gulls tagged in 2013 which were detected at least once at platform supply vessels. SOEP = Sable Offshore Energy Project.

		% of individuals detected by offshore vessels at least once in 2013				
		overall	Deep Panuke vessels		SOEP vessels	
	# tagged	all vessels	Ryan Leet	Atlantic Condor	Venture Sea	Panuke Sea
Herring Gull	12	42%	25%	17%	42%	17%
Great Black-backed Gull	32	28%	25%	3%	3%	9%

Satellite tracking – Satellite tags deployed on nine Herring Gulls in 2012 and 2013 resulted in a total of 1450 bird-tracking days and 24,880 locations in the Sable Island area, prior to migration departure (Table 5.2-7, Fig. 5.2-2). Tracking data have been modeled with a Bayesian state-space model for animal movements to provide better location quality estimates combining GPS locations and Argos PTT locations. 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 5.2-7 – Summary of tracking data obtained from 9 Herring Gulls tracked by satellite tags in one or both years, 2012 & 2013. Tag ID 115927 was recovered after it fell off the bird in 2012, and was redeployed (ID 115927b) in 2013. * Departure date not given for bird 115927 because tag fell off bird 22 June 2012. Data not shown for other platforms which had 1 or no locations of Herring Gulls within 200 m.*

					# locations within 200m of platform				
Tag ID	**Year**	**Departure from Sable***	**Days tracked in Sable area**	**# locations**	**Deep Panuke**	**Thebaud**	**Alma**	**All platforms**	**% of total locations**
115925	2012	23-Aug	89	2085	0	0	0	0	0.0%
115925	2013	28-Aug	158	3314	0	18	0	18	0.5%
115926	2012	12-Oct	138	2060	102	47	27	176	8.5%
115926	2013	29-Oct	220	2885	17	22	1	40	1.4%
115927	2012	na	26	478	0	0	0	0	0.0%
115927b	2013	19-Jul	43	1021	0	0	0	0	0.0%
115928	2012	9-Aug	74	1664	0	0	0	0	0.0%
115929	2012	26-Jun	29	686	0	0	0	0	0.0%
115929	2013	28-Jun	99	2242	0	0	0	0	0.0%
115930	2012	24-Oct	149	2203	5	73	1	79	3.6%
115930	2013	31-Oct	212	2767	7	43	0	50	1.8%
115931	2013	17-Aug	70	1582	0	40	0	40	2.5%
115932	2013	29-Oct	143	1893	16	152	2	170	9.0%
		TOTALS	**1450**	**24880**	**147**	**395**	**31**	**573**	**2.3%**

Plotting the number of bird locations relative to distance from platforms showed an apparent attraction effect within 200 m at 3 of the 6 platforms (Figure 5.2-3). Most interactions occurred during chick-rearing and post-breeding phases (Figure 5.2-3), between July and November (Figure 5.2-4), primarily by 3 of the 9 tagged individuals (Table 5.2-7). Overall, five of nine birds interacted with the platforms each in one or both years ranging from 0.5 to 9% of all locations occurring within 200 m of any platform (Table 5.2-7). Those individuals interacting with platforms in 2012 also interacted with platforms in 2013, suggesting individual specialization on platforms.

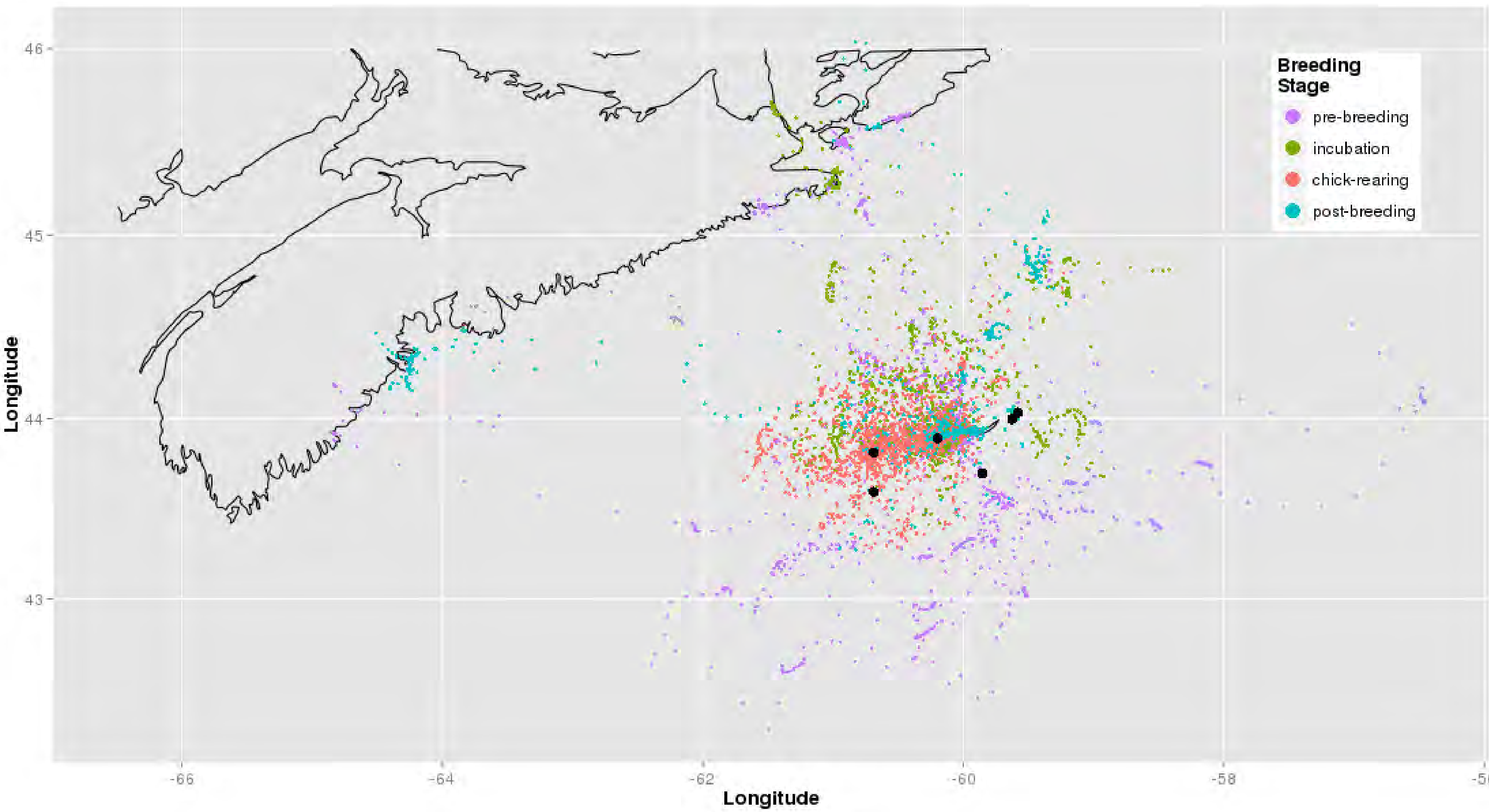


Figure 5.2-2 – Locations, classified by breeding stage, of 9 Herring Gulls tracked from Sable Island between May 2012 and December 2013. All locations in each year occur between dates of first and last detection on Sable Island, thus, omitting migrations and over-winter periods. Black dots are locations of 6 offshore natural gas platforms.

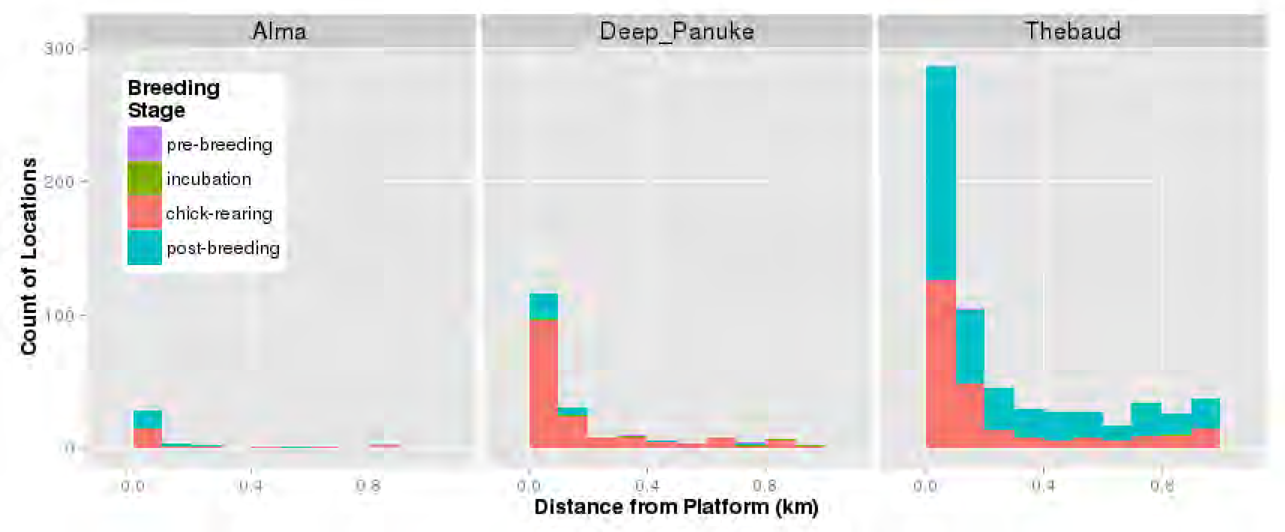


Figure 5.2-3 – Count of all Herring Gull locations, classified by breeding stage, within 1 km of platforms between May 2012 and December 2013. Counts are binned in 200 m increments. Data not shown for three platforms with fewer than 10 locations within 1 km.

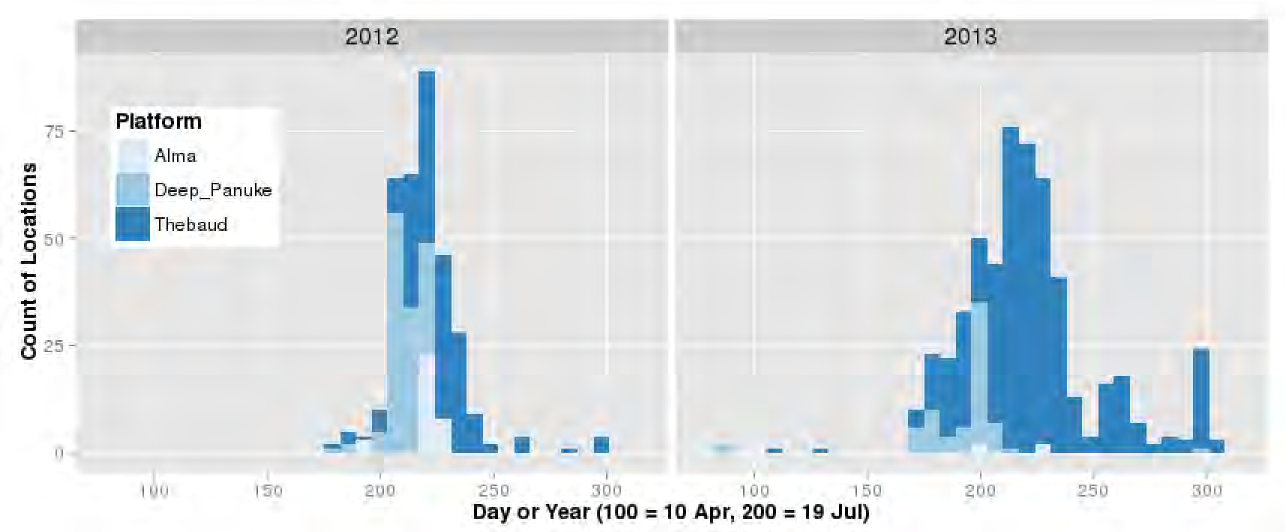


Figure 5.2-4 – Seasonal patterns of Herring Gull tracks occurring within 200 m of platforms around Sable Island. Counts are binned in 7 day increments. Data not shown for three platforms with fewer than 2 locations within 200 m.

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 nine satellite tracked individuals (Table 5.2-7, above), departure dates were highly variable including late June (1 individual in both years), July (1), August (3), and late October (4). Departures were followed by direct migration to mainland Nova Scotia and eventual migrations to southern Nova Scotia and New Jersey (Figure 5.2-5).

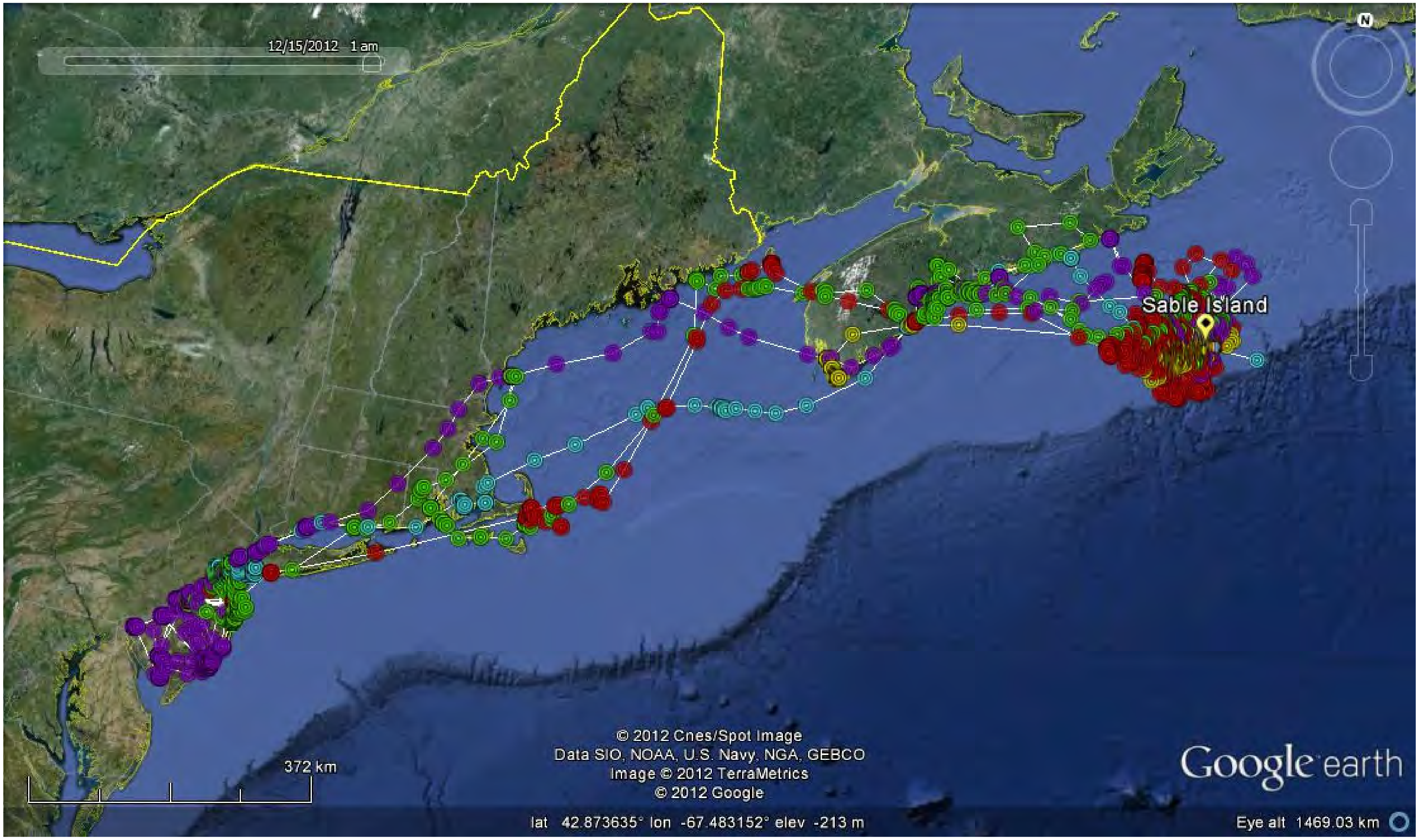


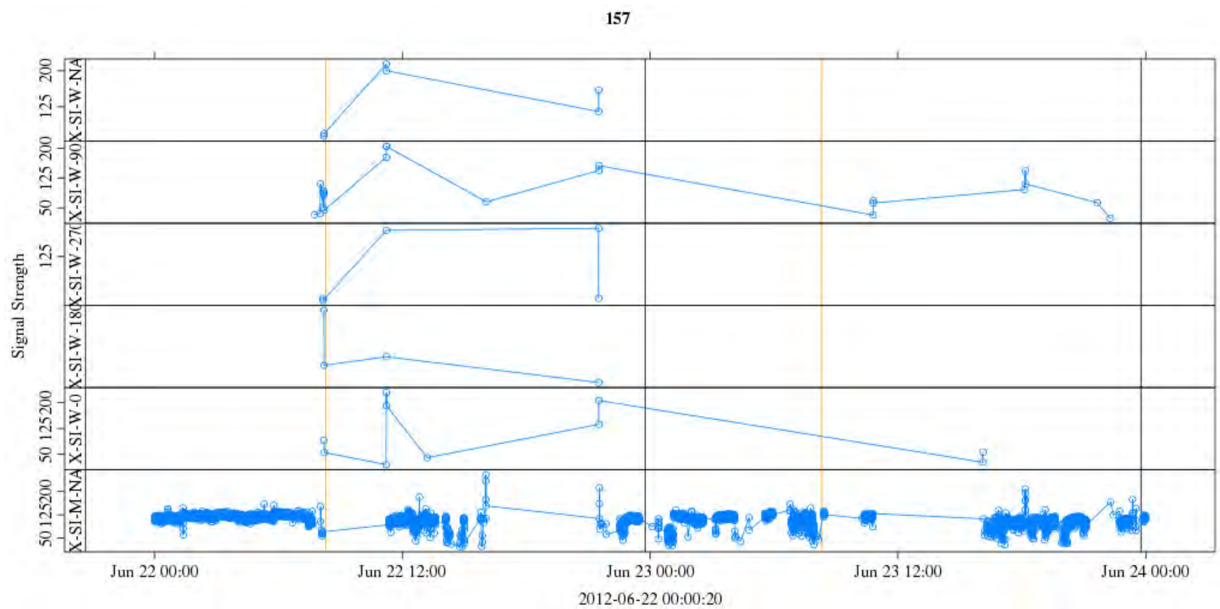
Figure 5.2-5 – Satellite tracking data from five Herring Gulls tagged on Sable Island (26-28 May 2012) until 20 December 2012. Migration routes are shown between Sable Island and New Jersey (4 birds) and southern Nova Scotia (1 bird in yellow).

5.2.2 Common and Arctic Terns

Preliminary assessment of tern detections, incubation patterns, foraging bouts and movement is summarized in this section. Continued analysis for an MSc student thesis will provide final results and publication in 2014.

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. Of the 49 transmitters deployed on Common and Arctic Terns on Sable Island in June 2013, all tags were recorded on multiple occasions by one or more of the active receivers on the island. Receiver failure at the East Colony in mid-July resulted in limited fine-scale foraging trip data; however, the East Light receiver remained functional throughout the season and provided detailed data on foraging trip movements. In 2013, there was evidence of terns abandoning their nest (and colony) and/or tags falling off of some individuals (~5); these occurred during late incubation and early chick rearing.

Activity patterns - During the 2012 season, terns from the Main Station colony were tracked continuously throughout the chick rearing and post-breeding period documenting colony attendance patterns and duration of foraging trip departures. Examples of colony attendance patterns measured by VHF detections are presented in Figure 5.2-6. Analysis of these attendance patterns will classifying data into "events" of 1) colony attendance, and 2) foraging bouts, each of which will have a start and end time which provide duration and time of day for events. Preliminary results of this analysis from five birds at Main Station colony showed slight differences in activity budgets between Common and Arctic Tern. The mean time spent for an individual foraging trip was identical between species: 4.9 ± 2.5 (SD) h for Common Terns and 4.8 ± 1.7 (SD) h for Arctic Terns. The mean colony attendance period was 6.3 ± 2.9 h for Common Terns and 3.7 ± 2.8 h for Arctic Terns. Similar analysis of the 2013 data is currently being conducted. Data from both Country Island and Sable Island will be used to determine foraging trip duration patterns. These foraging trip durations will be determined in a similar manner to 2012, with a focus on periods of absence from the colony. Example plots are provided below depicting the daily periods of absence (foraging trips) of individual terns nesting on Country Island. These plots will be conducted on all tagged individuals. Once the data is compiled for all individuals, future analysis will investigate factors influencing foraging trip and colony attendance patterns such as time of day, tides, weather, and breeding phase.



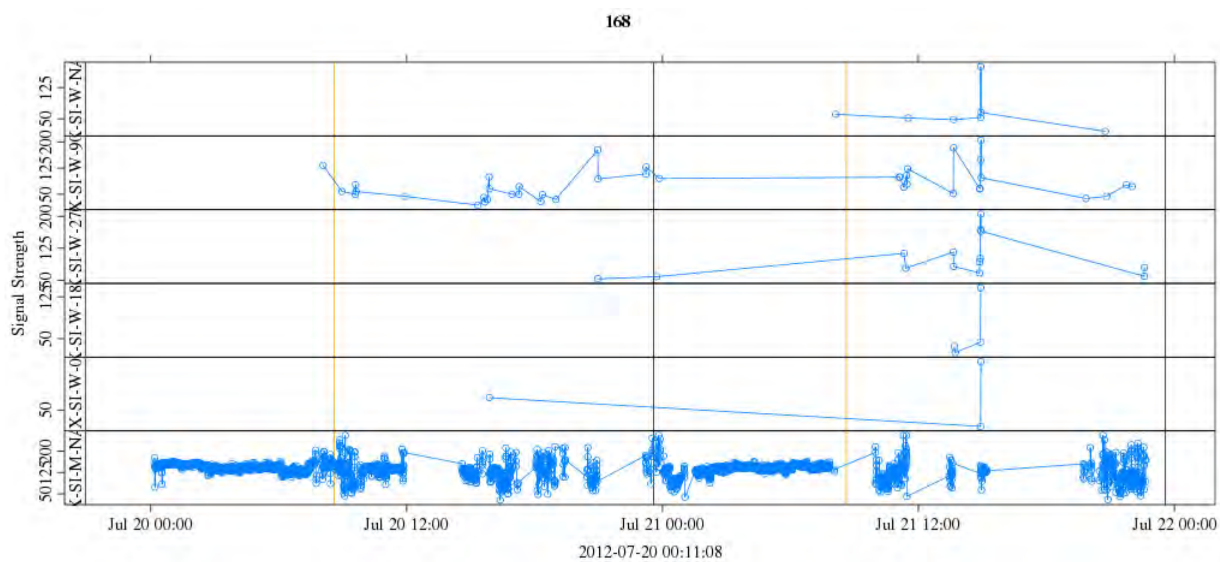


Figure 5.2-6 Example plots showing 2 days of colony attendance patterns in 2012 by one Common Tern (Tag ID 157, upper plot) and one Arctic Tern (tag ID 168, lower plot). Both birds were tagged at the Main Station colony where a receiver was deployed within the colony to monitor colony attendance patterns (lower panel within each plot; SI-M-NA) and 5 directional antennas were mounted in the Westlight Lighthouse (upper panels within each plot), approximately 1 km west of the colony. Each circle represents a VHF tag detection and blue lines connect detections in sequence for individual antennas. Gaps in detection periods indicated tern absence from the Main Station colony. Date is presented along the x-axis 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. Data are presented for each directional antenna from Sable Island (SI) West Light (W) oriented north (0), south (180), east (90), west (270) and a single omni-directional (NA). Vertical lines represent time of local sunrise (yellow) and sunset (black) during periods of VHF detections.

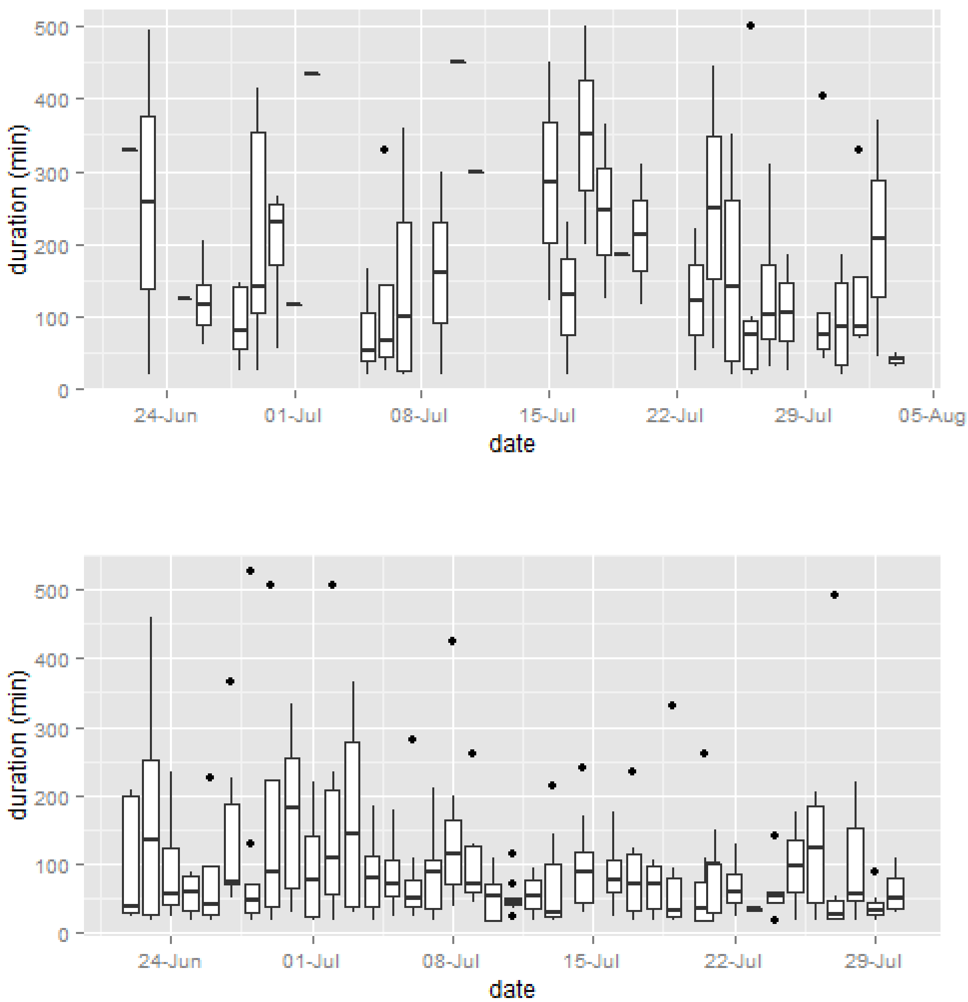


Figure 5.2-7 – Example plot of seasonal patterns of foraging trip duration (in minutes) for two individuals nesting on Country Island in 2012: Common Tern, tag ID 479, 22-June to 3-Aug (upper plot), and Arctic Tern, tag ID 474, 22-June to 30 July. Boxplots show means (horizontal bars), boxes extend to the first and third quartiles (the 25th and 75th percentiles), whiskers represent 1.5 x the inter-quartile range, and dots are outliers.

Movement patterns - VHF data will also be used to quantify "movement events" when direction of movement may be inferred from directional array of antennas, or from detections across multiple receiver stations. This will assess departure and return directions of foraging trips in order to identify important foraging areas around Sable Island. Preliminary analysis of movement events show movements across the island, between receiver stations 20 km apart. During the 2012 season, 3 tagged birds from the Main Station colony were detected flying by the East Light colony, and 7 tagged birds from the East Light were detected at the Main Station colony. During the 2013 season, 20 of the 50 tagged birds were found to move across the island being detected at receivers away from their respective colonies. These movements will be used to identify spatial patterns in foraging activity and identify foraging hotspots around Sable Island.

Receivers were deployed at the tips (commonly known as the East and West Spit) of Sable Island for the 2013 season to monitor tern activity at these locations throughout the breeding and post-breeding season. In these locations, large groups of terns have been observed roosting and feeding throughout various phases of the breeding season and, therefore, may be important habitat for nesting and post-breeding terns on Sable. Activity at the West Spit was higher in comparison to the East Spit: 9 and 3 of the 50 tagged birds were detected at West Spit and East Spit, respectively, at least once during the breeding season (returning to the colony afterwards). Some individuals were frequently detected at West Spit, with up to 20 trips during the breeding season.

Vessel-based receivers were deployed to confirm offshore foraging of terns and quantify bird-platform interactions. During 2012, no tern tags were detected by offshore vessels, however, this result was not surprising given the delayed timing of receiver deployments on vessels. Receivers were deployed on two vessels during the last week of July, one of which (the Panuke Sea) was working along the Nova Scotia coast at this time, rather than the offshore areas around Sable. The other receiver, deployed on the Ryan Leet, failed on 31 July due to electrical issues. The remaining two receivers aboard the Atlantic Condor and the Venture Sea were not deployed until August 7 and 14, respectively, but operated continuously thereafter in the Sable offshore area. Given that most terns had departed the Sable Island area by the last week of July (see mean departure dates above), there was little chance of any receiver detecting terns around the offshore platform. Nevertheless, a lack of detections in Augusts also suggests no bird-platform interactions are occurring post dispersal from Sable.

In 2013, vessel-based receivers were again deployed to detect offshore foraging movements of terns throughout the breeding season. Overall, the majority (over 95%) of tagged terns were not detected by vessel-based receivers. Two terns were detected by two vessels, the Ryan Leet and the Venture Sea (Figure 5.2-8), suggesting limited offshore foraging during the breeding and post-breeding season. The Venture Sea receiver detected one Arctic Tern (tag 404) on July 3rd; prior and following this detection the tern was detected by the East Lighthouse receiver. At the time of detection the vessel was located at 44.01087º N and -59.60848º W, roughly 15 km from East colony, 9 km from the nearest point of Sable Island, and 2 to 3 km from the nearest platforms, Venture and South Venture. The Ryan Leet receiver detected a Common Tern (tag 417) twice on August 14. These detections were separated by roughly 3.5 hours and likely represent a single foraging trip in which the tagged tern flew past the vessel twice (Figure 5.2-8). The location of the Ryan Leet at the time of initial detection was 44.21755º N and -62.08727º W, roughly 160 km from the nearest point of Sable Island, 70 km from mainland Nova Scotia, and 120 km from the nearest platform, Deep Panuke. During the same day, this individual was detected on Sable Island both before and after these offshore detections indicating that terns, post-breeding, may take very long offshore foraging trips. All tern detections by vessels were short in duration (< 1 min) suggesting that terns were flying by the vessels rather than spending long periods foraging near or around vessels and platforms.

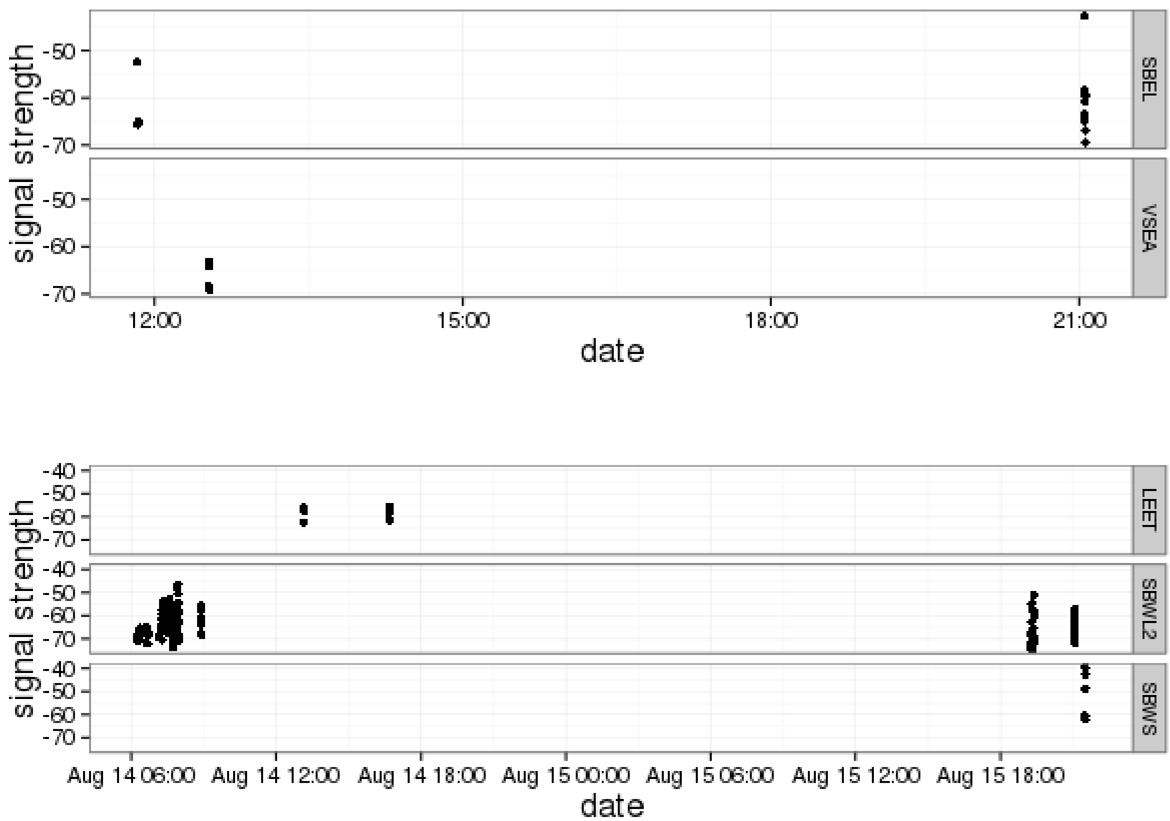


Figure 5.2-8 – Vessel-based receiver detections of foraging terns during breeding and post-breeding season in 2013. Upper plot: Arctic Tern (tag 404) detected at East Light receiver followed by detection on Venture Sea vessel receiver on July 3, 2013; tagged tern detected once again at East Light during breeding season. Lower plot: Common Tern (tag 417) detected at West Light receiver followed by departure and return to Sable Island on Ryan Leet receiver on Aug 14, 2013; tagged tern once again at West Light followed by West Spit receiver during the breeding season.

Dietary analysis - Stable isotope analysis of tern blood samples from Sable Island suggested dietary differences between the two species (Figure 5.2-9). 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.

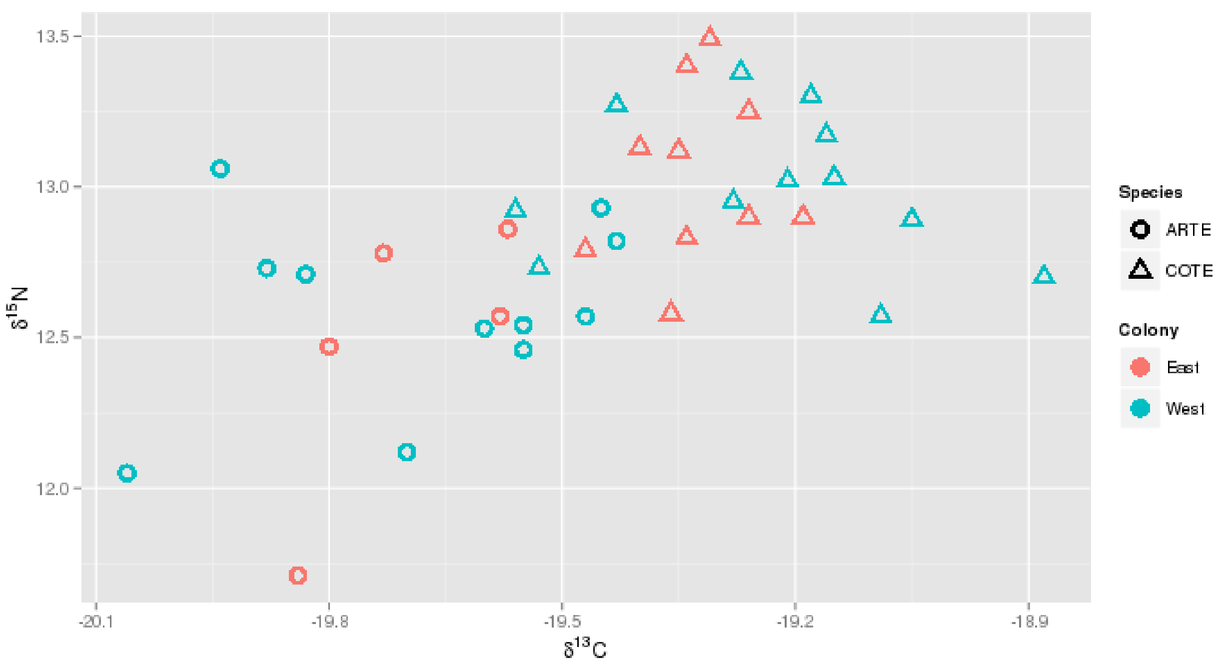


Figure 5.2-9 – Stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope values from blood samples of Common Terns (COTE) and Arctic Terns (ARTE) collected from two colonies on Sable Island: East Light (East) and Main Station (West) colonies. δ^{15}N values represent relative trophic level and δ^{13}C are related to dietary source.

Staging and post-breeding dispersal – Post-breeding, patterns of staging behavior on the tips of Sable Island also provide evidence of island use prior to migration. One case of staging behavior was detected at the West Spit by a Common Tern. Following the last detection at the Main Station colony, the bird was detected at the spit almost daily from August 17th to September 10th, 2013 (Figure 5.2-10).

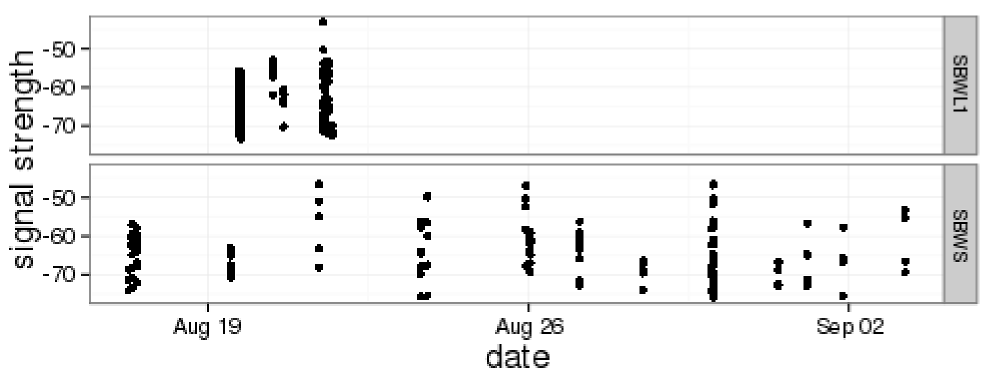


Figure 5.2-10 – Detections from automated receiver stations on Sable Island, 2013, near the breeding colony (SBWL1) and West Spit (SBWS) indicating post-breeding staging behavior of a tagged Common Tern (tag 419) at West Spit.

Island wide VHF monitoring also provided data on species specific departure dates from the colony in late July and early August. Mean departure dates (date of last detection on Sable) for terns from the Main Station colony for the 2012 season was 28-July ± 15.3 d (SD) for Common Terns and 25-July ± 16.2 d for Arctic terns. Median date of last detection for both species in 2012 was 29-July and all birds had departed by mid-August. In 2013, timing of departure (last detection at colony) was similar for Sable and Country Island, though departure dates were more protracted on Sable, possibly due to post-breeding staging behavior occurring on this island (Figure 5.2-11). Note, for calculations of departure timing in 2013 we omitted dates of last detection of tagged individuals prior to July 15 (this included some tags that fell off and individuals that abandoned breeding). The timing of departure from Sable Island marks a period after which we would no longer expect bird-platform interactions to occur.

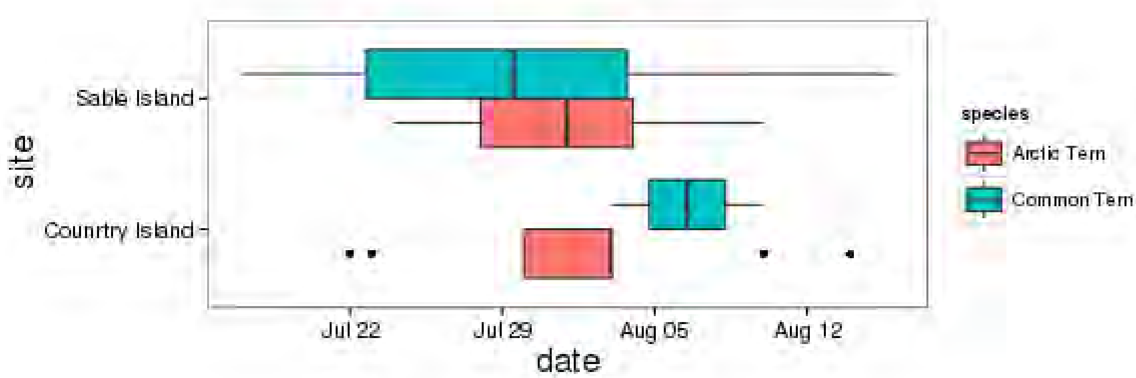


Figure 5.2-11 – Date of last detection at the breeding colony of tagged Common and Arctic Terns during the 2013 field season nesting on Country Island and two colonies on Sable Island. Boxplots show means (vertical bars), boxes extend to the first and third quartiles (the 25th and 75th percentiles), whiskers represent 1.5 x the inter-quartile range, and dots are outliers.

Receivers maintained by other projects at various locations in the Gulf of Maine allowed us to investigate regional movements during the post-breeding period in 2013. Four of forty-three (9%) tagged Common Terns from Country and Sable Islands were detected by receivers on Cape Cod, Massachusetts, with some individuals remaining in the area for up to 10 days (Figure 5.2-12). Diel patterns of detections suggest periods of foraging (away) and roosting (continuous signals) at these sites. Movements to Cape Cod within days following the last detection on Sable suggest rapid post-breeding dispersal by some proportion of the breeding population. Colony departures (Figure 5.2-11) and detections of Sable Island terns staging in the Cape Cod in early August (Figure 5.2-12) indicates a period after which tern interactions with offshore vessels and platforms are less likely to occur.

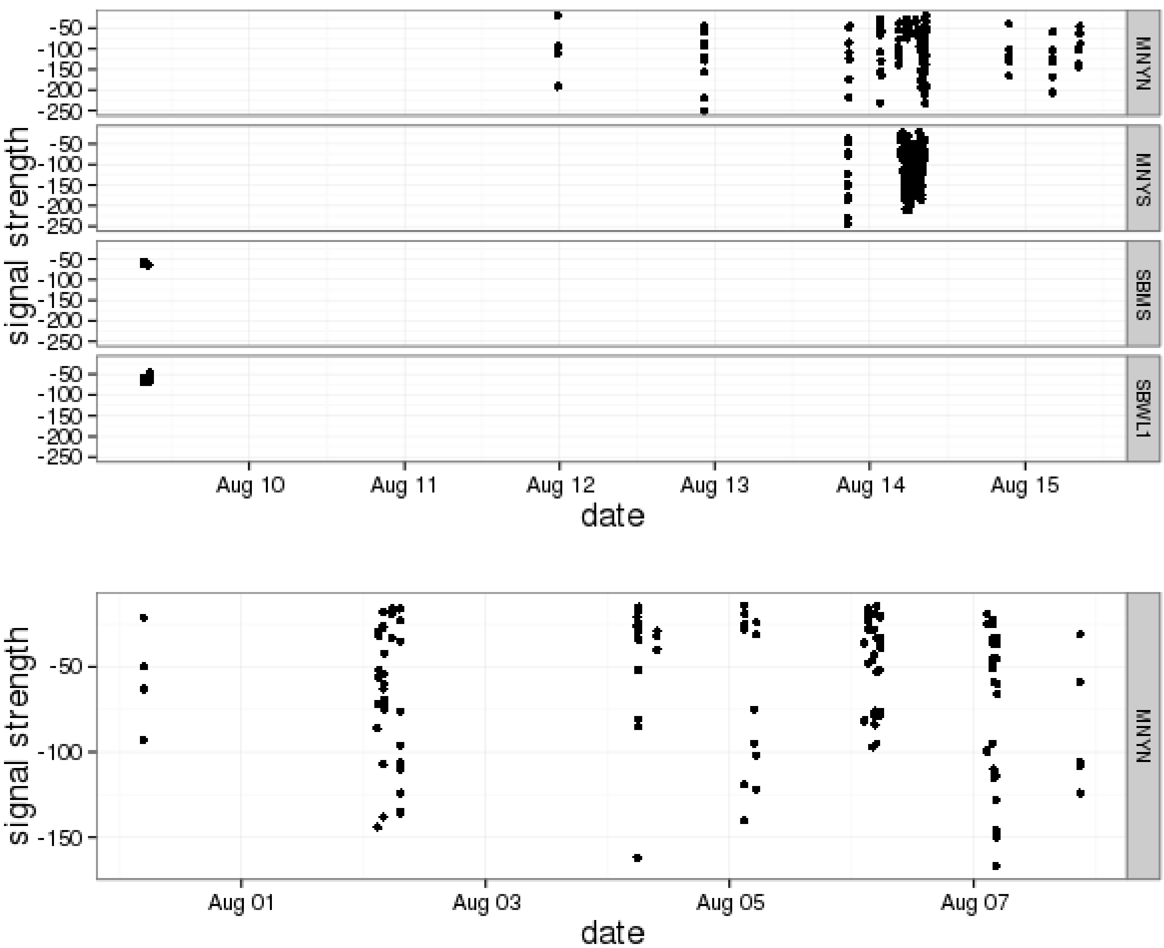


Figure 5.2-12 – Broad scale movement detections of Sable Island tern to Massachusetts, USA, 2013. Upper plot: Last detection of a tagged Common Tern (tag 420) on Sable Island (SBMS & SBWL1) followed by initial and continuing detections of Massachusetts receivers (MNYN & MNYS) during the post-breeding season. Lower plot: Daily detection of Common Tern (tag 370) staging in Cape Cod area.

5.2.3 Leach's Storm-petrel

VHF tracking - In each year VHF tags were deployed on Leach's Storm petrels on Bon Portage Island and Country Island 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 (both colonies), 23.8 ± 11.3 days in 2012 (both colonies), and 20.3 ± 10.3 days (Bon Portage Island) and 27.5 ± 10.2 days (Country Island) in 2013. 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. In 2012, 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 2013, there was no difference in fledging success rate on Bon Portage Island for burrows with VHF tags (68.75%) compared to control burrows (76.6%, . $\chi^2_1 = 0.16$, $p = 0.68$). In contrast, fledging success on Country Island was 6.7% for burrows with VHF tags and 15.8% for control burrows in 2012 and similarly low rates were again observed in 2013 for both tagged and control burrows. On Country Island, in both years, 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. See also below non-significant effects of GLS tags on petrel fledging success, suggesting limited effects of smaller VHF tags attached with similar methods.

Data on foraging trip and colony visit duration have been analyzed for Bon Portage Island in each year, and Country Island in 2011/2013 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 5.2-8) 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 5.2-8 - Mean duration of colony visits and foraging trips (h ± sd) during incubation and chick-rearing on Bon Portage (BP) and Country Island (CI; 2012 data not yet analyzed). Within columns, means with the same letters indicate durations that are not significantly different from each other.

	Colony visit duration (h)		**Foraging trip duration (h)**	
Site/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
BP 2013	64.0 ± 25.9 B	7.2 ± 7.4 A	87.2 ± 26.0 A	61.4 ± 11.2 A
CI 2013	69.3 ± 24.2 B	6.8 ± 4.1 A	95.0 ± 14.5 A	64.1 ± 5.9 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 5.2-13). From Bon Portage Island, mean departure directions were southerly and return directions were more variable 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.

There were no confirmed detections of Leach's Storm-petrels from supply vessels in 2012, though timing of receiver deployments and malfunctions (Section 5.1, Table 5.1-1) would have limited our ability to detect birds throughout the target study period in July through September. In 2013, when vessel data were more complete, only one storm-petrel tag was detected from a supply vessel (the Atlantic Condor) during the second week in July and this event included only four tag detections suggesting a very short interaction or, more likely, a bird passing by the area.

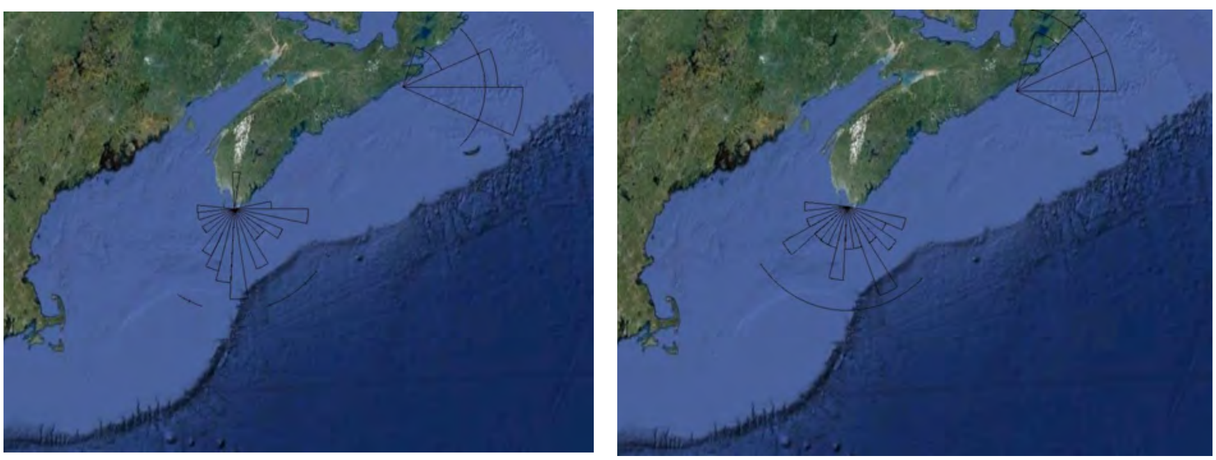


Figure 5.2-13 – Departure (left panel) and arrival (right panel) directions of Leach's Storm-petrels from colonies at Bon Portage Island (2011/2012) and Country Island (2011). Data from Country Island in 2012 and both locations in 2013 are still being analyzed. Movements were inferred from VHF telemetry 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 results – In 2012, 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. In 2013, GLS tags were recovered from 11 Storm-petrels from Country Island and 14 Storm-petrels from Bon Portage representing a 67%

recovery rate (11/15 from Country Island and 14/22 from Bon Portage Island). For all individuals but one, multiple foraging trips were recorded during deployments. 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 (Bon Portage Island, 2012). 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°. Tracks were analyzed with a Bayesian state-space-model to provide model twice-daily location estimates and eliminate spurious locations typical of GLS tracking data.

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 5.2-9). Foraging locations from individuals nesting on Country Island likely overlap with the platform areas around Sable Island (Figure 5.2-14). Subsequent analysis of these data will investigate the minimum distance between estimated locations and offshore platforms, and the proportion of tracks which transit through the platform area around Sable Island.

Table 5.2-9 - Summary of foraging trip characteristics of Leach's storm-petrels from Country Island (CI) and Bon Portage Island (BP) during 2012 and 2013 incubation. .

Year	2012		2013	
Island	CI	BP	CI	BP
Deployment duration (d)	17 ± 6	9 ± 4	20 ± 12	31 ± 17
Foraging trip duration (d)	6.2 ± 0.5	6.3 ± 1.2	4.9 ± 0.3	4.6 ± 0.3
Maximum distance from colony (km)	1086 ± 220	684 ± 209	983 ± 249	587 ± 149
Average distance travelled (km)	2659 ± 615	1013 ± 159	2117 ± 541	1371 ± 379

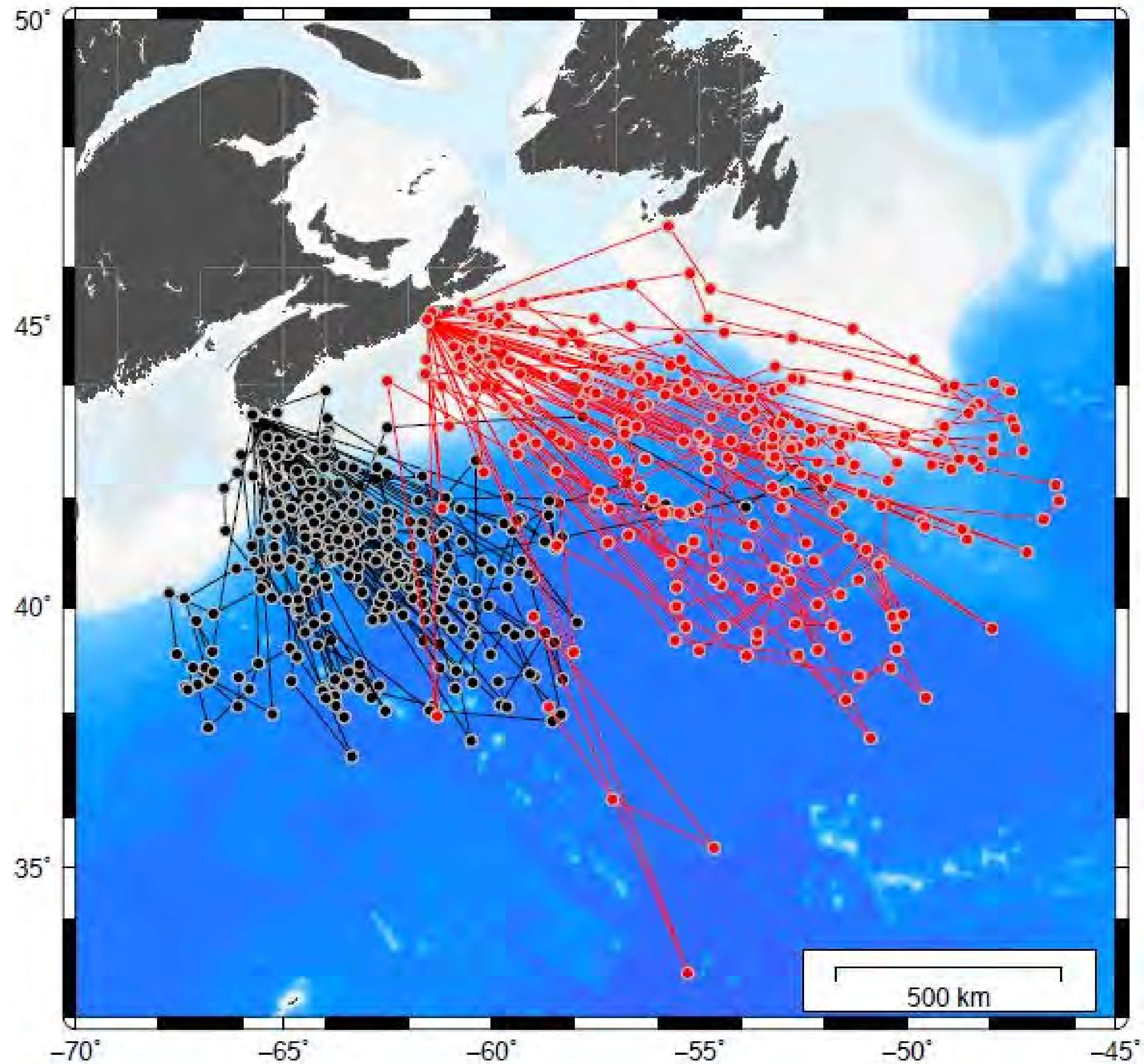


Figure 5.2-14 – Foraging ranges of Leach's Storm-petrels obtained from geolocation tags deployed during incubation period 2012 and 2013 at Bon Portage Island (n = 19 birds, black dots) and Country Island (n = 16, red dots). A State Space Model (SSM) was used to provide estimates of twice daily locations. Figure from Pollet et al. (in press): http://onlinelibrary.wiley.com/doi/10.1111/jav.00361/abstract

5.2.4 Ipswich Sparrow

In early summer 2012 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 2012 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. In August of 2012 and 2013 we deployed 44 and 64 VHF tags respectively on Ipswich Sparrows on Sable Island, Nova Scotia to determine timing, overwater route choice, and migratory patterns during fall migration. In April 2013 we deployed 21 VHF tags on IPSP on Conrad's Beach, Nova Scotia to determine timing, overwater route choice and migratory patterns during spring migration.

At present we have obtained complete VHF receiver data from mainland Nova Scotia and Sable Island in both study years. However, data from 20 Sep to 31 Dec, 2013, were only recently obtained, and further processing is required before they can be incorporated in the results below. Currently departure information for fall 2013 is based on the assumption that the point of first detection on the mainland can be used as a proxy for departure from Sable Island. These data form the basis of preliminary analysis presented here.

Fall Movements on Sable Island – In both years all sparrows were tagged within 2 km of the West Light receiver and all individuals were subsequently detected on this receiver. Detections at West Light in 2013 are more constant and frequent for adults compared to juveniles. This was expected as adults were still territorial in late August while juveniles are free to move among territories once fully fledged. Many birds were only detected during daylight hours on the island, indicating that once under cover of vegetation during the night they are out of range of the receivers. Throughout September and October, many of the juvenile sparrows but none of the adults were detected at the East Light receiver, 20 km away. This suggests extensive "exploratory" movements by the juveniles but limited movement within the island for adults. In 2013 the addition of receivers at the West and East Spits provided more detailed information. Up to 20 September 2013, 13 sparrows have been detected at West Spit (~20 km west of West Light) all of which were juveniles, consistent with adults remaining in territories and juveniles conducting exploratory flights to West Spit before their earlier departures.

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 in fall 2012, 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 for 2012. 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.

Based on the timing of detections on the mainland in 2012, it appears that hatch year birds arrived on the mainland earlier than adult 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 2012, 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). There were too few adult detections to compare differences among timing of arrival between sexes.

Based on mainland detections in 2013, the pattern and timing of arrival was consistent with results from 2012. Of the 39 IPSP that have been detected on the mainland, the majority (70%) arrived before 15 October, the remaining 30% arrived between 15 October and 11 November (Figure 5.2-15). There is also a marked difference in migration timing between adult and juvenile Ipswich Sparrows (Figure 5.2-16). First detections of juveniles on the mainland ranged from 17 September to 23 October, while adults first appeared a month later and ranged from 18 October to 11 November. There is very little overlap in migration timing – only one juvenile was detected on the mainland for the first time after adults began arriving.

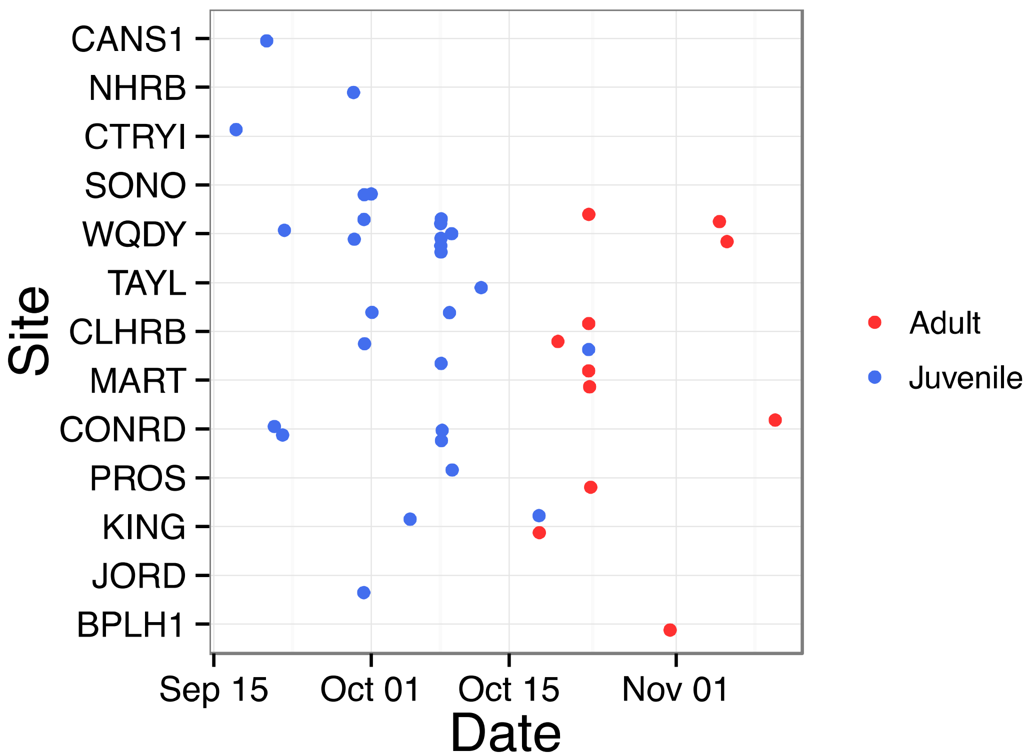


Figure 5.2-15 – Date and location (site) of first detection on the mainland for individual Ipswich Sparrows during fall migration in 2013. The 13 sites along the east and south shores of Nova Scotia are ordered longitudinally from north-east to south-west (top to bottom). Adults (red) initiate migration a month later than the first juveniles (blue) appear.

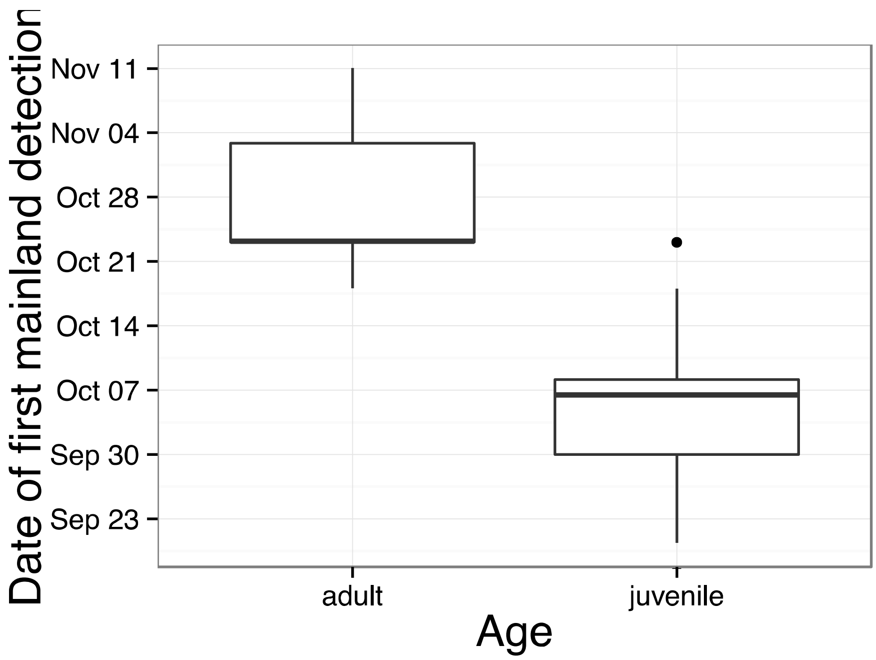


Figure 5.2-16 – Date of first detection on the mainland for adult (n = 11) and juvenile (n = 28) Ipswich Sparrows during the fall 2013 migration.

During the spring of 2013, birds were tagged on Conrad's Beach, NS, and we monitored the timing of their movements along the mainland coast prior to migration to Sable Island. The date of last detection for individuals on the mainland occurred between 16 April and 7 May (Figure 5.2-17). However since Ipsiwch Sparrows were only tagged for a short time period (12 to 18 April) and their spring migration in Nova Scotia can span between late March to early May (Stobo and McLaren 1975), this is not a complete representation of spring migratory time spans. It does indicate the length of time Ipswich Sparrows spend in Nova Scotia before attempting an overwater flight. Although it is not possible to know how long individuals were in Nova Scotia before they were tagged, it is evident that some individuals spent at least up to 22 days in Nova Scotia, including a large portion of this time at Conrad's Beach.

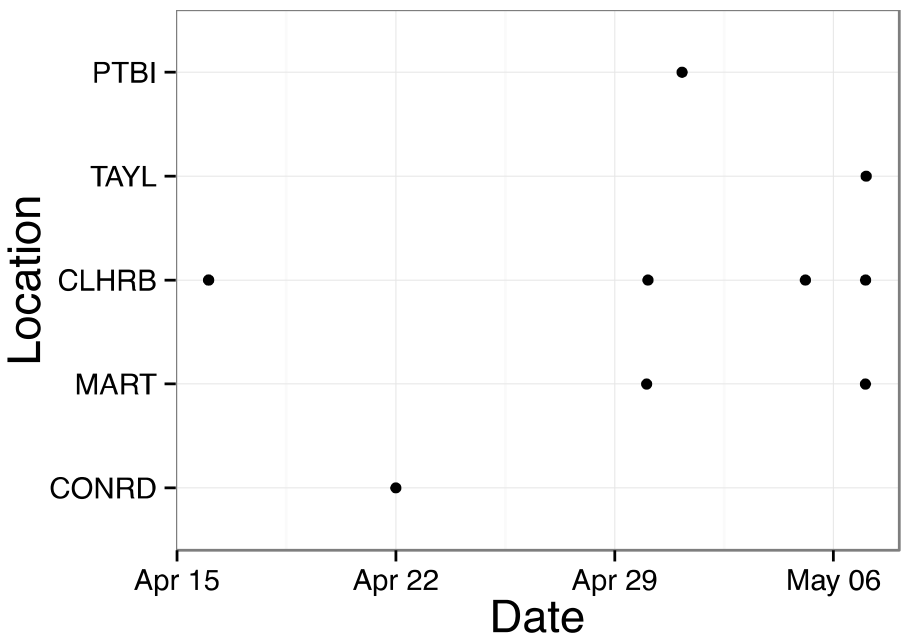


Figure 5.2-17 – Date and location of last mainland detection of Ipswich Sparrow in spring 2013. Sites ordered top to bottom from northeast to southwest along the Eastern Shore of Nova Scotia: Port Bickerton (PRBI), Taylor's Head (TAYL), Clam Harbour (CLHRB), Martinique beach (MART), and Conrad's Beach (CONRD).

Overwater Migratory Route – During autumn migration, the location of first mainland detections for individuals was used to estimate overwater route (distance and bearing) as well as the proportion of successful migrants. Using first detections as an index of the proportion of successful migrants, however, assumes that all individuals migrate to mainland Nova Scotia prior to heading south and assumes that all arrivals were detected by our network of receivers.

Fall data is consistent between years and indicates that over 50% of tagged Ipswich successfully migrate to mainland Nova Scotia (23/44 in 2012, 39/64 in 2013) (Table 5.2-10). In both years the majority of these detections were of juveniles, 15/23 in 2012 and 28/39 in 2013. Reasons for not detecting arrival dates and locations on the mainland include the following: a) some birds remained on Sable, as a small proportion remains on the Island over winter (Stobo and McLaren 1975), b) they took a more direct route to the US seaboard which bypassed mainland Nova Scotia, c) possible mortality during the overwater portion of their migration, or d) birds passed between receiver stations during migrations across Nova Scotia.

Table 5.2-10 – Total number of tagged birds and tagged birds that successfully reached mainland Nova Scotia during fall migrations in 2012 and 2013

	2012		2013	
	Tagged	**Detected on Mainland**	**Tagged**	**Detected on Mainland**
Adult male	7	4	16	6
Adult female	13	4	15	5
Juvenile	24	15	33	28
Total	44	23	64	39
Percent successful	52%		61%	

Of the 23 birds detected on the mainland in fall 2012, the majority (61%) were first detected at Taylor's Head Provincial Park or Country Island (Table 5.2-11). 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.

Table 5.2-11 - Location of initial detection of VHF tagged Ipswich Sparrows on mainland Nova Scotia during autumn migration 2012. Receivers were located at six sites from mid-September to late November.

	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**
Adult - unkn sex							1	**1**
Total	**4**	**10**	**3**	**0**	**0**	**2**	**4**	**23**

In the less patchy 2013 data, adults and juveniles appear to differ in their route choice, with adults displaying a more direct southerly route than juveniles (Figure 5.2-18). Juveniles were first detected across all but one site of the Nova Scotia coast indicating high variability in overwater route choice. Nevertheless, most of the arrival detections were concentrated in the north-eastern portion coastline: over half (67%) of the juveniles were first detected between Conrad's Beach (CONRD) and West Quoddy (WQDY) which cover a distance of 90 km on the Eastern Shore and would result in a 270 to 210 km overwater flight in a north-westerly direction (~290 degrees). These results are generally consistent with 2012 data for juveniles (Table 5.2-11) and differences are likely a result of the limited receiver network which was operational in that year. Adults appear to travel in a more westerly and south-westerly direction than juveniles. These overwater flights result in a more direct 210 to 450 km over-water flight with bearings between 260 and 300 degrees. The fact that one adult was detected for the first time flying past Bon Portage Island (BPLH1) – the most westerly site – could indicate that some adults may fly directly to the US seaboard and avoid Nova Scotia entirely – a more risky but direct flight to their wintering grounds.

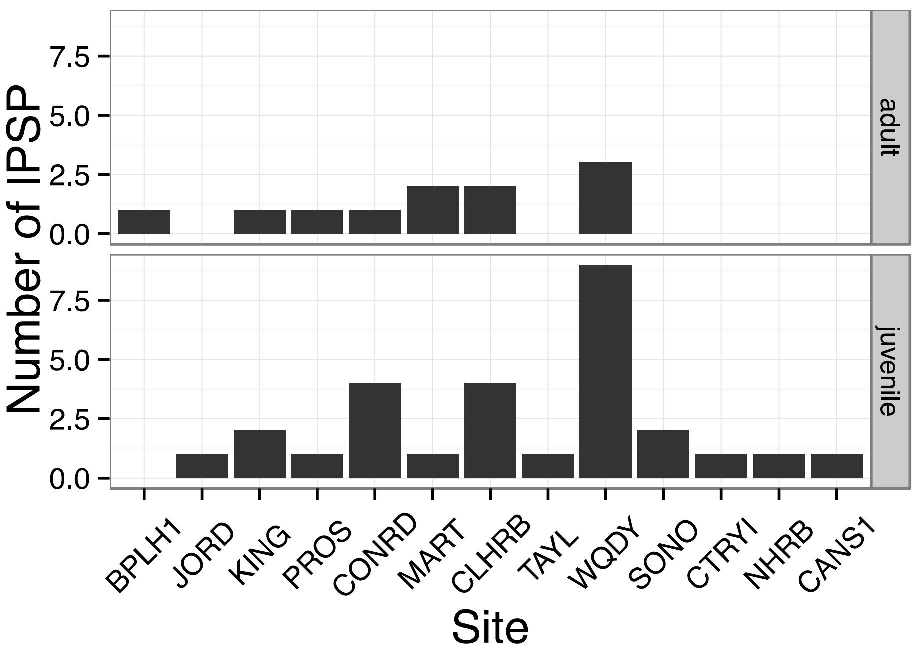


Figure 5.2-18 – Location of first mainland detection in fall 2013 by age categories. Sites are arranged longitudinally with BPLH1 as the most westerly mainland site and CANS1 the most easterly. Sites: Bon Portage Island lighthouse (BPLH1), Jordan River (JORD), Kingsburgh (KING), Prospect Point (PROS), Conrad's Beach (CONRD), Martinique Beach (MART), Clam Harbour (CLHRB), West Quoddy (WQDY), Sonora (SONO), Country Island (CTRYI), New Harbour (NHRB), Canso (CANS1).

In spring 2013, 10 of 21 VHF tagged sparrows successfully migrated to Sable Island (Table 5.2-12). Successful migrants were identified as those that were detected by the automated receivers on Sable Island (9 individuals) and/or those detected during manual tracking (8). Overwater migration of successful migrants was initiated immediately following sunset, successful birds departed from Conrad's Beach, and flew either directly to Sable Island or flew east along the coast before venturing overwater. Most birds were last detected at Clam Harbour (Figure 5.2-19), or the surrounding sites resulting in a south-east (110 degree) heading and a roughly 230 km overwater flight. The one exception being a final mainland detection at Port Bickerton, however, this sparrow was not detected on Sable Island for another 3 days and therefore its overwater route cannot be confirmed. In contrast to the more variable fall overwater routes, spring routes appear more consistent.

Table 5.2-12 – Total number of tagged birds and tagged birds that successfully reached Sable Island after spring migration from mainland Nova Scotia, 2013.

	Male	Female	Total
Tagged	18	3	21
detected on Sable Island	8	2	10
% Successful	44%	67%	48%

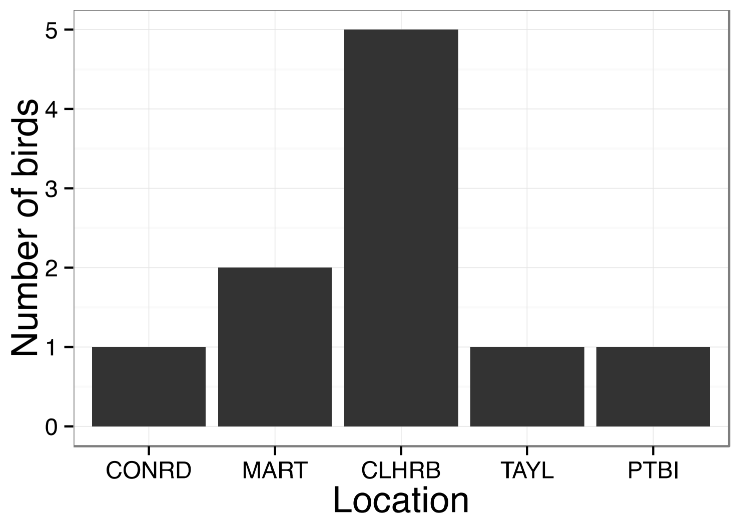


Figure 5.2-19 – Location of last mainland detection during spring 2013 migration. Sites: Conrad's Beach (CONRD), Martinique Beach (MART), Clam Harbour (CLHRB), Taylor's Head (TAYL), Port Bickerton (PTBI).

Detections on the mainland – In the fall 2012, 23 Ipswich Sparrows were detected at receiver stations along the mainland coast of Nova Scotia. The majority of detections occurred at night and all appear to be birds flying past in active migration. For example, the plot of an adult male detected at Taylor's Head Provincial Park on October 31st (Figure 5.2-20) 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). 10 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 5.2-21). 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).

Similar patterns of detection and movements were observed during fall 2013 – the majority of detections occurred at night as the birds fly by receiver stations during active migration. All locations along the Atlantic coast of Nov Scotia detected at least one Ipswich Sparrow. Finer details of mainland migratory movements are currently being analyzed.

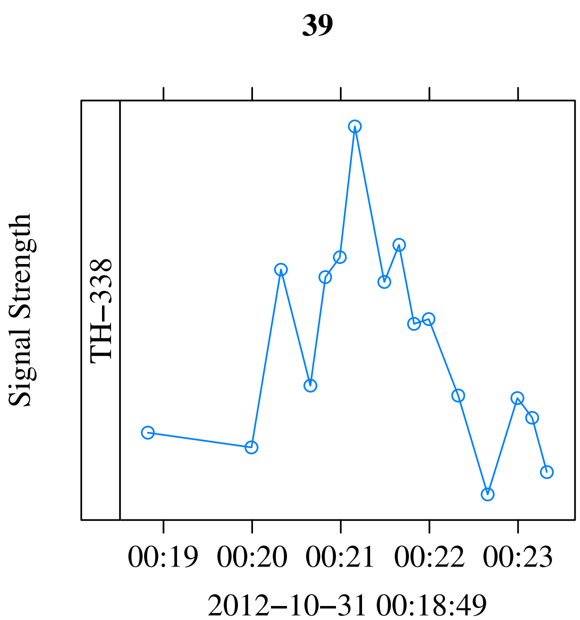


Figure 5.2-20 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#39) passing by a receiver station located at Taylor's Head (TH) Provincial Park (antenna orientation of 338°). Signal strength is a measure of the relative strength of the VHF signal detected and higher strength indicates closer proximity to the receiver station/antenna. Open circles represent individual tag detections and consecutive detections are joined by lines.

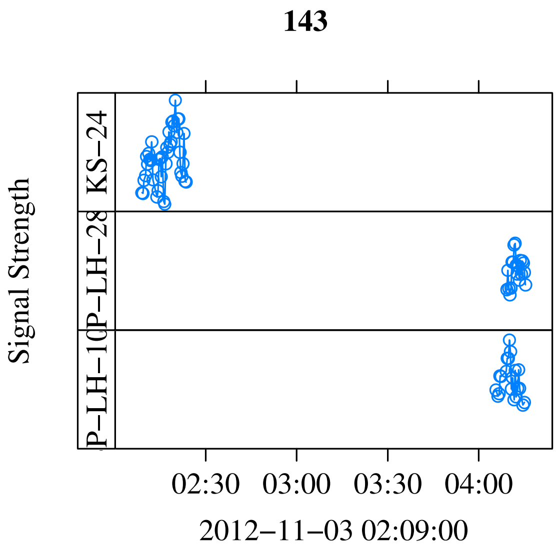


Figure 5.2-21 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#143) detected at multiple receiver stations in a single night. The sparrow was first detected at Kejimkujik National Park Seaside Adjunct at 02:09 h (upper panel) and ~2 h later detected by two antennas receivers on Bon Portage 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.

In spring 2013, all sparrows were detected at Conrad's Beach after tag deployment and appear to use this site as a staging area before departure overwater to Sable Island. The majority of detections at locations apart from Conrad's Beach were nocturnal flybys. They appear to be exploratory flights up and down the coast, or the result of aborted migratory flights over the water. Often, detections along the coast were followed by birds returning to Conrad's Beach where they were again detected continuously for long periods (several days), suggesting that birds aborting migration attempts may return to Conrad's for staging or reorientation for subsequent migration attempts. All 8 towers along the eastern shore detected at least one IPSP.

Detections from vessels – Receiver on the supply vessels were operational during most of the period during which Ipswich migration was expected and observed to occur. One exception was the high amounts of VHF noise on the Panuke Sea which would have limited detections in October and November of 2012 from this vessel on standby near the SOEP platforms.

During fall 2012, only one possible set of Ipswich Sparrow VHF detections was identified from the Venture Sea, but these detections were determined to be implausible after examination of other detections on Sable and the mainland. Therefore, there were no confirmed detections of Ipswich Sparrows from supply vessels in 2012.

During the fall of 2013, only one juvenile Ipswich Sparrow was detected by supply vessels. Sparrow 269 was detected three times between 8:00-11:00 UTC on 29 September by the Panuke Sea on standby near the Thebaud platform. Each detection period consisted of only 8-9 tag hits, therefore, all detection events were short in duration of less than 2 minutes. This individual was detecte on Sable both before and after these events, 9 hours prior at West Spit, and the following morning at West Light. Thus apparent attraction to the platform/vessels is uncertain and these detections are consistent with exploratory movements observed by juveniles moving around Sable prior to migration to the mainland. This individual departed Sable on 7 October.

During spring 2013, two sparrows were detected by the Ryan Leet supply vessel. Ipswich Sparrow 501 was detected on 14 May 2013 for approximately 5.5 hours and was not detected again (Figure 5.2-22), suggesting an unsuccessful migration and mortality. The vessel was located roughly halfway between Halifax and Deep Panuke, 110 km west of Sable Island. Ipswich Sparrow 505 was detected on 7 May 2013 for approximately 14 minutes and was detected on Sable Island 3 hours later (Figure 5.2-23). At this point the vessel was located 50 km south west of Sable Island near the Deep Panuke platform. These two detections confirm interaction with offshore supply vessels during the spring 2013 migration.

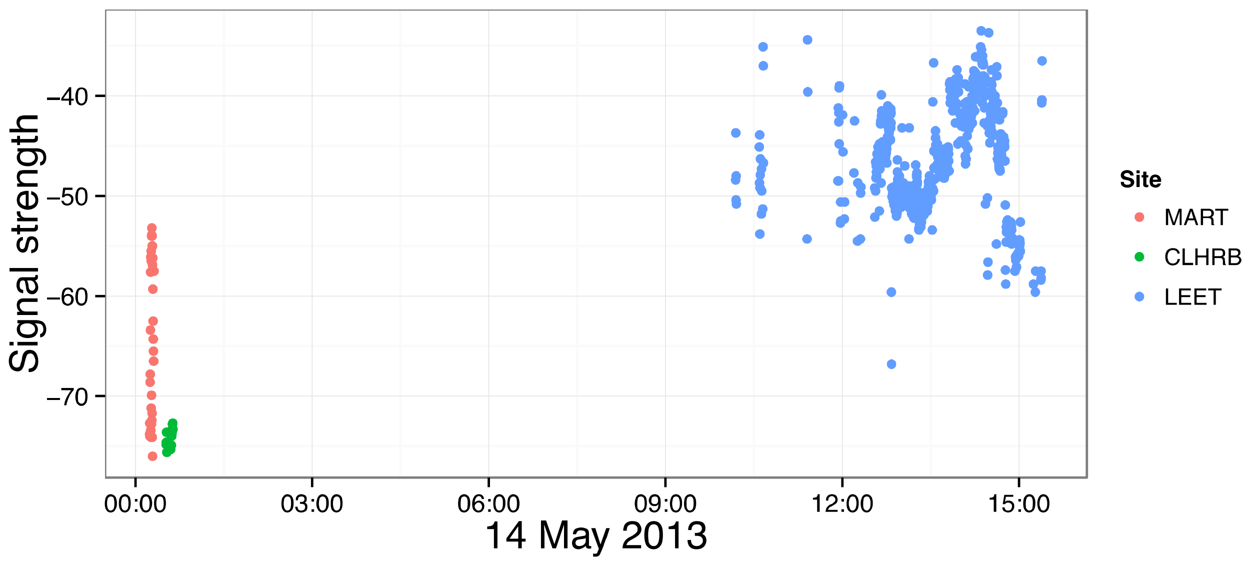


Figure 5.2-22– Ipswich Sparrow 501 detections on 14 May 2013, signal strength indicates the bird departed from Martinique Beach (MART), flew past Clam Harbour (CLHRB), and was detected almost continuously for 5.5 hours on the Ryan Leet vessel (LEET) and was not detected again.

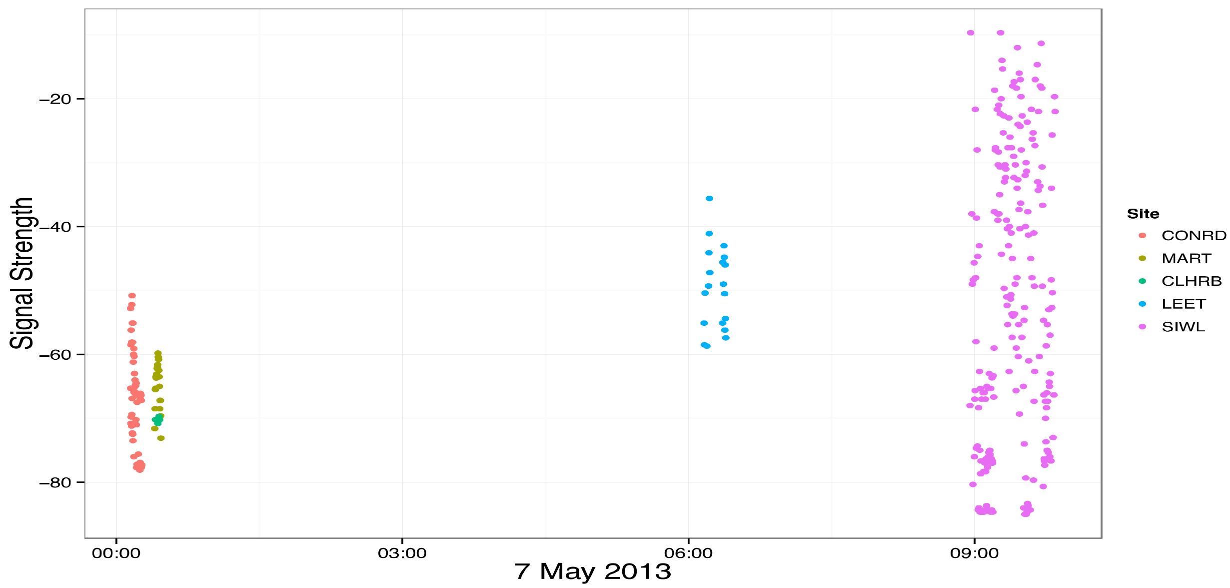


Figure 5.2-23 – Ipswich Sparrow 505 detections on 7 May 2013, signal strength indicates the bird departed from Conrad's Beach (CONRD), flew past Martinique Beach (MART) and Clam Harbour (CLHRB) and was detected for 14 minutes at approximately 6:00 UTC flying past the Ryan Leet vessel (LEET). Approximately 3 hours later it arrived on the West end of Sable Island and was detected at Sable Island West Light (SIWL).

5.2.5 Blackpoll Warbler

Analysis of 2012 data are presented here and assessment of 2013 results will follow in the next report.

We recorded departure flights from 61% (35/57) of 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 provides 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. During fall of 2012, there were no detections of Blackpoll Warblers on Sable Island receivers or offshore vessels, therefore, over-water migratory flights were not confirmed.

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 5.2-24), 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.

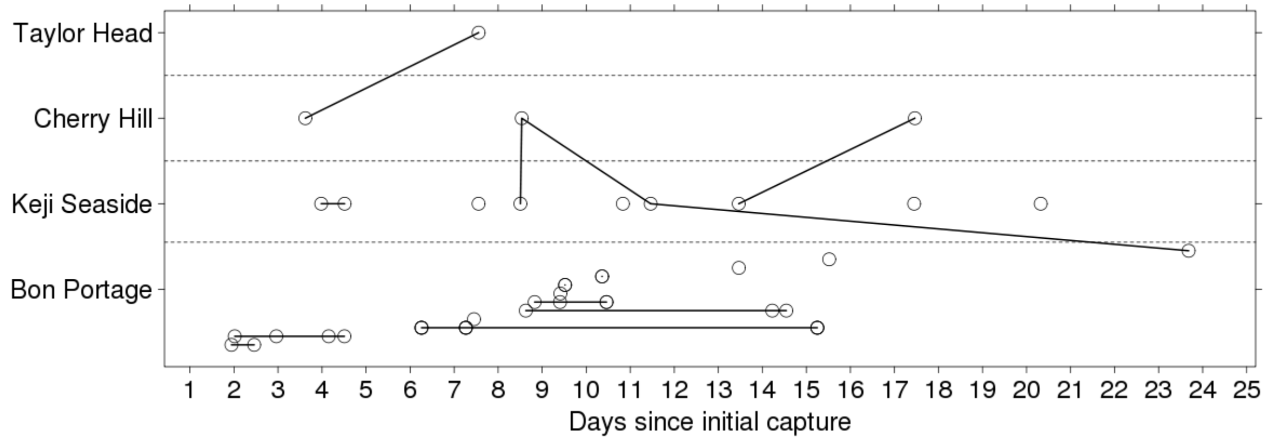


*Figure 5.2-24 - Summary of coastal detections for Blackpoll Warblers tagged on Bon Portage Island in 2012 (*n = *19). Individuals detected flying by Bon Portage Island one or more days after their initial departure from the island are included. Each point represents a detection event and solid lines connect detections of the same individual.*

***Detections from vessels* -** One offshore vessel, the Ryan Leet, was equipped with a second antenna which monitored the Blackpoll Warbler tag frequency (166.300) from 19 September to 13 November, 2012. Examination of vessel receivers for hits of Blackpoll Warbler tags found no plausible detections during this period. Most detections on this frequency consisted of runs of only 1 or 2 tag hits, most of which occurred simultaneously with other Blackpoll tag IDs and as well as non-valid tag IDs, suggesting these hits were a product of noise rather than true detections.

6. Discussion and Recommendations

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.

6.1.1 Direct evidence from tracking

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, see limitations of these data in 2012 in Section 5.1 and discussion below. Other types of tag deployments (wing-tags, satellite telemetry and geolocation sensors) provide complementary information on bird-platform interactions from a smaller subset of individuals.

VHF receivers deployed on platform supply vessels recorded bird-vessel interaction events from 6 individual gulls in 2012 (11% of tagged birds), 14 gulls in 2013 (32%), 2 Ipswich Sparrows during 2013 spring migration (9.5%), 2 terns from Sable in 2013 (4%), and no interaction events with other study species, seasons or years (terns, 2012; Ipswich fall migrations, 2012 and 2013; Blackpoll Warblers, 2012 and 2013; storm-petrels, 2011 to 2013). However, the 2012 results should be treated with caution due to the timing of receiver deployments, the location of vessels during deployment periods, receiver malfunctions early on during deployments, and high rates of VHF noise from vessel instrumentation (summarized in Section 5.1). Receivers were fully functional to record potential bird-platform interaction events for Ipswich Sparrow and Blackpoll Warbler migration periods in 2012. However, because most receivers were not operational until mid to late August 2012, in that year there was no opportunity to monitor interactions with terns which had departed the area by mid-August, limited opportunity to monitor storm-petrel interactions, and incomplete monitoring of gull-vessel interactions which are known to peak between mid-July and mid-August (see below). Vessel-based receivers were fully functional in 2013 to continuously track interactions of all species during all seasons.

Gulls - Despite the identified problems with VHF receiver on vessels, the 14 recorded gull-vessel interaction events in 2012 and the higher proportion of individual gulls interacting with vessels in 2013 provide some information on the timing, frequency, and duration of gull-platform interactions. First, interaction events were most common in August with fewer events recorded in September and October, a pattern which was also observed with wing-tags and satellite tags (below). Second, interaction events were more common at night than during the day, a pattern which was also observed with two events recorded by VHF in 2011 (Ronconi and Taylor 2012). Third, individuals typically interacted with supply vessels more than once, though the frequency of interaction events detected by VHF-tags in 2012 was much lower than expected given the results of satellite tracking from two Herring Gulls. Finally, VHF data from vessels in 2012 revealed that most gull-vessel interactions are short in duration, typically less than 30 minutes and maximum of 3.7 hours. These data, however, suggest an underestimate of gull-vessel interaction duration since VHF telemetry from 2 interactions in 2011 were each > 10 h, and 13% of satellite tracking interaction events from 2012 were > 10 h. The very short duration of interaction events recorded by VHF in 2012 is potentially a result of "noise" masking VHF detections. Subsequent analysis will investigate the patterns and durations of gull detections at vessels in 2013.

Another conclusion regarding gull-platform interactions which may be derived from VHF, wing-tag, and satellite telemetry data is that interactions are restricted to a portion of individuals and do not appear to be characteristic of the entire Sable Island population. In 2012, from each of 17 Herring and Great Black-backed Gulls for which we recorded good VHF tracking data, 29% (5/17) of tagged Herring Gulls and only 6% (1/17) Great Black-backed Gulls were detected from supply vessels. Likewise, 25% of wing-tagged Herring Gull individuals were observed from supply vessels in 2011 (Table 5.2-1), only 3 individual wing-tagged gulls were observed near platforms in 2012 (Table 5.2-2), and just two of six satellite tagged Herring Gulls interacted with platforms in 2012 (Table 5.2-5). In 2013, 42% and 28% of VHF-tagged Herring and Great Black-backed Gulls, respectively, interacted with platform vessels and 5 of 7 active Herring Gull satellite tags showed activity within 200 m of platforms. Together this suggests that from the breeding population of gulls on Sable, approximately 25-50% of Herring Gulls and 5-30% of Great Black-backed Gulls interact with platforms and supply vessels. All Herring Gull tags and nearly all Great Black-backed Gull tags were deployed on breeding adults, therefore, it is not known what proportion of chicks fledging from Sable also attend platforms.

Gulls deployed with wing-tags on Sable Island showed numerous interactions with platforms, but with considerable variance among individuals. In two years, 2011 and 2012, wing-tagged gulls of both species were most frequently sighted from supply ships and platforms between mid-July to mid-August, with occasional sightings in September and October. The timing of these interactions are in general agreement with patterns observed by satellite and VHF tags 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 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. No new wing-tags were deployed in 2013 and only one colour-banded gull was reported from platforms in that year. It is difficult, however, to compare resighting rates between years without accurate data on observation effort. In all 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 subsequent years resulting in decreased vigilance and/or reporting. Other factors that may be contributing to declining rates of resights at offshore platforms include tag loss or bird mortality. The study design does not allow for accurate mortality assessment, but rates appear to be low as only three mortalities have been reported thus far: one Herring Gull shot at a landfill site in Massachusetts, one Great Black-backed Back gull killed by a Bald Eagle in Maine, and one Great Black-backed Gull found dead on a side road in Nova Scotia. Loss rates are equally difficult to assess but at least some individuals have been resighted in each year since 2011, therefore, we don't suspect tag loss as a major factor in diminishing resightings.

Satellite tag deployments on nine Herring Gulls in 2012 and 2013 were in general agreement with patterns observed from wing-tag resightings. These tags revealed that only some individuals attend platforms (5 out of 9 tagged birds during 2012 and 2013) with most interactions occurring in July/August and less frequent interactions through September and October. From the time of tag deployments to their departures from the Sable area in late October, these individuals spent 0.5 to 9% of their time within 200 m of offshore platforms, with some individuals attending platforms in both years. 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.

Because satellite-GPS tags track birds anywhere, regardless of observer effort (wing-tags) or receiver deployment locations (VHF receivers on vessels), we were also able to quantify the spatial-temporal patterns of gull interactions with all platforms in the area. Of the satellite tag locations obtained within 200 m of platforms in 2012 and 2013, 69% occurred at the Thebaud platform, 26% at Deep Panuke, 5% at Alma, and less than 1% at the other three platforms. Thebaud and Deep Panuke are the only 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 5.2-5). Most individuals interacted with Thebaud platform more frequently but one individual (tag ID 115926 in 2012) interacted more frequently with the Deep Panuke platform. 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 (9 individual Herring Gulls in both year) and further analyses of 2013 VHF-tagged data will verify these findings.

Leach's Storm-petrels - 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. Subsequent analysis will examine the nearest distance of approach to platforms during these foraging trips and the proportion of time/locations within proximity of platforms. Bon Portage Island petrels also foraged on long-distance trips, capable of reaching the platforms around Sable, however, their trajectories were all southward and thus not overlapping with platform areas.

Terns - During 2013, platform supply vessels recorded VHF detections of one Arctic Tern and one Common Tern. The Arctic Tern was detected during the breeding period in July when the vessel was approximately 9km from Sable, and the Common Tern detection occurred post-breeding in August, more than 100 km from any platform or Sable. Neither of these detection events were very long in duration. Together these data suggest limited "offshore" foraging by terns around Sable Island and no evidence of attraction to platform supply vessels.

Ipswich Sparrows - There were no confirmed detections of Ipswich Sparrows from supply vessels in 2012 when birds were tracked during autumn migrations between Sable and mainland Nova Scotia. During autumn of 2013, one juvenile sparrow was detected multiple times by a vessel near the Thebaud platform on 29 September. These detection events were short in duration, occurred during a three hour period on one day, and the individual was later detected on Sable for more than a week prior to migration. The timing, duration, and frequency of these detection events do not suggest prolonged interactions or attractions to nearby platforms or vessels at this time of year, and these events are more consistent with "exploratory" movements of juveniles around the island prior to migration departures.

When tracking Ipswich migrations from the mainland to Sable during the spring of 2013, 2 of 21 tagged individuals were detected by platform supply vessels. One detection occurred near the Deep Panuke platform, was brief (~14 minutes), and this individual was later detected on Sable, therefore, successfully completing its over-water migration. The second event occurred while the vessel was in transit between Halifax and Deep Panuke during which time the sparrow was detected over a 5.5 h period and was later not detected on Sable, suggesting an unsuccessful migration and mortality. During that same period, the crew of another platform supply vessel described a similar event during which a sparrow, matching the description of an Ipswich, attended the vessel for several hours and was later found dead on the deck. Together, these events suggest that Ipswich may be vulnerable to vessel, and possibly platform, attraction during their spring migrations. In total, only 48% (10 of 21 tagged birds) successfully completed their spring migration from the mainland to Sable. At least two of these died near the tagging site presumably killed by predators, but the fate of the other unsuccessful migrants are unknown.

6.1.2 Indirect evidence from seabird colony monitoring

VHF receiver stations coupled with wing-tag resightings and satellite telemetry 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.

From all years, data from 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 June to 31 October. Likewise with Great Black-backed Gulls, the first report of wing-tagged gull away from the colony was on 25 June, 2012, 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 suggest the following:

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. However, at least some VHF-tagged GBBG in spring 2013 were detected on Sable in December/January of 2013/2014, demonstrating that summer breeders also return to the island for winter foraging opportunities.

Preliminary analysis of VHF monitoring of tern colony attendance patterns from 2012 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. An expanded array of receivers in 2013 confirmed that individuals are traveling along the length of the island beyond 20 km from their respective colonies, and some are also making trips to the island spits both during and after the breeding season. The frequency of these movements around Sable will be assessed further, but together with the paucity of offshore detections (above) this suggests limited “offshore” foraging and low potential for platform interactions.

Stable isotope analysis from terns at two Sable Island colonies in 2012 revealed dietary differences between 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. Preliminary analysis of 2012 colony attendance patterns showed similar duration in foraging trip length for both species, but less time at the colony for Arctic Terns, suggesting they are making foraging trips more frequently. Subsequent analysis will further investigate the differences in foraging patterns and direction of foraging trips 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.

During all years, foraging trips by Storm-petrels from Bon Portage (BP) and Country Island (CI) lasted 3-5 days and GLS tracking confirmed that they are 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. Subsequent analysis of GLS data will investigate the proportion of locations and the proportion of trips which overlap with platform areas.

6.1.3 Indirect evidence from songbird tracking

In order to assess their relative risk to platform interactions, tracking Ipswich Sparrows from their nesting grounds was conducted to quantify the timing and direction of movements during fall migration. Ipswich Sparrows tagged in August during 2012 and 2013 undertook migratory departures from Sable Island between September and November; juveniles departed earlier than adults in both years. Juveniles and adults also appear to differ in migration routes which would impact their likelihood of interaction with platforms in the Sable area. In both years, most juveniles first made landfall between Country Island and Conrad's Beach (highest numbers near Taylor's Head, 2012, and West Quoddy, 2013) 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. In contrast, first detections of adult Ipswich Sparrows on the mainland typically occurred from Conrad's Beach and areas south-west of there, which suggests a longer over-water flight but more direct route towards wintering areas in the US coastline. This route followed by adults is therefore more easterly and south-easterly, increasing the potential for overlap with Thebaud and Deep Panuke platforms, depending on the location of departure from Sable. Thus, current data suggests that during the autumn migration the relative risk of platform interaction is greater for adult sparrows than for juveniles. Moreover, a lower proportion of tagged adults, compared to juveniles, were detected on the mainland, suggesting lower migratory survival rates.

During spring migration, towers along the eastern shore were established to detect Ipswich movements and assess departure locations for over-water flights to Sable. Most departures of successful migrants occurred near Martinique Beach and Clam Harbour. Direct routes from these locations to Sable would by-pass the offshore platforms. However, during this period we had no receiver towers active south of Conrad's Beach and at least two individuals were detected by vessels (see above) in areas outside of this direct pathway. The limited sample size (n = 21), incomplete receiver network, and high proportion of unsuccessful spring migrants leaves a significant level of uncertainty in our knowledge of timing and route choice during spring migration. Nevertheless, the lack of detections north of Clam Harbour during spring, and the two migrants detected by vessels, suggests a potentially higher risk (compared with fall migration) of overlap between spring migration routes and offshore platforms and vessels.

In 2012, 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. In 2013, none of the 48 individual Blackpoll Warblers tagged at Glasgow Head (Canso Peninsula) were detected by Sable Island or supply vessel receivers. Many individuals were detected moving SW along the coastline of NS, and it is suspected that most of the individuals tagged likely departed from locations that would not have put them in proximity to offshore platforms. More analysis is required of these data.

In 2012 at Bon Portage Island, three Blackpoll Warblers 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. 2013 data from Bon Portage Island is still being analyzed.

7. Deployment of Platform Sensors

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 and use of existing platform radar signals. Our revised goal was to have a VHF receiver/antennas installed prior to spring field studies (April 2013) and access to platform radar signal in June 2013 so that it can be available for testing in July/August 2013 prior to autumn migration. Continued delays in platform commissioning in 2013 resulted in no opportunity to install VHF equipment or test the usage of platform radars for bird detection. Deep Panuke First Gas was achieved in December 2013 and the installation of bird monitoring equipment is now scheduled for the spring of 2014.

7.1 Radar

One of the objectives of this project was the development of radar as a tool to monitor bird activity around the Deep Panuke platform. This objective was met, albeit with several set-backs along the way which, in the end, did not allow the implementation of a radar monitoring system. Nevertheless, we identify here some of those limitations so that future attempts to use radar may avoid similar pitfalls.

7.1.1 RACON interference and Chebucto Head polarization test

In July, 2011, a site visit to the Deep Panuke platform in Mulgrave, NS, was conducted to evaluate options for positioning of the radar and VHF antennas/receiver. During this visit it was discovered that a Radar Beacon (RACON) installed on the PFC may become a problem for the planned bird-radar deployment. When triggered, RACONs send out morse-code patterned pulses in response to incoming marine radar signals. This can cause two kinds of interference: 1) obstruction of targets on bird radar due to a large number of RACON response pulses, and 2) potential safety hazards due to our triggering the RACON too often, leading to its not being able to respond adequately to ships. After this discovery we worked on identifying solutions to this problem in 2011.

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

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

7.1.2 Use of platform radars

Due to the RACON interference problem, we were not able to place our own radar on the Deep Panuke platform (PFC). Instead, in conjunction with Encana and SBM engineers, we examined options to utilize existing S-band surveillance and possibly X-band wave radars. The PFC's S-band radars are two Furuno 13.4 kW S-Band scanners with ~2 m open-array antennas. The radar processors are two Furuno FAR 2137BB RPU's, networked via NAVNET into a single remote display, which multiplexes the two radars into a single sweep (one large sector from each radar; each radar has sector blanking on the portion of its sweep pointing inboard). The RPUs and the display are in the control room on the main deck of the PFC and there should be enough space in the control room for a separate computer to connect to the two RPUs. The X-band wave radar black-box is also in the control room and a subcontractor would be required to investigate whether and how to interface with this radar.

After several discussions with Encana and SBM engineers, the use of existing platform radars to detect birds was deemed not feasible at this time for a variety of reasons. Future endeavors to use radar from offshore platforms should consider the limitations presented above. With time and resources, it is possible that radar could be used to monitor birds at platforms, In the final project report we will make recommendations for a path forward for successful implementation.

7.1.3 Radar trials at Point Tupper flare stack

Unable to test the feasibility of radar on the offshore platform, we instead tested the use of radar to monitor bird activities at a flare stack on the mainland of Nova Scotia. ExxonMobil provided access to their Point Tupper facility where a radar was positioned adjacent to a flare stack. This radar was run over 8 nights (Jul 30/31, Sep 17/18, Sep 26/27, Oct 7/8), a period which spans the expected timing of migration for songbirds in Nova Scotia. Data will be processed later to assess bird detections.

7.2 Other sensors

Other sensors, in addition to bird-radar and telemetry, may provide additional valuable information on the patterns of bird interactions with offshore platforms. These include thermal and other low-light cameras, and acoustics monitoring of bird calls (Gauthreaux and Livingston 2006; Hüppop et al. 2006). On the Deep Panuke platform, one area of interest is the monitoring of bird activities around the flare stack and the flare itself. The intense heat generated from the flare will preclude the use of thermal cameras around the flare, but thermal cameras could still be useful to monitor birds on or around the platform, including the water surface. Alternatively low-light cameras may take advantage of ambient light generated from the flare and platform lights. Acoustic monitoring of bird calls has already been used successfully from an offshore production platform in the Gulf of Mexico

(Farnsworth and Russell 2007); this option can provide supplementary information on bird species identification which can be distinguished from bird calls.

Engineering, testing, and implementation of acoustic, thermal, and low-light sensors are likely feasible for offshore platforms, however, this was beyond the scope of our project due to financial and time constraints. Problems likely to be encountered during implementation include ambient noise (acoustic monitoring), attenuation of ambient light levels (low-light cameras), unknown detection range (thermal, low-light, and acoustic), most effective mounting and orientation of equipment (all sensors), and platform operations safety (all sensors). Safety concerns for sensors are related to the use of various electrical equipment in outdoor areas which must meet stringent safety standards for platforms, especially those with platforms that are producing sour gas. Electrical equipment must be intrinsically safe and/or enclosed in explosion proof housing which are commercially available for cameras (e.g. www.pelco.com) but we are unaware of similar systems for acoustic monitoring equipment. The other factors, including noise, light levels, detection range, and equipment placement, are likely more easily tested at on-shore facilities with flare stacks prior to offshore implementation.

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

Pollet, I.L., Ronconi, R.A., Jonsen, I.D., Leonard, M.K., Taylor, P.D., Shutler, D., in press. Foraging movements of Leach's storm-petrels *Oceanodroma leucorhoa* during incubation. Journal of Avian Biology. DOI: 10.1111/jav.00361

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.

Appendices

Appendix I –VHF receiver deployments 2011-2013

Table 1 – Summary of VHF receiver deployments in 2011. Receiver type included SRX-600 and SRX-DL (www.lotek.com). SOEP = Sable Offshore Energy Project, which includes vessels attending various platforms operated by ExxonMobil.

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

*Table 2 – 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). 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	6-Dec	25	116
Totals	**Islands**				3-Jun	16-Nov	83	628
	Mainland				8-Sep	8-Nov	34	224
	Vessels				18-Jul	6-Dec	81	403
	Grand Total				**3-Jun**	**6-Dec**	**198**	**1255**

Table 3 – Summary of VHF receiver deployments in 2013/2014. Receivers/antennas were scanning VHF frequency 166.380 MHz. All receivers were Sensor Gnomes (custom made receivers described in section 4.2) except early deployments (March to May) at SBWL and SBEL (SRX-600; www.lotek.com). 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	Site Code	Antenna type and (number of antennas)	Antenna configuration (compass degrees)	Start	End	No data (days)	Tracking (days)
Islands								
Sable	West Light	SBWL	9-el (6), omni (1)	30,90,150,210,270,330	19-Mar-13	31-Dec-13	27	260
	East Light	SBEL	9-el (4)	0, 90, 180, 270	20-Mar-13	13-Nov-13	0	238
	West Spit	SBWS	5-el (2)	318,355	1-Jul-13	2-Jan-14	30	155
	East Spit	SBES	5-el (1)	58	1-Jul-13	2-Jan-14	18	167
	Main Station	SBMS	omni (1)	n/a	9-Jun-13	15-Aug-13	0	67
	East Colony	SBEC	omni (1)	n/a	31-May-13	10-Jul-13	0	40
Country Island	Lighthouse	CTRYI	9-el (4)	82, 168, 262, 348	22-Jun-13	23-Nov-13	0	154
Bon Portage	Lighthouse	BPLH	9-el (2)	20, 144	29-Sep-13	9-Feb-14	0	133
Mainland								
Eastern Shore	Canso (spring)	CANSOSPR	9-el (2)	201, 340	24-Apr-13	22-Jun-13	0	59
	Canso 1	CANS1	9-el (3)	30, 90, 150	14-Sep-13	6-Mar-14	0	173
	Canso 2	CANS2	9-el (3)	210, 270, 330	9-Sep-13	5-Nov-13	0	57
	Port Felix	PTFE	9-el (2)	151, 319	8-Apr-13	23-Jun-13	0	76
	New Harbour	NHBR	9-el (2)	various	8-Apr-13	6-Mar-14	0	332
	Drum Head	DRUM	9-el (2)	168, 258	8-May-13	2-Aug-13	0	86
	Port Bickerton	PTBI	9-el (2)	166, 266	8-Apr-13	2-Aug-13	0	116
	Sonora	SONO	9-el (2)	154, 357	8-Apr-13	6-Mar-14	11	321
	West Quoddy	WQDY	9-el (2)	180, 360	8-Apr-13	6-Mar-14	0	332
	Taylor's Head	TYLR	9-el (2)	60, 240	10-Apr-13	29-Nov-13	0	233
	Clam Harbour	CLHRB	9-el (2)	188, 290	8-Apr-13	5-Dec-13	4	237
	Martinique Beach	MART	9-el (2)	88, 214	10-Apr-13	2-Dec-13	0	236
	Conrad's Beach	CONR	9-el (2)	128, 210	10-Apr-13	23-Jun-13	0	74
	Conrad's Beach	CONR	9-el (3)	53, 70, 191	16-Sep-13	29-Nov-13	0	74
South Shore	Prospect Point	PROS	9-el (2)	180, 280	10-Aug-13	17-Nov-13	0	99
	Kingburg	KING	9-el (2)	32, 212	2-Aug-13	6-Mar-14	0	216
	Berlin	BERL	9-el (2)	160, 350	10-Aug-13	12-Mar-14	11	203
	Keji Seaside	KEJI	9-el (2)	78, 258	6-Sep-13	12-Mar-14	33	154
	Jordan Bay	JORD	9-el (2)	8, 154	3-Aug-13	31-Dec-13	0	150
Vessels								
Ryan Leet	Deep Panuke platform	LEET	omni (1)	n/a	19-Apr-13	10-Mar-14	47	278
Atlantic Condor	Deep Panuke supply	ACON	omni (1)	n/a	16-Apr-13	28-Nov-13	0	226
Panuke Sea	SOEP platforms	PSEA	omni (1)	n/a	8-Jul-13	13-Mar-14	0	248
Venture Sea	SOEP platforms	VSEA	omni (1)	n/a	24-Apr-13	11-Dec-13	0	231
Totals	**Islands**				19-Mar-13	9-Feb-14	75	1214
	Mainland				8-Apr-13	12-Mar-14	59	3228
	Vessels				16-Apr-13	13-Mar-14	47	983
	Grand Total				**19-Mar-13**	**13-Mar-14**	**181**	**5425**

APPENDIX D 1

2013 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 birds recovered between the following dates:

From January 1, 2013 to December 31, 2013 under the authority of Permit # LS 2568.

NAME ___ Marielle Thillet (Environmental Advisor) ______ TELEPHONE # ________(902) 492-5422
(PLEASE PRINT)

ORGANIZATION _______Encana Corporation__________ FAX # __________(902) 425-2766

ADDRESS ________1701 Hollis Street, Halifax, NS _______ POSTAL CODE _________ B3J 3M8

E-mail _______ marielle.thillet@encana.com

SIGNATURE ____ DATE ________January 17, 2014

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

Phone: 506-364-5044
Fax: 506-364-5062
e-mail: permi.atl@ec.gc.ca

Renew Permit ? Yes _X_ No _____ If yes, please forward any required changes.

(a) PFC Commissioning and production [Jan 1, 2013 - ongoing]

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

Position: PFC area (see attached map) and support vessels between PFC area and Halifax

General activity of vessel: as per above

Search effort for live birds: opportunistically by all platform / vessel staff

(b) Subsea Asset Inspection Survey [Jul-Oct 2013]

Vessel Name: Atlantic Condor

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

General activity of vessel: ROV survey of subsea equipment

Search effort for live birds: opportunistically by all vessel staff

(c) Flowline Maintenance Program [Apr 27-May 10, 2013]

Vessel Name: MV Intrepid (International Telecom)

Position: PFC area (see attached map)

General activity of vessel: removal of concrete tunnels and installation of scour protection (sand bags) on flowlines

Search effort for live birds: opportunistically by all vessel staff

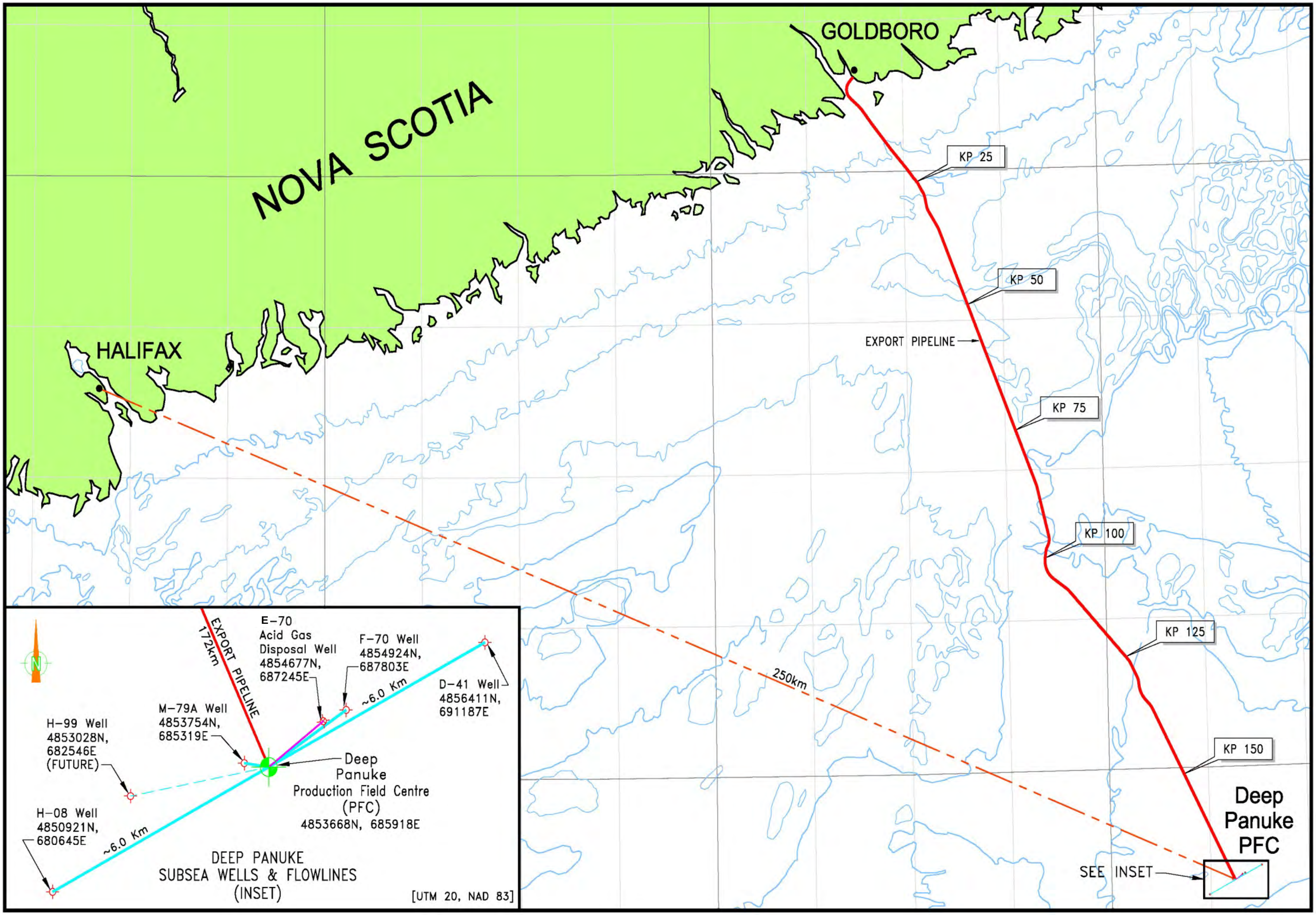
(d) Rock Placement Program [Aug 27-Sep 2, 2013]

Vessel Name: Flintstone rock placement vessel (Tideway)

Position: PFC area and gas export pipeline around KP69 (see attached map)

General activity of vessel: rock placement for subsea asset scour protection

Search effort for live birds: opportunistically by all vessel staff


NOVA SCOTIA
GOLDBORO
HALIFAX
KP 25
KP 50
EXPORT PIPELINE
KP 75
KP 100
KP 125
KP 150
250km
Deep Panuke PFC
SEE INSET
EXPORT PIPELINE
172km
E-70 Acid Gas Disposal Well 4854677N, 687245E
F-70 Well 4854924N, 687803E
~6.0 Km
D-41 Well 4856411N, 691187E
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]

Retrieval and Release of Birds on Atlantic Condor__________ Year 2013

			Found Dead		Captured Alive				Comments
					Un-oiled		Oiled*		
Date	Species	Total	DOAS	Oiled *	DIC	Rls'd	DIC	SFR	Condition Action Taken Fate of Bird
April 23	IPSP [a]	1	1	No					The sparrow was reported to have been on board the supply vessel on 23 April and observed flying back and forth between the vessel and the Deep Panuke platform during operations, looking for a place to perch. The following morning the bird was found dead aboard the supply vessel and discarded overboard by the crew.

a - Passerine, with a description matching that of an Ipswich Sparrow ("pale brown with yellow markings above the eyes")

DOAS – Disposed of at Sea.
DIC – Died in Care.
Rls'd – Released.
SFR – Sent for Rehab.

***Oiled Birds**: **Both live and dead birds are to be sent to shore for treatment of the birds and /or analysis of the oil.**

Retrieval and Release of Birds on MV Intrepid__________ Year 2013

			Found Dead		Captured Alive				Comments
					Un-oiled		Oiled*		
Date	Species	Total	DOAS	Oiled *	DIC	Rls'd	DIC	SFR	Condition Action Taken Fate of Bird
May 9	TBMU	1				1			Murre was found onboard May 9 in the afternoon close to vessel position N 43 48.8843 W060 42.1318. Its right foot had damage on the webbing such that the middle toe was exposed, no sign of infection. It was preening when first seen. No sign of oil. It did not show any sign of wariness when first approached, but appeared to shiver when approached again later in the afternoon. (See photos below.) EC was contacted for directions when the bird was found and instructed to put the bird in a box and bring it back to shore. EC staff (C. Gjerdrum) came to pick up the bird from the vessel when it arrived at Halifax dock the next morning (May 10). EC staff confirmed the bird to be a thick-billed murre. EC staff took the bird to the mouth of the harbor to release it. Bird was incredibly feisty and eager to get into the water once taken down to the shore. It had no problem moving over the rocks it was placed on, and into the water. From there, it swam easily and could be seen diving and preening, likely trying to clean himself up after a day in a box. EC staff confirmed foot injury to be an old one and did not believe that it could have happened on the ship.

DOAS – Disposed of at Sea.
DIC – Died in Care.
Rls'd – Released.
SFR – Sent for Rehab.

***Oiled Birds**: **Both live and dead birds are to be sent to shore for treatment of the birds and /or analysis of the oil.**

Thick-billed murre stranded on Intrepid Vessel (May 9, 2013)

Retrieval and Release of Birds on Deep Panuke PFC__________ Year 2013

			Found Dead		Captured Alive				Comments
					Un-oiled		Oiled*		
Date	Species	Total	DOAS	Oiled*	DIC	Rls'd	DIC	SFR	Condition / Action Taken / Fate of Bird
Oct 1	Common Nighthawk	1			1				The PFC contacted ECA onshore on Oct 3 (8 am) indicating that a young bird of prey which seemed to be a falcon had been found lying in same area for the past 3 days and required onshore assistance. EC was contacted immediately for guidance and advised to let the bird be because a falcon could be dangerous to handle and should be able to move on by itself. Photos were requested from the PFC to confirm bird ID. PFC staff then indicated that the bird had already been put in a box and sent photos - see below (9:30 am). Photos were forwarded to EC who determined that the bird was not a falcon but rather a Common Nighthawk, which is a SARA Threatened Species. EC indicated that the bird was an insect-eater, so likely not in good shape on the platform and advised to send the bird to Hope for Wildlife for rehabilitation on the next available flight/vessel (12:00 pm). Hope for Wildlife was contacted for a heads up. Unfortunately, the bird died overnight (before 6 am, Oct 4). It was transferred to the support vessel Ryan Leet the next day (Oct 5) (preserved in the freezer) and arrived in Halifax the next morning (Oct 6). The bird was picked up on Monday (Oct 7) by EC staff (C. Gjerdrum). EC sent the bird to necropsy at the Atlantic Veterinary College (Canadian Cooperative Wildlife Health Centre, Atlantic Region) in UPEI. They reported the following on Jan 17, 2014: "This was a beautiful specimen to examine....I have only had the chance to look at one previously and forgot how truly spectacular they are. It was an immature male that was emaciated. There was no signs of any disease processes during the gross examination and the digestive tract was completely empty. I have taken tissues for microscopic examination just in case there are underlying disease problems. Currently, the working diagnosis is emaciation/starvation."
Oct 26	LHSP	1						1 Rls'd	PFC contacted ECA onshore on Oct 27 and indicated that the previous day a storm petrel was brought to the Radio Room. The petrel had some oily substance on him, his feathers were all stuck together. PFC crew washed oil off the bird, dried him off then kept him in Radio Room until he stopped shivering - he settled down for a while and seemed very tired. When he was dry and started wanting to move, the bird was taken outside and put in a quiet dry corner in one of the legs. When PFC crew went out to check on the bird he had moved and was shivering so he was brought back inside and put in a box until he was released that night. _Note_: following this incident, additional guidance was provided to the PFC crew to remind them of the following: - contact ECA office to get EC guidance for any oiled/injured/unusual (e.g. non-marine) birds (only implement the Williams and Chardine protocol for non-injured non-oiled storm petrels); - not to feed or clean a bird; and - use cardboard boxes for bird recovery and not to line them up with any material to prevent injuries.

DOAS – Disposed of at Sea.
DIC – Died in Care.
Rls'd – Released.
SFR – Sent for Rehab.

***Oiled Birds**: **Both live and dead birds are to be sent to shore for treatment of the birds and /or analysis of the oil.**

Common Nighthawk stranded on PFC (Oct 3, 2013)

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 at least one line for each day that birds are found.

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). If more space is required, use comment section.

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

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.

Retrieval and Release of Birds on ________________________________ Year ________

					Captured Alive				Comments		
			Found Dead		Un-oiled		Oiled*				
Date	Species	Total	DOAS	Oiled *	DIC	Rls'd	DIC	SFR	Condition	Action Taken	Fate of Bird

DOAS – Disposed of at Sea.
DIC – Died in Care.
Rls'd – Released.
SFR – Sent for Rehab.

***Oiled Birds**: **Both live and dead birds are to be sent to shore for treatment of the birds and /or analysis of the oil.**

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	UNJA
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 D 2

Common Nighthawk Wildlife Diagnostic Report (March 2014)

Wildlife Diagnostic Report
Canadian Cooperative Wildlife Health Centre
Atlantic Veterinary College
University of Prince Edward Island
550 University Ave, Charlottetown, PEI C1A 4P3
Phone: 902 628-4314 Fax: 902 566 0871

Diagnosis Date : 2014-03-05 **Necropsy # : A1135-14**

Incident Information

Incident Code :	CCWHC.107801	Location :	Address : Sable Island, Nova Scotia Latitude : 43.812696 Longitude : -60.688368
Species :	Common Nighthawk *(Chordeiles minor)*		
Age :	Immature		
Sex :	Male		
Weight :	47.4 g		
Date Received :	2014-01-16		

Finder/Submitter Information

Submitter :
Carina Gjerdrum
Canadian Wildlife Service - Dartmouth, NS
45 Alderney Drive, 16th Floor
Dartmouth, Nova Scotia, B2Y 2N6
Phone : (902)426-9641
Fax : (902)426-6434
Email : carina.gjerdrum@ec.gc.ca

Finder :
Marielle Thillet
Nova Scotia
Phone : 902-492-5422
Email : marielle.thillet@encana.com

Information Provided With Specimen

This Common Nighthawk was found alive on the EnCana Deep Panuke offshore gas platform, located near Sable Island, NS (43 48' 45.704", 60 41' 18.126") on October 1, 2013. It was held in captivity for two days but later died on its own. It was submitted by Marielle Thillet from EnCana to Carina Gjerdrum of CWS- Dartmouth. The nighthawk was later received by the CCWHC on January 16, 2014.

Diagnosis and Interpretation

Final Diagnosis

1. Emaciation - Starvation

Interpretation

This immature male common nighthawk's inability to fly and eventual death were most likely associated with the metabolic abnormalities resulting from emaciation due to severe protein-calorie undernutrition. By the time the bird was captured, it was likely past the point of recovery, and the stress of captivity just hastened its eventual demise. Traumatic injuries or infectious disease problems were not identified to account for the bird's debilitated physical condition so primary starvation was the likely etiology.

It is not uncommon to find increased mortality from a variety of causes in the youngest cohort of the population. Starvation is one of the more frequent etiologies encountered in the death of these immature individuals, and it is inexperience at foraging that leads to their failure to obtain adequate sustenance.

Test Results

Necropsy

An immature male (small testes and bursa of Fabricius present) common nighthawk (*Chordeiles minor*) is presented for necropsy. The bird is emaciated with marked pectoral muscle atrophy and a complete absence of adipose tissue stores (body weight = 47.4 g). The proventriculus and ventriculus are empty and the koilin is bile stained. There is scant black intestinal content. Gross abnormalities are not present in other body systems.

Histology

Artifacts due to mild to marked post mortem decomposition and freezing are present in the tissues examined making accurate microscopic examination difficult.

Bursa of Fabricius - There is marked lymphoid depletion.

Brain, Heart, Lung, Proventriculus, Ventriculus, Intestine, Pancreas, Liver, Kidney, Adrenal and Testes - No significant findings.

Virology

As part of the National Avian Influenza Virus Surveillance Program in wild birds, samples from this specimen were submitted for testing. You will be contacted if significant results are obtained.

Pathologist(s) Scott McBurney

Confidentiality Notice

APPENDIX E

OTN Report – Acoustic Tracking of Marine Species near N.S. Offshore Oil and Gas Platforms, First Field Season (January 2014)

Acoustic tracking of marine species in Nova Scotia waters from receivers positioned near N.S. offshore oil and gas platforms: report on the first field season

Brendal Davis and F. G. Whoriskey
Ocean Tracking Network (OTN); Dalhousie University

27 January 2014


OCEAN TRACKING NETWORK

DALHOUSIE UNIVERSITY
Inspiring Minds

Fig. 1. *Using the shark table to surgically implant an acoustic tag in a blue shark.*

Executive summary

With Deep Panuke E&T and R&D Fund support, Ocean Tracking Network personnel successfully fitted 20 female juvenile blue sharks off of Eastern Passage, Nova Scotia, with Vemco V16 (16mm) acoustic tags to track their movements in the Northwest Atlantic Ocean.

Tagging was conducted as part of a summer course (*Biology and Conservation of Sharks, Skates and Rays*) for senior undergraduates at Dalhousie University, which trained 23 students in shark capture and tagging, and telemetry techniques.

Six VR2W acoustic receivers were deployed around Sable Island in late summer 2013 to support blue shark tracking. Additional acoustic receivers were placed on offshore oil and gas infrastructure belonging to Encana, ExxonMobil, and Statoil. A receiver was also placed on an ROV (remotely operated underwater vehicle), which inspected the Deep Panuke pipeline.

At present, a total of 4212 detections of the tagged sharks have been retrieved, mostly from the inshore portions of the OTN Halifax Line. We anticipate additional detections on the outer portion of this line once data offload/servicing of these receivers is completed in early 2014. Additional detections were made on autonomous marine vehicles belonging to OTN, and on the newly-deployed Sable Island receivers. While none of the tagged sharks were detected on the receivers deployed by industry partners on buoys in proximity to their offshore platforms, these receivers did register an acoustically tagged grey seal. This animal was originally tagged on Sable Island on 30 June 2013. Subsequently it was detected on the Wave Rider buoy associated with Encana's Deep Panuke field (coordinates- 43.81200, -60.66500). The animal was first detected on 6 July 2013, and again on 10 Aug 2013.

All project milestones are on track or exceeded. We expect this and next year's work on the project to make a valuable contribution to our understanding of how the North Atlantic's top predators' use migratory pathways and hotspots in our oceans.

Fig. 2. *The Halifax Line acoustic telemetry line, comprised of 256 active stations over 200km from Chebucto Head, Halifax, to the Scotian Shelf. This line captures north-south movements of acoustically tagged animals including Atlantic bluefin tuna, Atlantic cod, Atlantic salmon, Atlantic sturgeon, grey seal, spiny dogfish, blue shark and white shark.*

Introduction

In 2013, the Deep Panuke E&T and R&D Fund supported Dalhousie University's Ocean Tracking Network proposal to conduct acoustic telemetry work in the Deep Panuke offshore oil and gas development region of Canada's East Coast.

The purpose of the study was to:

- Document the movements and marine habitats used by valued marine species in the Northwest Atlantic Ocean, particularly around Nova Scotia,
- Acoustically tag a currently understudied top predator (blue sharks, *Prionace glauca*) to provide fundamental information about the species' distribution and survival in Nova Scotia waters,
- Expand the capacity of North American east coast acoustic telemetry networks by augmenting acoustic receiver coverage in the region by deployments of new receivers on infrastructure associated with the offshore oil and gas industry, and through training of new professionals.

Key objectives included:

- Conduct a pilot project to deploy and maintain acoustic receiver units on appropriate offshore oil and gas infrastructure in Nova Scotia to complement existing receiver coverage,
- Quality Assurance/Quality Control the data from detections of tagged animals at these sites and store it in the OTN data warehouse,
- Capture, tag, and release 20 blue sharks per year for two years (2013 and 2014),
- Transmit recorded detection information from the data warehouse to the national and international investigators who have tagged the fish,
- Document movements, habitat use, and survival of acoustically-tagged marine animals, many of which are highly migratory (e.g., we are recording the movements of Bluefin tuna through NS waters from the Gulf of Mexico into the Gulf of St. Lawrence),
- Make the information freely available to end-users, including industry, government, and the public,
- Train 18 students per year in the use of the marine tracking technology and animal tagging,
- Expand the project to other offshore oil and gas platforms globally if this pilot project is successful.

This report gives initial results from the first field season of the project. All milestones for 2013 were met on time.

Methods

The surgical team was trained by the university veterinarian on the surgical implantation of acoustic tags into sharks prior to the 2013 field season. The Dalhousie University Animal Care Committee pre-approved all animal-handling procedures. All students were given a classroom demonstration on how to handle, tag, release, and track pelagic sharks based on current best practices of catch-and-release shark fishing. In addition, they were trained in the collection of scientific data and the application of veterinary techniques for shark surgery and post-surgery care.

In the field, 100lb rod-and-reel fishing lines and barbless J-hooks were used to catch sharks. Sharks were attracted to the fishing lines by a chum-slick. During fishing, two rods were set; one at the surface (< 4 m depth), and the second at a depth of > 30 m. Hooked sharks were brought to the boat as quickly as possible and hoisted into a specially constructed ‘surgical table’, which positioned the animal for surgery with its ventral side up and provided a gap on the bottom to accommodate the dorsal fin (Fig. 1). Individuals of this species enter into a state of tonic immobility when they are placed on their backs.

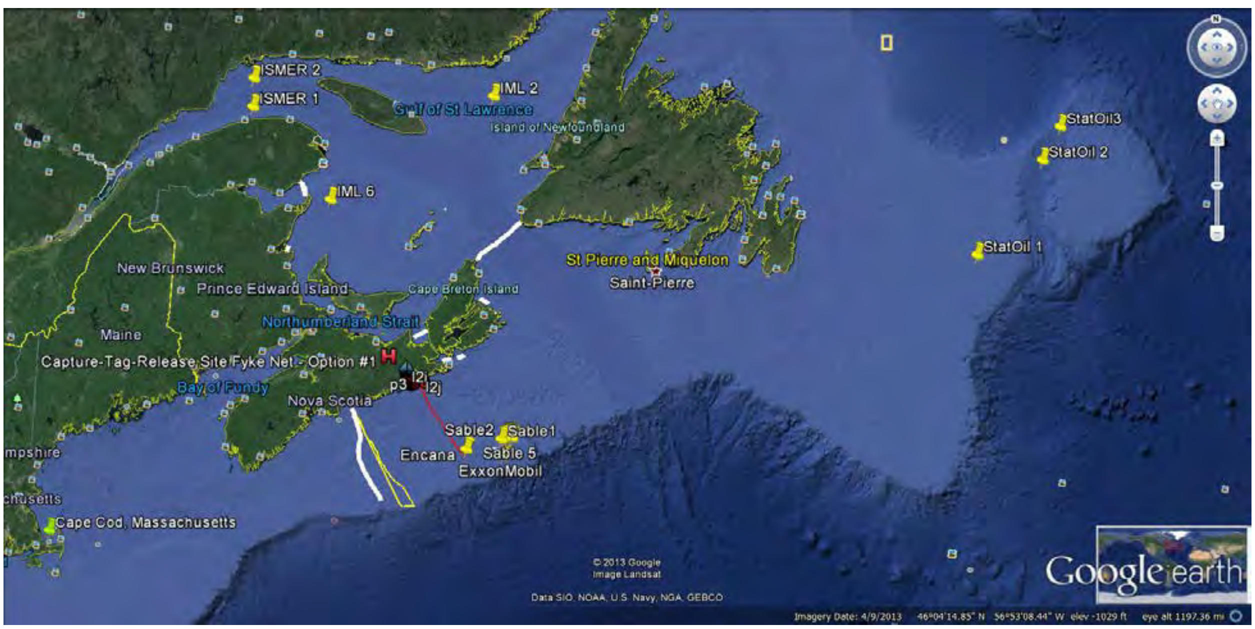


Fig. 3: *Placement of the OTN acoustic receivers in the project area. White lines show the approximate locations of lines of acoustic receivers. Yellow pins show individual receivers placed on moored buoys operated by various project partners. The yellow lines give representative course tracks for Slocum gliders carrying mobile receivers. The red line gives the approximate course track of the autonomous vehicle that carried a mobile receiver along the Deep Panuke pipeline.*

Once on the shark table, the animal's gills were irrigated to provide oxygen. Prior to surgery, the shark length and girth were measured (cm). Weight (kg) was calculated from the formula weight in kg = $(\text{length} * (\text{girth})^2)/800$, where length and girth are in inches. Sex was identified and recorded.

After sterilizing the surgery area (midway ventral side up between the pectoral and anal fins), a 3-4 cm incision was made in the abdomen, and the tag was inserted into the peritoneal cavity. Silk sutures were used to close the incision. The entire surgical procedure took less than seven minutes. Sharks were released as quickly as possible to reduce handling time and stress.

The acoustic telemetry infrastructure in the region includes the OTN Halifax Line and the OTN Cabot Strait Line (Figs. 2,3). In addition to these fixed lines, the OTN Wave Glider and Slocum electric gliders carried modified receivers to detect tagged animals during missions (Fig. 4).

Encana (one receiver at the Deep Panuke site), ExxonMobil (one receiver at the ExxonMobil Sable Offshore Energy Project site) and StatOil (three receivers at Flemish Cap sites) authorized the trial deployment of acoustic receivers on oceanographic buoys associated with their respective offshore oil platforms. Encana also permitted the attachment of a receiver to an ROV, which annually inspects the pipeline from the Deep Panuke site to the Nova Scotia coastline. A hand-held VR100 receiver was deployed from the blue shark charter vessel during the five tagging missions.

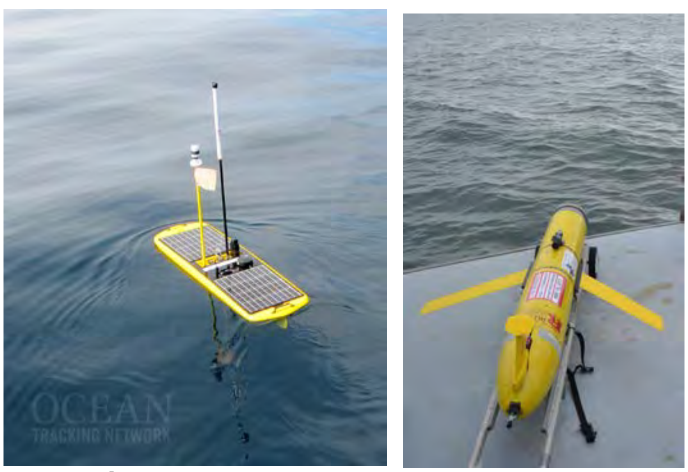


Figure 4. Wave Glider (left), and Slocum Glider (right). Both types of autonomous vehicles were fitted with acoustic receivers and deployed during the study.

Results and discussion

Over three missions between 31 July and 2 August 2013, 20 blue sharks were successfully caught, named, tagged, and released (Table 1). During this period, 23 students were trained in the capture, handling, tagging and tracking of acoustically tracked sharks as part of the

Dalhousie University undergraduate course *Biology and Conservation of Sharks, Skates and Rays.* Sharks frequently show distribution patterns in the ocean in which individuals of similar sizes and ages group together; all sharks captured and tagged were juvenile females indicating the Eastern Shore area of Nova Scotia was favored by juvenile female blue sharks in 2013. This species is known to segregate by size and age. Young males and large females are uncommon in Nova Scotia waters, for unknown reasons. The six year lifespan of the tags that we have placed in our study's blue sharks will help us understand the movements of the species and hopefully permit us to identify some of the factors that contribute to the observed segregation in the species.

Using acoustic tags with a six-year battery life, and assuming that a significant portion of the tagged sharks survive for this duration, we should be able to document shifts in behavior as they grow and mature. This will provide valuable long-term information on the species where relatively little information currently exists. All 20 tagged sharks were subsequently detected on acoustic receivers lines in the region following receiver data offload. Thus, all animals successfully recovered from initial stress associated with capture and tagging. At this time, data analysis is preliminary and incomplete, as we have offload information from about 45% of the receivers on the OTN Halifax Line as of January 2014. We expect this download to be completed during the January—February 2014 period.

From the date the experimental animals were released through 1 December 2013, a total of 4,212 blue shark detections were recorded by the inner portion of the Halifax Line, Sable Island receivers, and the OTN autonomous vehicles. The majority of these detections come from the inner Halifax Line (n=4197). There were five additional detections from the gliders; two from Brianna on 7 October 2013 and three from Wryley, 2 days later, 9 October 2013. All ten detections from Sable Island were from Percy on 27 September 2013. No detections of the tagged blue sharks were obtained from receivers placed either on Encana or ExxonMobil offshore infrastructure, or on the Encana ROV. At this time, the receivers placed at the StatOil sites have not yet been retrieved. Two individuals were detected by the OTN Slocum glider during its mission covering the Halifax Line; one on 7 October and another on 9 October.

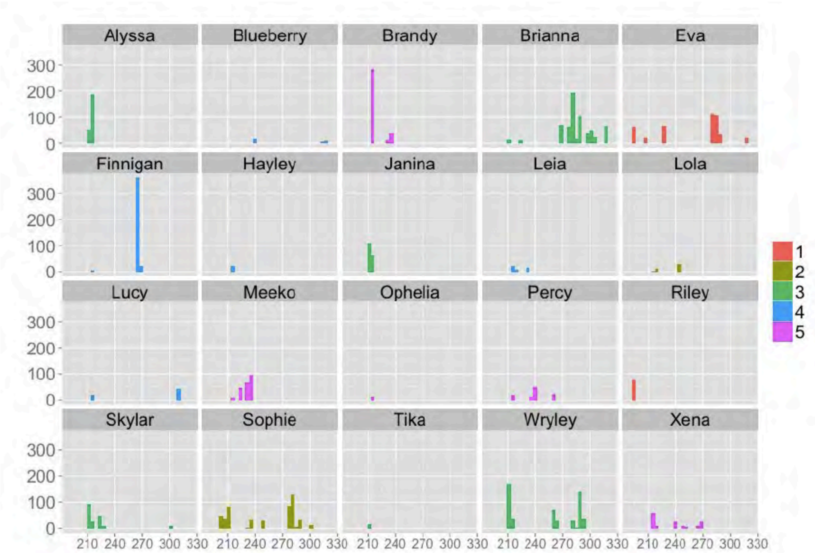
ANIMAL_ID (floy tag ID, pit tag code, etc.)	TAG ID CODE	CAPTURE LATITUDE	CAPTURE LONGITUDE	LENGTH (cm)	WEIGHT (kg)	SEX
Eva	26651	44.209163	63.27934	160	33	F
Percy	26652	44.20216	63.24593	138	20	F
Riley	26653	44.21458	63.23736	158	30	F
Meeko	26654	44.20345	63.25824	130	17	F
Sophie	26655	44.21245	63.227145	153	25	F
Brandy	26656	44.20226	63.24866	140	23	F
Lucy	26657	44.17844	63.23646	162	28	F
Xena	26658	44.20221	63.23848	164	41	F
Leia	26659	44.18082	63.22768	137	21	F
Hayley	26660	44.18111	63.22008	151	25	F
Blueberry	26661	44.17669	63.23979	152	25	F
Finnigan	26662	44.18141	63.22412	143	22	F
Wryley	26663	44.17254	63.23924	116	8	F
Brianna	26664	44.21387	63.24617	141	22	F
Tika	26665	44.20386	63.24852	152	25	F
Janina	26666	44.22348	63.24687	149	25	F
Lola	26667	44.201745	63.219623	139	18	F
Alyssa	26668	44.21659	63.23805	156	28	F
Ophelia	26669	44.20432	63.26720	129	11	F
Skylar	26670	44.21658	63.23802	162	31	F

Table 1: *Animal name (Animal_ID), tag ID code; latitude/longitude of catch and release location, length, calculated weight (to nearest kg), and sex of the 20 tagged sharks.*

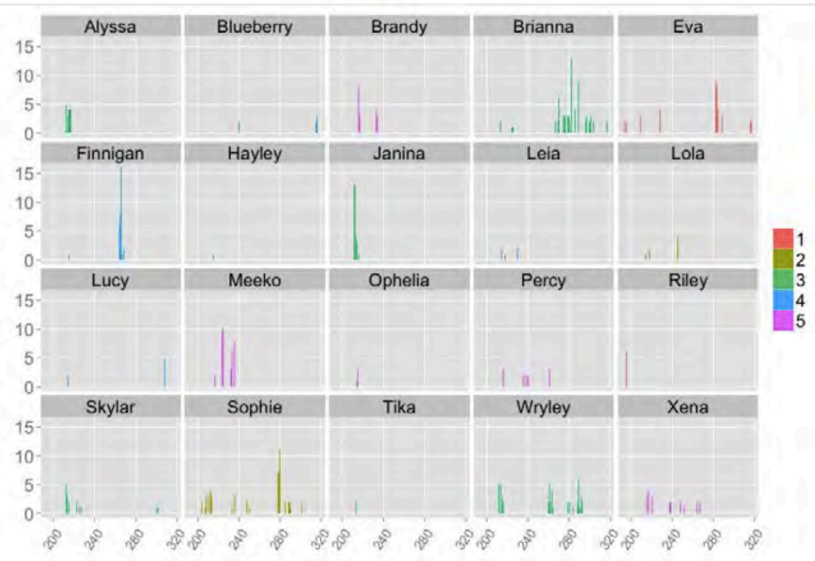
A summary of all detections of all sharks, by day of the year, is given in Fig. 5.

To simplify the analysis, multiple detections by the same individual on the same day at the same station were treated as a single confirmation-of-presence at a given station on a given day. This resulted in a new dataset containing 419 detections. Detections at a given station for individual sharks were fewer than 15 per day (Fig. 5b). Fig. 6 gives the number of detections on different days of the year per individual shark for the Halifax line.

Preliminary information suggests that these juvenile sharks generally remained in the area around Halifax through the summer and autumn. Detections dropped off on the inshore portion of the Halifax Line towards the end of September, with our last detections occurring in mid-November. If these animals subsequently moved offshore to avoid winter conditions we should see additional detections on the yet-to-be downloaded offshore portions of the Halifax Line. If they moved to the south, we may receive data on these movements from our collaborators who maintain acoustic receiver lines in U.S. waters. These lines cover coastal areas from Maine to Florida.



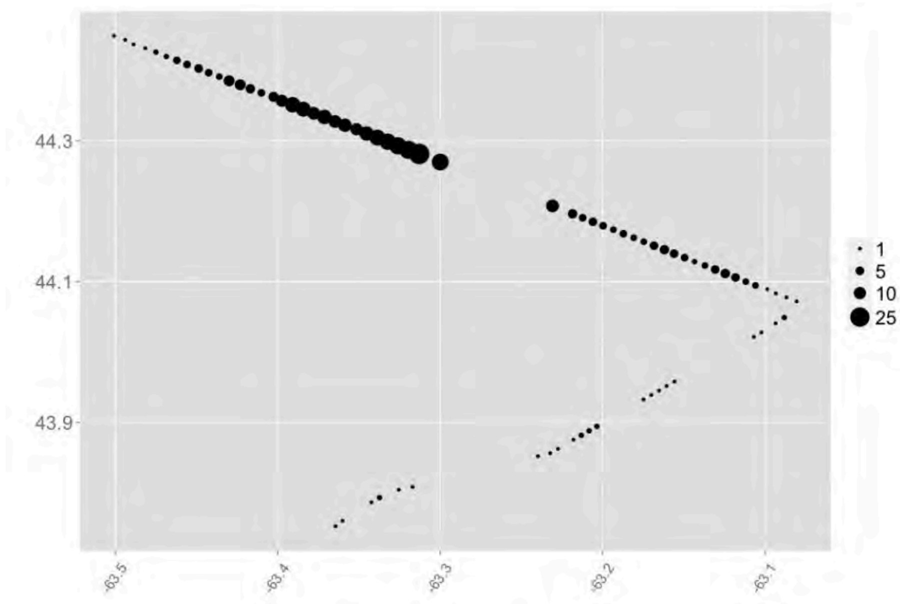
(a) All detections.



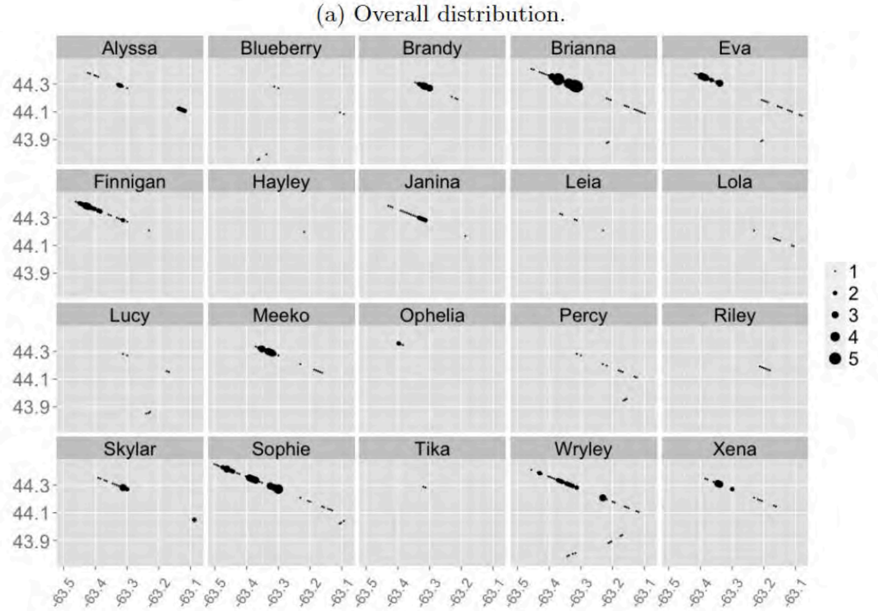
(b) After duplicated were removed.

Figure 5. *(a) Number of detections (Y axis) on the day of the year (X axis; Jan 1 = 1, Dec 31 = day 365) per individual shark for the HFX Line. (b) Number of Halifax Line stations (Y axis) on which individual sharks were detected, by day of the year (X axis). Information on individual sharks is given in Table 1. Animals plotted in the same color were tagged on the same day.*

Most of the detections of tagged sharks occurred on the inner portions of the Halifax Line (Fig. 6a). We interpret this information with caution because of the incomplete nature of our information from the Halifax Line. However, the pattern may indicate that the majority of the animals remained in the inshore region for most of the study period, close to the point where they were tagged. This suggests that the majority of animals of this size and age showed some degree of site fidelity, although this pattern did not apply to all of the experimental animals. One tagged shark (Percy) was detected on multiple receivers of the Halifax line, and subsequently at Sable Island (Fig. 7). Hence some individuals were wanderers.



(a) Overall distribution.



(b) Distribution per shark.

Figure 6: *Plots of number of detections at each station by individual sharks between release and 1 Dec 2013. Stations are plotted in decimal degrees according to their latitude (Y axis) and longitudes (X axis). The size of the circle indicates the scale of detection frequency at each station. Panel (a) shows pooled data from all sharks. Panel (b) breaks down detections by individual sharks. The portion of the Halifax line covered by these data has a V shape, which was required to avoid mooring receivers in areas of high fishing intensity.*

Figure 7. Detections of shark "Percy" on receivers on the Halifax line (left side of the figure), and at Sable Island (right side of the figure).

Concluding Remarks

The 2013 field season was highly successful. Considerable data has been obtained on tagged blue sharks, and we anticipate more will become available as the rest of the Halifax Line receivers are offloaded.

As noted earlier, none of the tagged sharks were detected at the offshore oil infrastructure sites. We suspect that this is explained by some degree of site fidelity to the area where sharks were initially tagged and released. As these animals grow larger, they may range farther afield. We also did not have detections from the Encana ROV which patrolled the continental shelf from the Deep Panuke site to the Nova Scotia mainland; however, two individual sharks were detected by the OTN Slocum glider. Lack of detections by the Encana ROV may indicate that there were no tagged animals in this area. Alternatively, it is possible that the noise from the operation of the vehicle impaired our ability to detect the coded tags of our animals. With permission of the company, we will reattempt this mission in 2014, but include a broad-spectrum sound sensor that will let us determine if interference affects receiver detection ability.

Student training

The study has given undergraduate students valuable practical experience, and their comments on the experience were universally positive. A selection of their comments includes:

“This was one of the most interesting courses I have taken. I left many days in deep thought or inspired by the content, and any course that is able to do this is clearly on the right track.’

“Great class. Loved every minute of it. Learned a lot!’

“One thing I really loved about this course was going out to see sharks in the wild.”

“This was the coolest class ever!”

Of the 23 students, 22 responded that their favorite thing about the course was ‘shark tagging’.

Media coverage

The project generated considerable positive interest in the media. Several local TV news crews filmed the capture and tagging of the experimental animals, and the field activities were also covered by radio, newspapers and web information services. Dalhousie University’s new president, Dr. Richard Florizone, joined the students for a day of tagging and also captured one of the sharks used in the study.

Media coverage included:

Blue sharks tagged and tracked off Nova Scotia (CBC)
http://www.cbc.ca/news/canada/nova-scotia/blue-sharks-tagged-and-tracked-off-nova-scotia-1.1309567

New study aims to track blue sharks off Nova Scotia coast (CTV)
http://www.ctvnews.ca/sci-tech/new-study-aims-to-track-blue-sharks-off-nova-scotia-coast-1.1393059#ixzz2qOemJdDf

New Dal president joins marine mission to tag blue sharks (Chronicle Herald)
http://thechronicleherald.ca/metro/1145300-new-dal-president-joins-marine-mission-to-tag-blue-sharks

Dalhousie students set out to tag, track sharks off the coast of N.S. (CTV)
http://atlantic.ctvnews.ca/dalhousie-students-set-out-to-tag-track-sharks-off-the-coast-of-n-s-1.1392688

New funding for shark research in Nova Scotian waters
http://sharkyear.com/2013/new-funding-for-shark-research-in-nova-scotian-waters.html

Acknowledgements

We thank Art Gaetan of Blue Shark Fishing Charters for his guidance in capturing the experimental animals. We thank Encana for permission to place an acoustic receiver on their Deep Panuke site, and another on the ROV used to inspect their pipeline. Bruce Batstone and Marc Batt of AMEC successfully arranged for the deployment and recovery of the equipment at the Deep Panuke site, and Encana representative Rob Myers placed the receiver on the Encana ROV. We thank Statoil for permission to install three receivers on their equipment on the Flemish Cap. Bruce Doyle made the contacts with StatOil and arranged for receiver deployment and retrieval. We also thank ExxonMobil (Megan Tuttle) for permission to place a receiver on this company's infrastructure in the Sable Offshore Energy Project area. The Department of Fisheries and Oceans provided shiptime to service the receivers on Sable Island in autumn 2013. Baker Blue Ocean (Darrin Baker) provided the charter to initially deploy the Sable Island receivers. Duncan Bates and Susan Dufault from OTN provided field and database logistics to the project, and Marta Mihoff helped wth drafting figures. Aurelie Cosandey-Godin assisted with the preliminary data analysis, and Nikki Beauchamp provided the report design and edited the text. Everyone is thanked for their contributions.

APPENDIX F

2013 Observations from Supply Vessels and PFC of Marine Wildlife

Visual observations from the Vessels and PFC				
Date	**Condor**	**Ryan Leet**	**PFC**	**Vessel Position**
year round	various untagged gulls			
10-May-13		2 pilot whales		Standby (43*46.81' N, 060*40.98' W)
20-May-13	3 minke whales feeding on school fish			43°51.0'N, 060°50.8'W (on route to Hfx)
	1 fin whale			43°57.4'N, 061°12.6'W (on route to Hfx)
21-May-13		grey seal		Standby (43*49.14' N, 060*45.18' W)
23-May-13		approx. 10 porpoises		Standby (43*47.55' N, 060*38.25' W)
24-May-13		1 minke whale		Standby (43*47.78' N, 060*42.14' W)
20-Jun-13	1 seal			(44°13.3' N, 062°16.3' W)
15-Aug-13	1 whale			(44 - 10 N, 062 - 04 W)
01-Dec-13			2 snowy owls	

Snowy owl photos from the PFC:

Two snowy owls at the PFC, on Dec 1, 2013.

One snowy owl at the PFC on Dec. 1, 2013.

APPENDIX G

2013 Flare Plume Observations

Flare Smoke at the PFC:

The condition of the flare is monitored continuously by one of the cameras in the PFC Central Control Room (CCR) pointing at the flare at all times (as well as with operators routinely checking up outside). Whenever smoke is observed, the production technicians take action and look into the reason for the dirty flare; e.g. additional dilution gas may be added to get a clean burn.

No systematic flare smoke data was compiled for 2013 (as it was a busy transition year with the platform commissioning and start-up). However, our Encana Onboard Representatives (OBR) look at the condition of the flare whenever they do a walk around. They indicated that most of the time the flare was burning very cleanly with no smoke observed. There were certainly instances during start-up of wells or whenever systems were being pumped to the flare where smoke was generated, but this was certainly the exception rather than the norm. Over his last trip of 2013 to the PFC (three weeks in Dec 2013-Jan 2014), our OBR recalled noticing smoke on approximately three occasions. Each time it was for a short duration (approximately 30 minutes) and consisted of a small plume, just enough to leave a smoky trail for 100' or so depending upon wind conditions, which then disappeared when the flare was burning cleaner. The photos below show typical flare conditions recorded by the CCR camera.

Systematic flare smoke monitoring was initiated in February 2014 including recording of flare smoke shade twice a day using a Ringelmann smoke chart. These observations will be provided in the 2014 annual report.

Flare smoke photographs:

The flare at the PFC on February 12, 2014.

The flare at the PFC on February 13, 2014.

The flare at the PFC February 14, 2014.

APPENDIX H

2013 Sable Island Air Quality Monitoring

EXXONMOBIL / Encana AIR EMISSIONS ANALYSIS FOR 2013

March 27, 2014

Submitted By: Dr. Mark Gibson
CEO, Kingfisher Environmental Health Consultants

Acronyms

APS	Aerodynamic Particle Sizer
AS	Air Server
BC	Black carbon
CH_4	Methane
ESRF	Environmental Studies Research Funds
GC	Gas Chromatograph
GEM-MACH-10	Global Environmental Multiscale model - Modelling Air quality and Chemistry ($10\ km^2$ grid cell)
H_2S	Hydrogen Sulfide
O_3	Ground-level ozone
LRT	Long-Range Transport
MS	Mass Spectrometer
NAPS	National Air Pollution Surveillance network
NMHC	total-Non Methane Hydrocarbons
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PM	Particulate matter
$PM_{2.5}$	Fine atmospheric particles with a median aerodynamic diameter less than, or equal to, 2.5 microns
SO_2	Sulfur dioxide
TD	Thermal Desorber
VOC	Volatile organic compounds
WHO	World Health Organization

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Executive Summary

Kingfisher Environmental Health Consultants (KEHC) were contracted to complete a number of specific tasks related to air emissions on Sable Island for Encana and Exxon Mobil that include: acquisition of meteorological and air quality data pertaining to monitoring on Sable Island for 2013, conducting data analysis and graphing of air quality and meteorological data, investigating spikes in air monitoring data, checking wind direction/wind speed and contacting Sable Offshore Energy Project (SOEP)/Encana to identify potential correlation with a particular facility's operations, as required.

This air monitoring report covers the following air quality metrics measured on Sable Island: nitric oxide (NO), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), hydrogen sulfide (H_2S) and fine particulate matter with a median aerodynamic diameter, less than or equal to, 2.5 microns ($PM_{2.5}$). Total volatile organic compound (VOC), methane (CH_4) and non-methane hydrocarbons (NMHC) concentrations are new additions to the 2013 air quality report. It was discovered during the data acquisition process that VOC species monitoring was discontinued in January 2009. Data acquisition for total-VOC, CH_4 and NMHC was restarted in May 2013 by Dr. Gibson's research group at Dalhousie University, and therefore only a percentage of the year's data has been collected. A description of the new air pollution instruments (funded by the ESRF) that are currently deployed and will be added to Sable Island in 2014 will be provided.

It was found that the average wind vector for 2013 was 256° which is consistent with prevailing winds in the NE Atlantic. The most important feature of the air pollution data acquired in the 2013 year was one event where the NOX emissions 'spike' threshold (1-hr period) was exceeded and likely not a result of O&G operations. The back trajectory analysis revealed that it came from the Westerly/North Westerly direction, which eliminates O&G operations as the source. The NOx spike was likely due to continental outflow. There were three H_2S spikes investigated which were likely due to instrument drift rather than O&G operations.

Elevated daily average concentrations that rose above three standard deviations above the mean were found for all pollutant data sets except for O_3, CH_4 and total VOC. The 1st highest daily average $PM_{2.5}$ concentration of 22.79 μg/m^3 on November 28, 2013 had a back trajectory to the South, which is in line with the North Triumph platform. Elevated $PM_{2.5}$ concentrations may also be a consequence of sea salt spray and further investigations of the $PM_{2.5}$ chemistry and/or O&G operations would need to be conducted to confirm this.

There were no breaches of the National Air Quality Standards, Canada Ambient Air Quality Objectives (CAAQO) or Canada Wide Standard for any of the air pollution metrics contained in this report.

1.1 RATIONALE & BACKGROUND

Sable Island is also one of the most important locations in the world for conducting climate monitoring with weather records dating back to the 1871 (Inkpen et al., 2009, GreenHorseSociety, 2012). Because the Island is 160 km from main land Nova Scotia it can be thought of as a truly marine influenced sampling location. Thus, it is in the perfect position to monitor emission from the ocean as well as continental outflow from North America (Inkpen et al., 2009). While sources of anthropogenic $PM_{2.5}$, total-VOCs and trace reactive gases are well known, it is recognized that there are still large gaps in knowledge with regards to biogenic emissions of terpenes and other VOC emissions from terrestrial (forest fires and vegetation) and marine sources (phytoplankton and direct emissions from the ocean) that act as pre-cursors of intermediate harmful chemical species, e.g. formaldehyde and glyoxal, pre-cursors of cloud condensation nuclei (CCN), secondary organic aerosols (SOA) and O_3; all of which perturb climate, earth systems and health (Gibson et al., 2013c, Gibson et al., 2013a, Palmer et al., 2013, Gibson et al., 2009b, Gibson et al., 2009a, Monks et al., 2009, Palmer and Shaw, 2005). In addition the transport of nitrogen and sulphur aerosol species from local and upwind continental sources can impact the terrestrial and aquatic flora and fauna on Sable Island (Gibson et al., 2013a). Therefore, understanding local and long-range upwind sources of $PM_{2.5}$, $PM_{2.5}$ chemical components, VOCs and trace reactive gases to the Sable Island airshed is important, not just for local air quality, but from the perspective of climate inventories and climate forcing (Monks et al., 2009).

Two detailed air emission reports have been conducted pertaining to the Sable Island airshed, (Inkpen et al., 2009) and (Waugh et al., 2010). The Environment Canada project report "Sable Island Air Monitoring Program Report 2003-

2006", identified a knowledge gap in monitoring to adequately identify impacts from the offshore O&G pointing to the need for enhanced on-island monitoring of industrial emissions, including VOC and PM speciation in the Scotian Shelf Airshed (SSA) (Inkpen et al., 2009). Waugh et al., (2010) mention in their report that some of the short-term spikes in data might be due to local source influences resulting from offshore oil and gas (O&G) activities in the vicinity of Sable Island (Waugh et al., 2010).

Sable Island's unique location in the Atlantic ensures that it receives significant transboundary air pollutant flows from areas in the NE US and the Windsor - Québec corridor as well as significant amounts of sea salt (Waugh et al., 2010). Frontal systems have been shown to "push" pollution into narrow "vertical bands" of high concentrations ahead of the front and have been identified as causing relatively large, but short-lived, spikes in air quality data on Sable Island (Waugh et al., 2010). In addition, previous studies have shown that seasonal fluxes of natural marine emissions (terpenes, dimethylsulfide, VOCs) are likely to react in the atmosphere to form secondary O_3 and $PM_{2.5}$ which further contribute to the total air pollution mix on Sable Island (Gibson et al., 2013c, Gantt et al., 2010). Waugh et al., (2010) reported a number of long-range transport (LRT) events that were identified from air mass back trajectories, synoptic charts and maps of air pollution monitoring data in the NE US and E Canada prior to the air mass reaching Sable Island. These air pollution maps were obtained from the US data base AIRNow (http://airnow.gov/) (Waugh et al., 2010).

Because of the recommendations of the Inkpen et al., (2009) and Waugh et al., (2010) reports, funding was made available through the Environmental Studies Research Funds (ESRF) for a four year project, the aim of which is to unambiguously apportion the source contribution of the O&G facility operations to the total concentration of VOC's on Sable Island. This ESRF funding was awarded to Dr.s' Mark Gibson and Susanne Craig, Departments of Process Engineering and Applied Science and Oceanography respectively. This project will also have the value added component of being able to apportion the marine and LRT emissions/pollution impacting the Sable Island airshed. A feature of this project is the live streaming of the continuous monitoring data to a website data display. In addition, threshold concentrations for O&G relevant air pollutants have been set to alert Encana and Exxon Mobil in the event of spikes in air pollution concentrations. When this occurs, Dr. Gibson works in concert with the O&G facility operators to determine if the spike was related to O&G facility activity or a result of another local or LRT source. The ability of O&G facility operators to quickly respond to any air pollution spikes will safeguard air quality, marine ecosystems, marine fisheries, O&G facility operations, O&G occupational health and safety.

The O&G industry has had a presence on the Scotian shelf since the late 1960's (CNSOPB, 1990). Currently, Exxon Mobil have a number of platforms in operation at five fields offshore Nova Scotia: Thebaud, Venture, North Triumph, Alma and South Venture. A platform at Thebaud provides central facilities for gathering and dehydration. A second platform provides compression of the gas from all fields, while a third platform at this location provides wellhead facilities for the Thebaud field itself. Hydrocarbons produced at the four other platforms are transported through a system of subsea flowlines to the Thebaud platform. After dehydration at Thebaud, the raw gas is transported through a subsea flowline to landfall at Goldboro, Nova Scotia, and to a gas processing plant located nearby. There the gas is conditioned by the removal of natural gas liquids (NGLs) to meet high quality sales gas specifications. The sales gas is then shipped to markets in eastern Canada and the northeastern United States, through the Maritimes & Northeast Pipeline (M&NP). NGLs are transported by pipeline to the Point Tupper Fractionation Plant for final processing before being sent to market in the form of propane, butane and condensate (Per. Comm, Environmental Manager – Exxon Mobil).

Encana's Deep Panuke Offshore Gas Development Project involves the production of natural gas from an offshore field located approximately 250 km southeast of Halifax and the transportation of that gas via subsea pipeline to shore, and ultimately, to markets in Canada and the United States. At the end of commissioning activities, the platform flared nitrogen and buy-back sales-quality natural from June 3rd to August 7th, 2013. On August 7th, 2013, the first well was opened and the platform started flaring acid gas, though "First Gas", i.e. full production rate, was not achieved until December 2013. Production is anticipated to continue for a mean production life of 13 years. The Project utilizes a jack-up type offshore platform as its Production Field Centre (PFC) tied back to production wells with subsea flowlines and umbilicals (CNSOPB, 2013). Figure 1 and Table 1 below presents the geographical location of the O&G platforms surrounding Sable Island on a map and table form (source: http://www.cnsopb.ns.ca/pdfs/sable_area_platforms.pdf). Figure 2 shows the locations of facilities on Sable Island and on-island combustion sources.

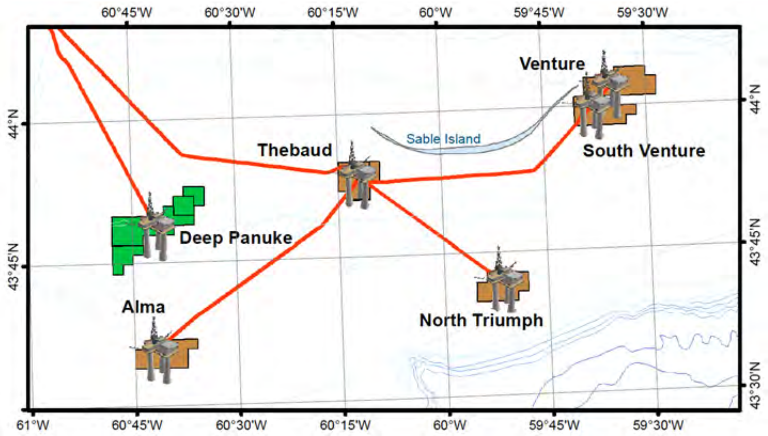


Figure 1. Location of the O&G platforms surrounding Sable Island

	Platform Centre Location - NAD83			
	Geographic		UTM (Zone 20)	
Platform Name	Latitude	Longitude	Northing	Easting
Thebaud	43° 53' 28.4" N	60° 11' 57.2" W	4863604.8	724963.3
Thebaud Process Jacket	43° 53' 30.8" N	60° 12' 00.0" W	4863676.7	724898.3
Venture	44° 01' 59.8" N	59° 34' 54.3" W	4881245.1	773902.9
North Triumph	43° 41' 56.6" N	59° 51' 13.6" W	4843261.4	753522.2
Alma	43° 35' 47.1" N	60° 41' 19.3" W	4829644.9	686560.9
South Venture	43° 59' 50.6" N	59° 37' 38.6" W	4876899.3	770420.7
Deep Panuke	43° 48' 45.704" N	60° 41' 18.126" W	4853666.9	685917.2

	Platform Centre Location - NAD27			
	Geographic		UTM (Zone 20)	
Platform Name	Latitude	Longitude	Northing	Easting
Thebaud	43° 53' 28.1" N	60° 11' 59.9" W	4863377.6	724909.9
Thebaud Process Jacket	43° 53' 30.5" N	60° 12' 02.7" W	4863449.5	724844.9
Venture	44° 01' 58.0" N	59° 34' 12.5" W	4881019.4	773848.6
North Triumph	43° 41' 56.4" N	59° 51' 16.4" W	4843035.7	753467.9
Alma	43° 35' 46.8" N	60° 41' 22.0" W	4829417.0	686507.0
South Venture	43° 59' 50.4" N	59° 37' 41.4" W	4876673.5	770366.4
Deep Panuke	43° 48' 45.439" N	60° 41' 20.804" W	4853441.1	685863.0

Table 1. Geographic locations of the O&G platforms surrounding Sable Island

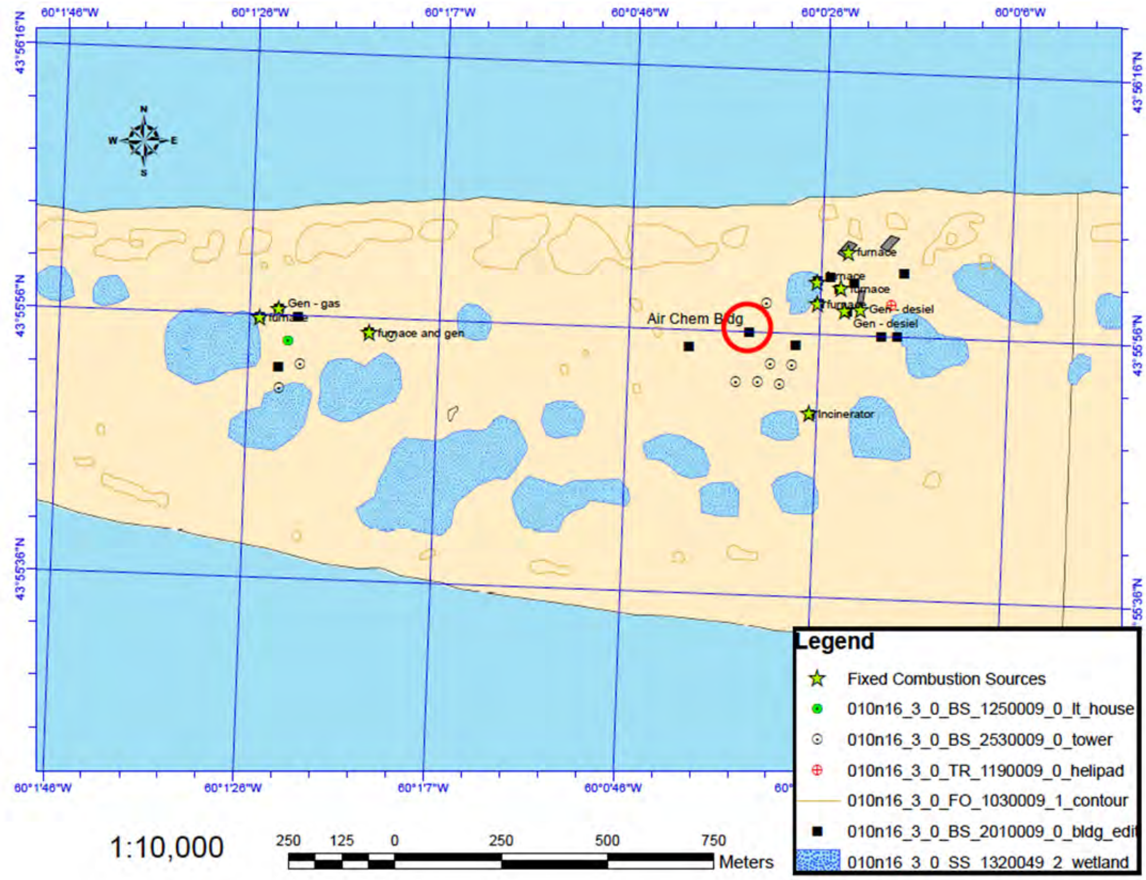


Figure 2. Location of facilities and on-Island combustion sources on Sable Island.

1.2 GOALS

The goal of the air quality-monitoring component of the EEM program is to collect information on potential effects originating from the offshore platforms that may affect Sable Island or that can be monitored from the island. Sable Island provides a unique platform upon which to augment the offshore EEM program.

1.3 OBJECTIVES

Acquire a better understanding of both ambient air concentrations in the Sable area and quantitatively identify any possible effects from offshore operations, while taking into consideration localized emission sources on Sable Island itself including air traffic to and from the island, diesel electric supply and waste incinerations at the research station.

1.4 2013 Air Quality Monitoring on Sable Island

1.4.1 Nova Scotia Environment, Sable Island, Air Quality Monitoring and Reporting

In 2008 a new data management system was installed on Sable Island. This new system includes the hardware (an industrial computer, uninterrupted power supply and surge protector) and software (DRDAS). The new system collects digital monitoring and diagnostic data from the instruments for O_3, $PM_{2.5}$, NO_x, SO_2 and H_2S on a continuous basis (Waugh et al., 2010).

A request was made to Nova Scotia Environment on February 7, 2014 for detailed information regarding the maintenance, management and QA/QC of the instruments on Sable Island. Feedback has yet to be received.

A list pertaining to instrument maintenance, calibration, swap out or new instrument installed for 2013 is in the process of being assembled (related to communication with NSE above).

1.4.2 Instrumentation on Sable Island

Table 2 provides a summary of the air pollution instrumentation that is currently, or shortly to be deployed in 2014, on Sable Island. Table 2 also provides the funding/in-kind contributor and the temporal resolution of the measurement of sample collection.

Table 2. Summary of instrumentation on Sable Island and funding source

Equipment	Contributor	Comments
Air Monitoring Shed	ESRF (100%)	
Teledyne NO_x Analyzer	NAPS (100%)	Hourly
METOne BAM $PM_{2.5}$	NAPS (100%)	Hourly
Teledyne H_2S Analyzer	Encana Corporation (100%)	Hourly
Teledyne SO_2 Analyzer	NAPS (100%)	Hourly
TECO O_3 Analyzer	Environment Canada (100%)	Hourly
Thermo Partisol 2000 dichotomous sampler Federal Reference Method	EC - NAPS (100%)	24-hr, simultaneous, integrated filter sample of $PM_{2.5}$ (fine) and $PM_{2.5-10}$ (coarse) particle mass
TSI 3031 Ultrafine particle monitor	ESRF Funding (Gibson/Craig) ***To be deployed in 2014***	15-min
TSI 3321 Aerodynamic Particle Sizer	ESRF Funding (Gibson/Craig) ***To be deployed in 2014***	1-15 min
Thermo 55i total VOC Analyzer	ESRF Funding (Gibson/Craig) ***Deployed March 21, 2013***	Hourly
Markes International Air Server 3 and Unity 2 for VOC species concentration on the Island	**Gibson in-kind** Running in the laboratory at Dalhousie	Hourly
Additional Markes International Unity 2 and Thermo GC-ISQELITE MS for the analysis of VOC species collected on Island by thermal desorption tubes	**Gibson in-kind** **Thermo in-kind MS** Running in the laboratory at Dalhousie	Daily
TSI DRX DustTrak 8533 for Total PM, PM_{10}, $PM_{2.5}$ and PM_1	ESRF Funding (Gibson/Craig) ***Deployed March 21, 2013***	1-60 min
Thermo 5012 black carbon analyzer	ESRF Funding (Gibson/Craig) ***Deployed March 21, 2013***	Hourly
Data display and data archive	ESRF Funding (Gibson/Craig) ***Running***	N/A
2x Markes International MTS-32, for the collection of 32-daily VOC species samples onto thermal desorption tubes for analysis back in Halifax	ESRF Funding (Gibson/Craig) ***To be deployed in 2014***	24-hr
Thermo 1300 GC and Thermo ISQ MS for VOC species concentration	ESRF Funding (Gibson/Craig) ***Running perfectly in the laboratory at Dalhousie University*** ***To be deployed in 2014 if power can be installed in the air chemistry building***	Hourly

1.5 ANALYSES

1.5.1 Data Acquisition

Air quality data for 2013 thus far was obtained from two sources. Nova Scotia Environment, who has provided QA/QC'd $PM_{2.5}$, O_3 and SO_2 (incomplete data set), and Dr. Gibson's recorded raw data collection system at Dalhousie University that began in May 2013. It is important to note that this report contains results and analysis of non-QA/QC'd data in addition to QA/QC's data. All data acquired from Nova Scotia Environment ($PM_{2.5}$, O_3 and SO_2) are QA/QC'd. Total VOC, CH_4, and NMHC data in this report are QA/QC'd. All remaining data (NO, NO_2, NO_x and H_2S) are not yet QA/QC'd, but for data workability purposes all data concentration points recorded as < -0.1 were removed from the data set, and all values ≥ -0.1 and < 0 were set to zero.

1.5.2 Air Quality Standards pertaining to Sable Island

Table 3 contains the air quality standards for Canada, Nova Scotia and the World Health Organization (WHO). These air quality regulations will be used for comparison with the 2013 air quality data pertaining to Sable Island.

Table 3. Nova Scotia Air Quality Regulations (*Environment Act*) and *Canadian Environmental Protection* Act Ambient Air Quality Objectives (Suggested air monitoring thresholds - $\mu g/m^3$ (ppb))

Pollutant and units (alternative units in brackets)	Averaging Time Period	Nova Scotia: Maximum Permissible Ground Level Concentration	Canada: Canada Wide Standards	Canada: Ambient Air Quality Objectives: Maximum Desirable	Canada: Ambient Air Quality Objectives: Maximum Acceptable	Canada: Ambient Air Quality Objectives: Maximum Tolerable	World Health Organization (WHO)
Nitrogen dioxide $\mu g/m^3$ (ppb)	1 hour	400 (213)	-	-	400 (213)	1000 (532)	(105)
	24 hour	200 (106)	-	-	**200 (106)**	300 (160)	
	Annual	100 (53)	-	60 (32)	100 (53)	-	(21)
Sulfur dioxide $\mu g/m^3$ (ppb)	1 hour	900 (344)	-	450 (172)	900 (344)	-	
	24 hour	300 (115)	-	150 (57)	**300 (115)**	800 (306)	(7.5)
	Annual	60 (23)	-	30 (11)	60 (23)	-	
Total Suspended Particulate Matter (TSP) $\mu g/m^3$	24 hour	120	-	-	120	400	
	Annual	70 (geometric mean)	-	60	70	-	
PM2.5 (fine) $\mu g/m^3$	24 hour, 98th percentile over 3 consecutive years	-	30 (by 2010)	-	-	-	
	24 hour				**120**		25
	Annual			60	70		10
PM10-2.5 (coarse) $\mu g/m^3$		-	-	-	-	-	
PM_{10} (sum of fine and coarse)	Annual						50
Carbon Monoxide mg/m^3 (ppm)	1 hour	34.6 (30)	-	15 (13)	35 (31)	-	
	8 hour	12.7 (11)	-	6 (5)	15 (13)	20 (17)	
Oxidants – ozone $\mu g/m^3$ (ppb)	1 hour	160 (82)	-	100 (51)	**160 (82)**	300 (153)	
	8 hour, based on 4th highest annual value, averaged over 3 consecutive years	-	(65) (Brownell et al.)	-	-	-	(50)
	24 hour	-	-	30 (15)	50 (25)	-	
	Annual	-	-	-	30 (15)	-	
Hydrogen sulphide $\mu g/m^3$ (ppb)	1 hour	42 (30)	-	-	-	-	
	24 hour	**8 (6)**	-	-	-	-	

1.5.3 On Island Emission Sources

Because of the need to provide power, space heating, water heating and cooking facilities it was necessary to install generators, furnaces and cooking appliance infrastructure on Sable Island to meet this requirement. Because of the anticipated impact on air quality measurements from these heating appliances and power generators they were situated as far away as possible to the East of the air chemistry building (per. comm. Gerry Forbes, 2013). The combustion sources on Sable Island include:

- Generators
- All purpose utility vehicle & vehicle garage
- Furnace at Operations building
- Furnace at the staffhouse
- Furnace at the OIC house
- Furnace at the Triplex

1.6 RESULTS

This section covers data analysis results, graphing and additional analysis results related to the assessment of air quality on Sable Island.

1.6.1 2013 Air Quality Data

Table 4 contains the descriptive statistics and data completeness for 2013 air pollutant metrics for the hourly non-QA/QC'd data. Table 5 contains the descriptive statistics and data completeness for 2013 air pollutant metrics for the hourly QA/QC'd data.

Table 4. Descriptive statistics and data completeness for hourly non-QA/QC'd 2013 air pollutant metrics

Metric	n	Mean	Std Dev	Max	99pct	98pct	95pct	75pct	Median	25pct	Min	Data Completeness (Year)
NO_2 *[ppb]*	2358	0.15	0.49	13.4	1.94	1.4	0.7	0.1	0	0	0	26.92%
NO_x *[ppb]*	2414	0.20	0.73	27.1	2.3	1.5	0.8	0.2	0	0	0	27.56%
NO *[ppb]*	3565	0.08	0.25	13.6	0.5	0.4	0.2	0.1	0	0	0	40.70%
SO_2 *[ppb]*	5298	0.17	0.17	3	0.6	0.5	0.4	0.3	0.1	0	0	60.48%
H_2S *[ppb]*	3199	0.80	1.69	78	3.7	3.5	3.3	1.4	0.3	0.1	0	36.52%

pct = percentile
Note: non-QA/QC'd SO_2 was included to show the importance of using QA/QC'd data for analysis

Table 5. Descriptive statistics and data completeness for hourly QA/QC'd 2013 air pollutant metrics

Metric	n	Mean	Std Dev	Max	99pct	98pct	95pct	75pct	Median	25pct	Min	Data Completeness (Year)	Data Completeness (Time Active)
SO_2 *[ppb]*	4038	0.13	0.10	1.6	0.5	0.4	0.3	0.2	0.1	0.1	0	46.10%	-
$PM_{2.5}$ *[μg m^{-3}]*	4655	8.51	5.59	110.2	25.83	23	18.7	11	7.7	4.7	0	53.14%	-
O_3 *[ppb]*	8686	33.59	7.59	61.1	50.2	48	45.6	38.8	33.4	29.1	4.9	99.16%	-
BC *[μg m^{-3}]*	5507	0.08	0.14	3.48	0.51	0.40	0.28	0.1	0.04	0.02	0	62.87%	96.31%
CH_4 *[ppm]*	4404	0.48	0.83	2.12	2.06	2.05	2.04	0.66	0	0	0	46.16%	70.72%
NMHC *[ppm]*	4404	0.33	0.17	2.02	0.99	0.91	0.76	0	0	0	0	46.16%	70.72%
Total VOC *[ppm]*	4404	1.02	1.60	8.04	4.12	4.10	4.07	1.99	0	0	0	46.16%	70.72%

pct = percentile

It is important to understand that analysis drawn from non-QA/QC'd data can be highly different from QA/QC'd data sets. For example, when comparing SO_2 concentrations in Tables 4 and 5 the observed maximums, percentile values, and data completeness are different although for some points seem similar. However, when comparing the SO_2 QA/QC'd and non-QA/QC'd data in a time series plot they appear largely different (to be discussed further later in the report). This being said, it can be seen that the data completeness for the year for all the non-QA/QC'd data in Table 4 is poor for 2013: NO_x (27.56%), NO_2 (26.92%), NO (40.70%), and H_2S (36.52%). This is a factor of the difficulties gaining access to the Island due to intermittent flights and bad weather. This is a major challenge conducting any of the air quality measurements on the Island and is entirely out of the control of NSE, Air Quality Section and Dr. Gibson's research group.

For the QA/QC'd hourly data in Table 5 it is observed that data completeness for the year was excellent for O_3 (99.16%) during 2013; the O_3 analyzer is the most robust of all of the instruments on the Island. The remaining data completeness for the year was poor for 2013: SO_2 (46.10%), $PM_{2.5}$ (53.14%), BC (62.87%), CH_4 (46.16%), NMHC (46.16%), and total VOC (46.16%). When annual data completeness is below 75% NAPS do not use the data for seasonal comparisons. When the data completeness drops below 75% it impairs robust seasonal statistical analysis of the data. As can be seen in Tables 4 and 5 the mean (minimum : maximum) NO_x concentration was 0.2 (0.0 : 27.1) ppb; SO_2 0.13 (0.0 : 1.6) ppb; H_2S 0.8 (0.0 : 78.0) ppb; $PM_{2.5}$ 8.51 (0.0 : 110.2) μg/m^3; O_3 33.59 (4.9 : 61.1) ppb; BC 0.08 (0.0 : 3.5) μg/m^3; CH_4 0.48 (0.0 : 2.1) ppm; NMHC 0.33 (0.0 : 2.0) ppm; and total VOC 1.02 (0.0 : 8.0) ppm. All but O_3 recorded minimums with a concentration of 0.0 ppb/ μg/m^3.

The Thermo 5012 BC analyzer and the Thermo 55i total VOC analyzer (total VOC includes CH_4 and NMHC), were both deployed to Sable Island in March 2013 and began recording data in May 2013. Therefore, these data sets are incomplete for the year, but their data completeness for their time active is adequate thus far: BC (96.31%), CH_4 (70.72%), NMHC (70.72%), and total VOC (70.72%). The reason for the drop in data completeness for the total-VOC and CH_4 is that gas delivery to the Island was difficult and personnel to re-start the instrument have not been able to gain access to the Island due to bad weather. The need for gas generators for the Thermo 55i total-VOC and CH_4 instrument is becoming acutely apparent.

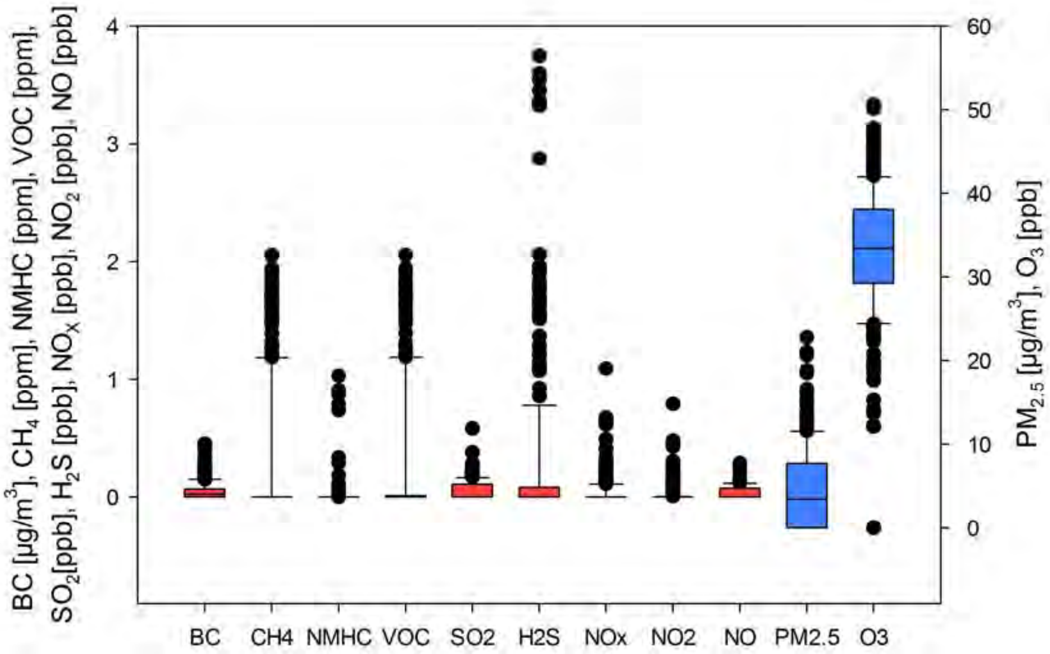


Figure **3**

Figure 3 provides a non-parametric visualization (box-whisker plot) of the daily average air pollution data for 2013. Box plots provide insight into the central tendency, variance and range of data by means of a non-parametric visualization.

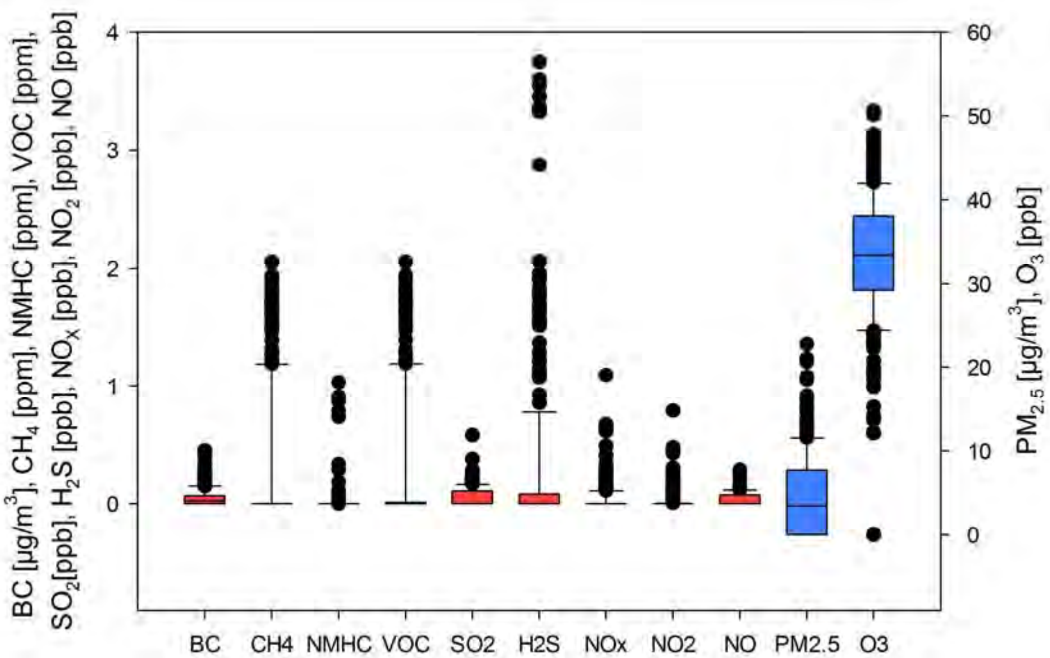


Figure 3. Box-whisker plot of the daily average air pollution data for 2013

Figure 3 shows that the greatest variability was seen within the $PM_{2.5}$ and O_3 2013 daily average observations, with the remaining pollutant data having significantly less variability. The remaining pollutant data sets have little variance in comparison, as their inter-quartile ranges are small and less than one ppb/ppm/µg m^{-3}. Of the remaining data, H_2S displays the largest outlying values from its inter-quartile range, while CH_4 and total VOC display the second largest. BC, NMHC, SO_2, NO_X, NO_2, and NO all display little variance with outliers not straying far from their inter-quartile ranges.

Figure 4 provides a time series plot of the available NO, NO_2 and NO_x daily average data for 2013.

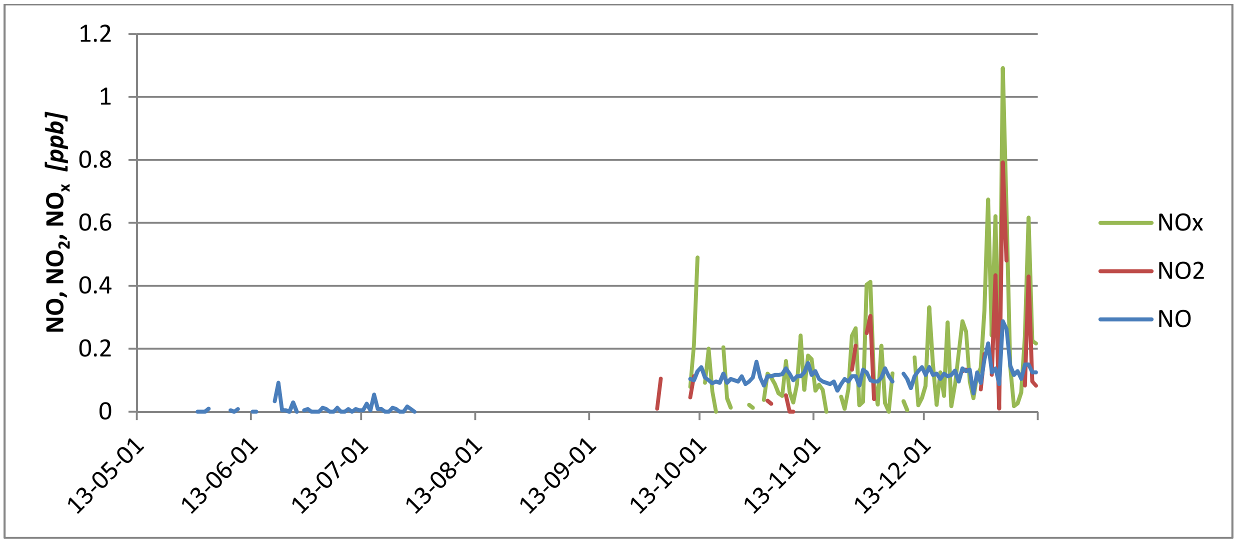


Figure 4. Time series plot of the available NO, NO_2 and NO_x daily average data for 2013

The time series shown in Figure 4 has a low data completion however it shows a relatively steady trend in NOx October through December, with periodic 'spikes' occurring throughout this period with multiple spikes clustered in mid-December. There is one NO_x spike, one NO_2 spike and two NO spikes in the data above where the daily average concentrations are greater than 3 standard deviations above their mean daily average concentration. These spikes are investigated later in Section 1.6.4. It is important to note that the data completeness for NO, NO_2 and NO_X is too low to draw accurate seasonal conclusions for their concentrations on Sable Island.

Figure 5 provides a time series plot of the available SO_2 daily average data for 2013.

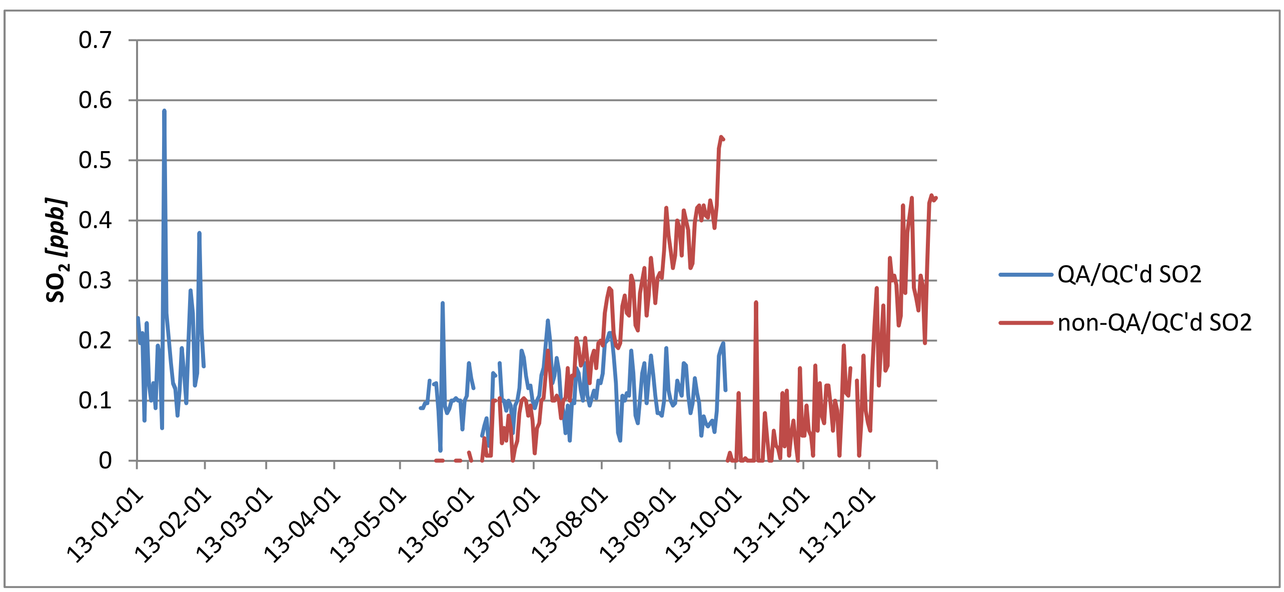


Figure 5. Time series plot of the available SO_2 daily average data for 2013

SO_2 is related to the combustion of sulfur containing fuels. The SO_2 is either from coal burning power plants in Nova Scotia, power plants in eastern US, ship emissions or O&G production around Sable Island. Figure 5 shows both the QA/QC'd and non-QA/QC'd SO_2 concentration data for 2013 on Sable Island. In the QA/QC's data, 'spikes' are observed in January, and then a relatively stable trend is observed from May through September. The non-QA/QC's data displays increasing concentrations from June through September, and then again from October through December. This illustrates the importance in using QA/QC'd data when drawing analytical conclusions. While in many cases data sets are only slightly shifted when QA/QC'd allowing conclusions on general trends and 'spikes' to be drawn, this is not always the case as shown in Figure 5. The large difference in data values for SO_2 in Figure 5 may be the resultant of a pulsed fluorescence data drift in the SO_2 analyzer.

For the remainder of the report only the QA/QC'd data will be analyzed for SO_2. There are two spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. These spikes are later investigated in Section 1.6.4. It is important to note that the data completeness for SO_2 is too low to draw accurate seasonal conclusions for SO_2 concentrations on Sable Island.

Figure 6 provides a time series plot of the available $PM_{2.5}$ daily average data for 2013.

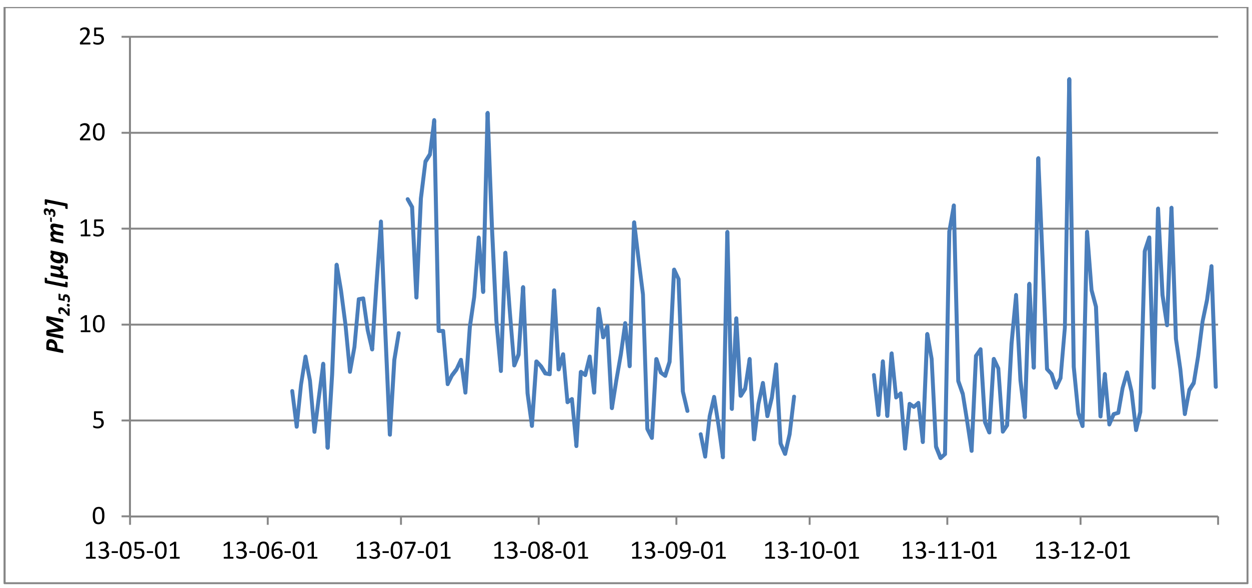


Figure 6. Time series plot of available $PM_{2.5}$ daily average data for 2013

The time series plot of $PM_{2.5}$ shown in Figure 6 shows highest daily average concentrations in July and November. There are three spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. These spikes are later investigated in Section 1.6.4. It is important to note that the data completeness for $PM_{2.5}$ is too low to draw accurate seasonal conclusions for $PM_{2.5}$ concentrations on Sable Island.

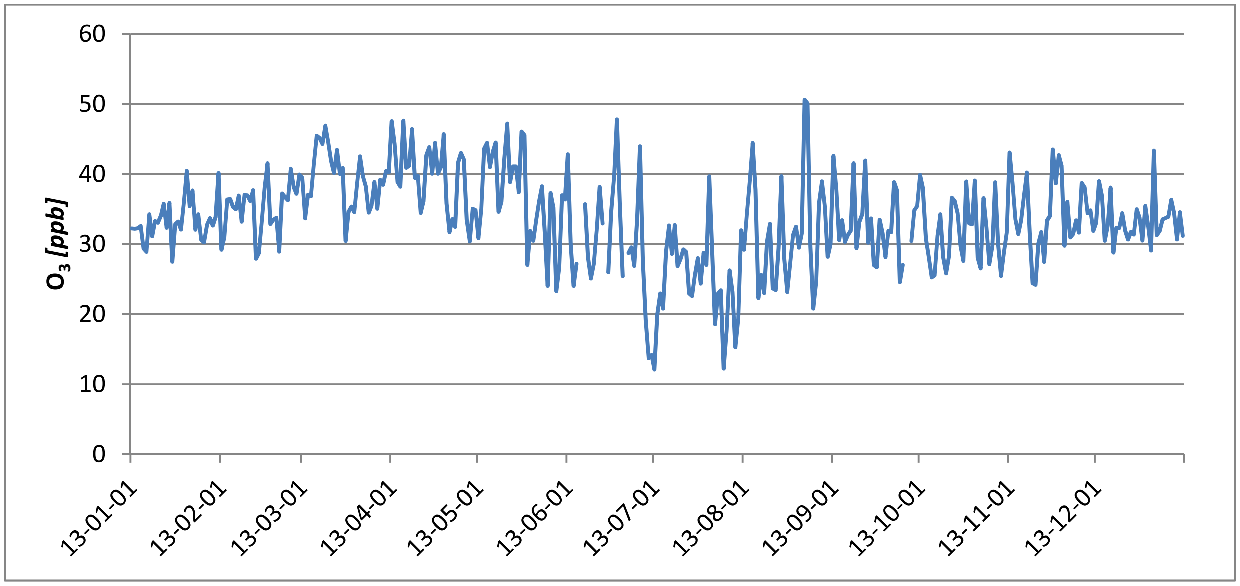


Figure 7 provides a time series plot of the available O_3 daily average data for 2013.

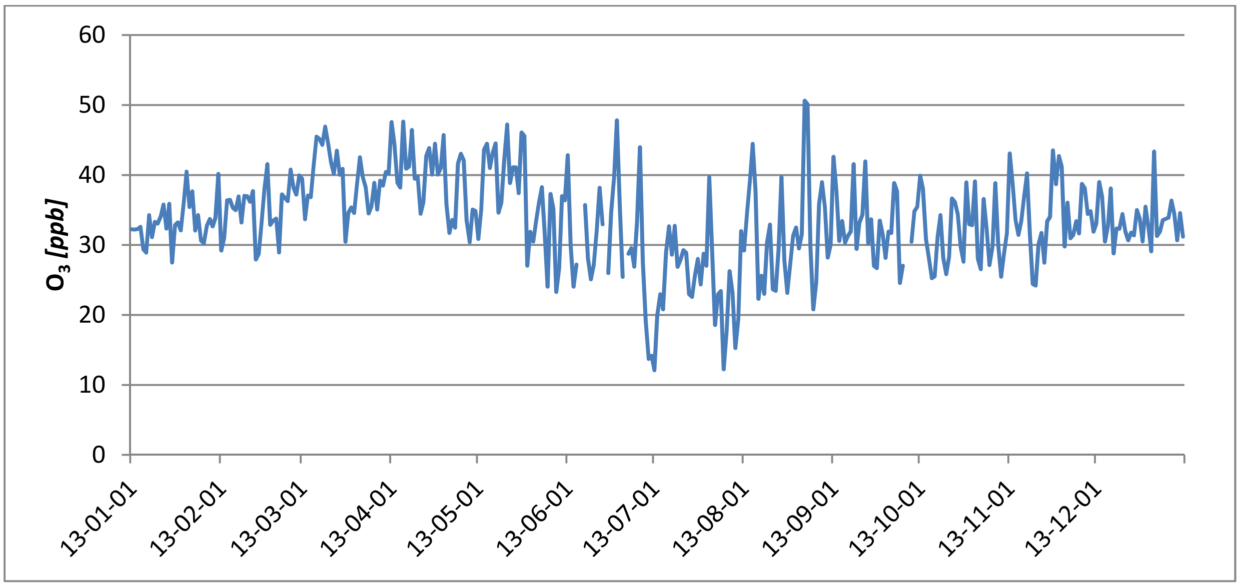


Figure 7. Time series plot of the available O_3 daily average data for 2013

The annual spring maximum O_3 concentration is typically in mid-March (Gibson et al., 2009a), but Figure 7 shows the maximum concentration was a little later in 2013 centered around April. Figure 7 also displays characteristic episodic spikes during the summer due to LRT smog outflow and forest fires from the continent and an increase in O_3 during the winter due to a reduce ceiling height and air pollution outflow from the NA continent (Gibson et al., 2009a). There are no spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration.

Since O_3 is a secondary air pollutant that takes many hours to form it is probably not related to O&G production around Sable Island but rather associated with smog outflow from the mainland. However, under stagnant, high pressure synoptic conditions, it is possible that there may be O_3 production on the Scotian Shelf from primary gases (terpenes) produced by phytoplankton that react with combustion related NO_x from the O&G production activity to produce O_3. Alternatively, the primary NO_x and VOCs produced by O&G production may themselves produce additional O_3, or a combination of these natural and man-made processes together would cause an increase in O_3. The latter changing in magnitude and direction both diurnally and as the season's progress. The ESRF study will investigate if this natural-man made O_3 formation coupled process is indeed occurring.

Figure 8 provides a time series plot of the available H_2S daily average data for 2013.

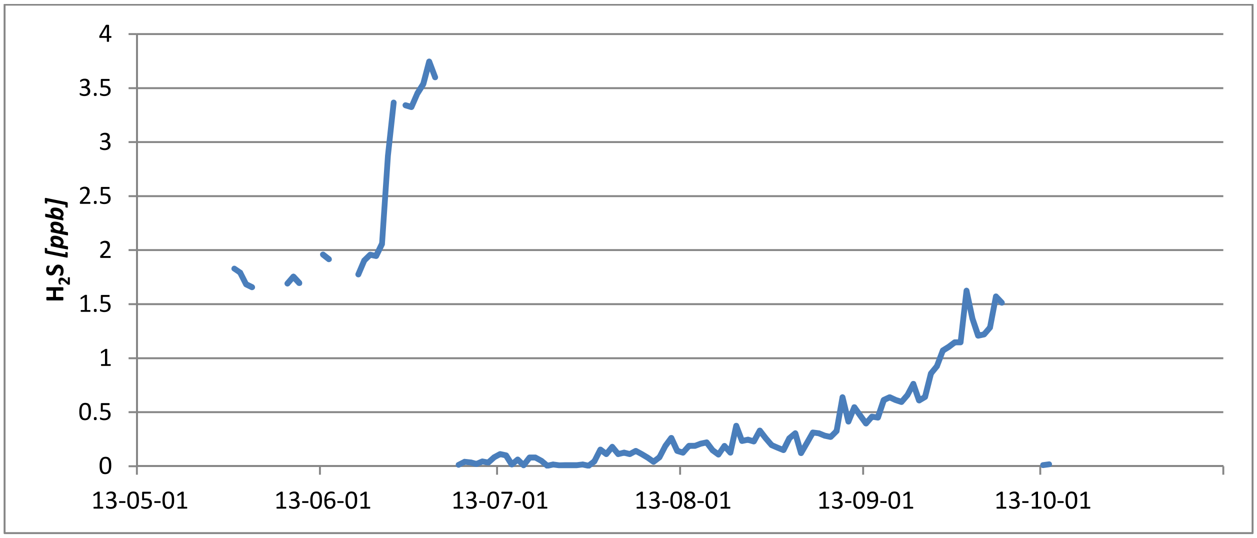


Figure 8. Time series plot of the available H_2S daily average data for 2013

Figure 8 shows a slow increase in daily average H_2S concentrations from July through September, with sporadic spikes from May to June. However, the data completeness is too low to draw accurate seasonal conclusions. The increasing trend from July through September may also be the resultant of a pulsed fluorescence data drift. From this data there are two spikes where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. These spikes are later investigated in Section 1.6.4.

Figure 9 provides a time series plot of the available black carbon daily average data for 2013.

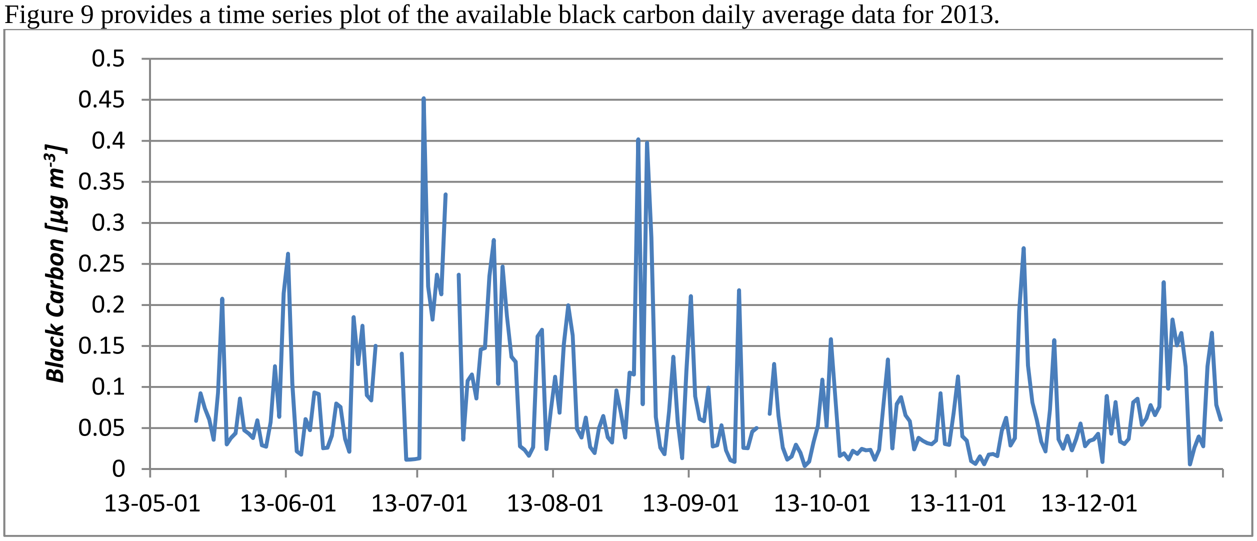


Figure 9. Time series plot of the available black carbon daily average data for 2013

The time series plot for BC shown in Figure 9 shows the largest black carbon pollutant concentrations occurring in the summer from July through August compared to the remaining data. There are four spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. These spikes are later investigated in Section 1.6.4. It is important to note that the data completeness for BC is too low to draw accurate seasonal conclusions for BC concentrations on Sable Island.

Figure 10 provides a time series plot of the available CH_4 daily average data for 2013.

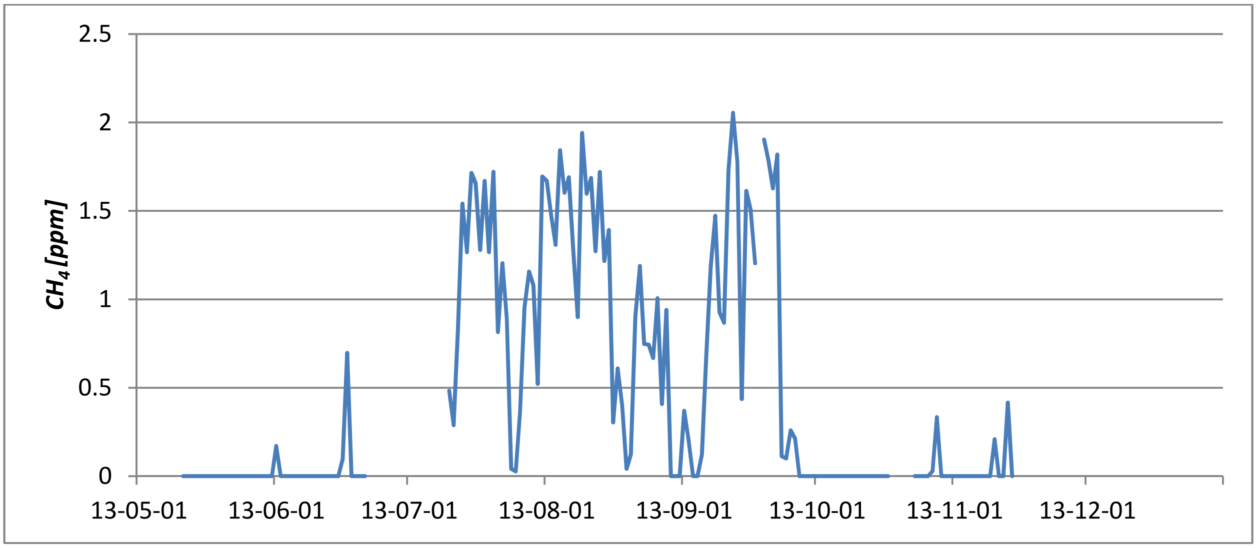


Figure 10. Time series plot of the available CH_4 daily average data for 2013

The time series plot of CH_4 shown in Figure 10 displays a concentration range of data with no noticeable abnormal spikes. There are no spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. It is important to note that the data completeness for CH_4 is too low to draw accurate seasonal conclusions for CH_4 concentrations on Sable Island.

Figure 11 provides a time series plot of the available NMHC daily average data for 2013.

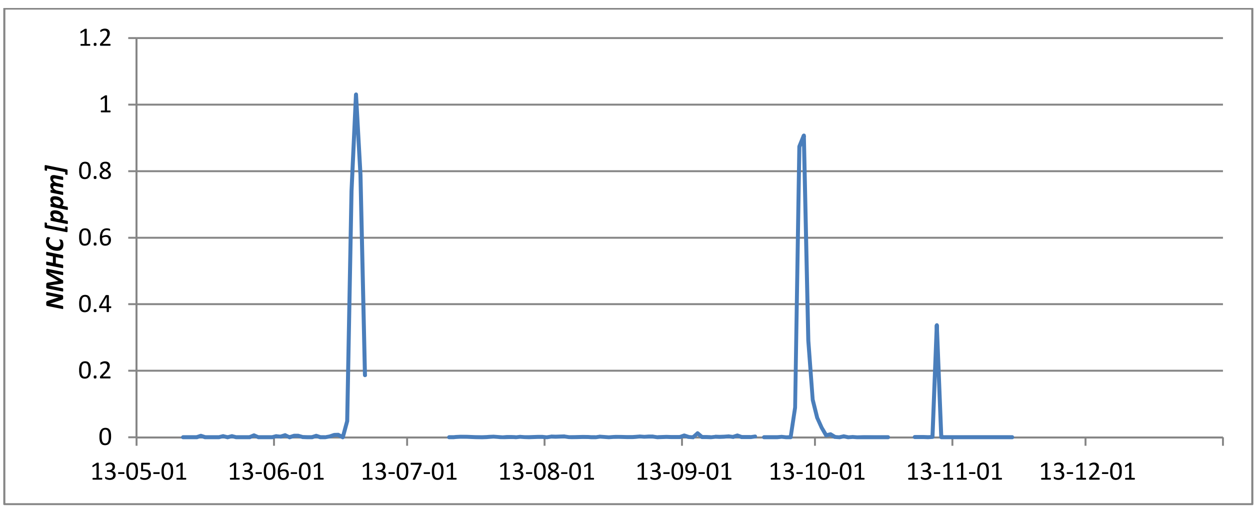


Figure 11. Time series plot of the available NMHC daily average data 2013

The time series plot of NMHC shown in Figure 11 displays daily average concentrations that occur mostly around 0 ppm. There are five days in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration of 0.49 ppm. These spikes are later investigated in Section 1.6.4. There is a sixth spike in the data that is below 0.49 ppm that occurred on October 28th. This spike was included in the Section 1.6.4

investigation as it is a visible outlier in the time series plot above. It is important to note that the data completeness for NMHC is too low to draw accurate seasonal conclusions for NMHC concentrations on Sable Island.

Figure 12 provides a time series plot of the available total VOC daily average data for 2013.

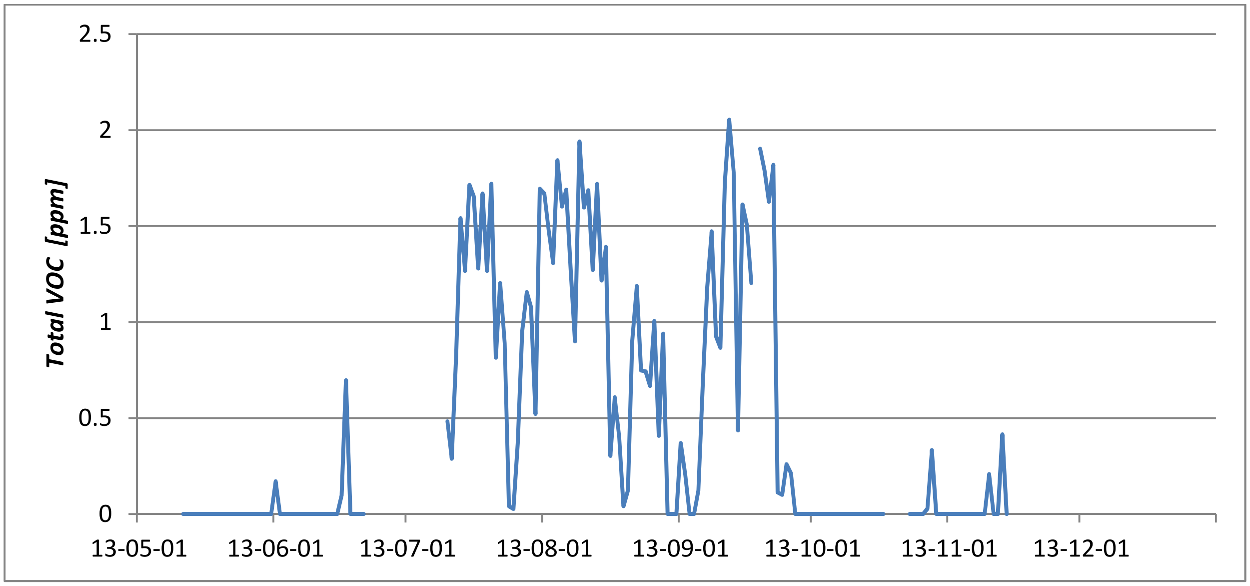
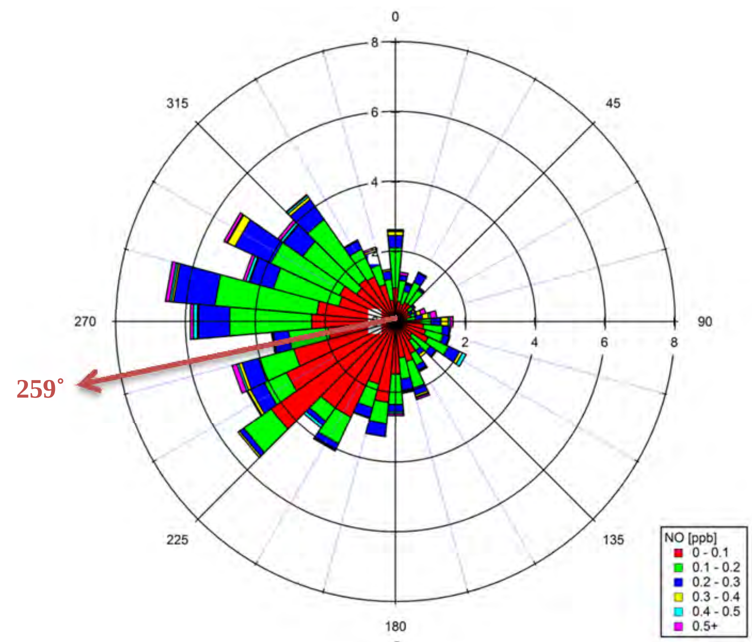
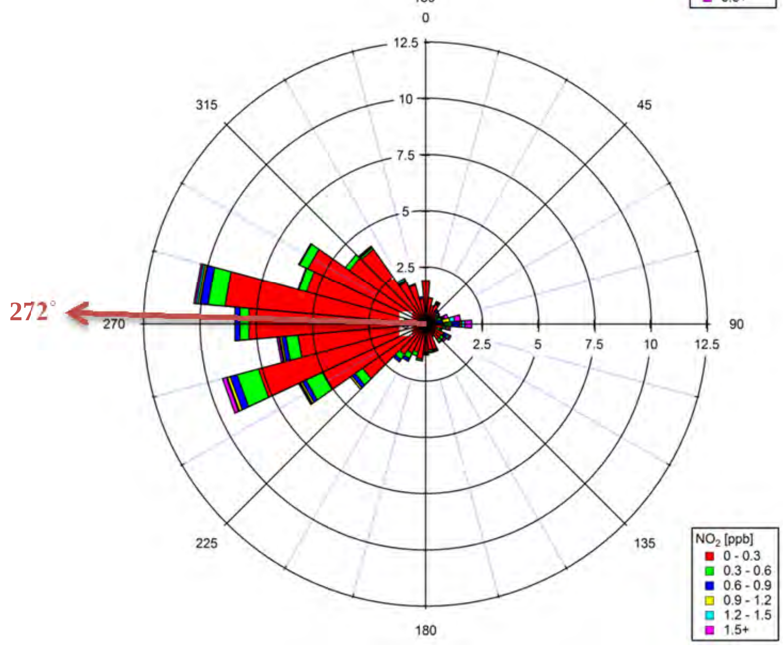


Figure 12. Time series plot of the available total VOC daily average data 2013

The time series plot of total VOC shown in Figure 12 displays a concentration range of data with no noticeable abnormal spikes. There are no spikes in the data above where the daily average concentrations are greater than 3 standard deviations above the mean daily average concentration. It is important to note that the data completeness for total VOC is too low to draw accurate seasonal conclusions for total VOC concentrations on Sable Island.

Figure 13 shows a pollution rose for NO, NO_2 and NOx in 2013. The average NO, NO_2 and NO_X vectors for 2013 were 259°, 272°, and 279° respectively.


0
8
6
4
2
315
45
270
90
2
4
6
8
259°
225
135
180
NO [ppb]
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5+


0
12.5
10
7.5
5
2.5
315
45
272°
270
90
2.5
5
7.5
10
12.5
225
135
180
NO2 [ppb]
0 - 0.3
0.3 - 0.6
0.6 - 0.9
0.9 - 1.2
1.2 - 1.5
1.5+

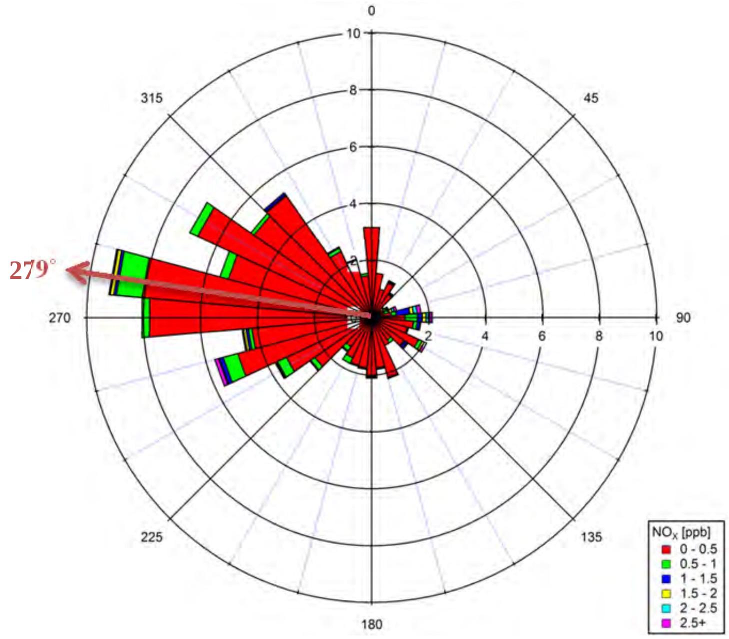


Figure 13. Pollution rose for NO, NO_2 and NO_X in 2013

The NO_x pollution roses show an Easterly and South Westerly directional dependence for NO_X concentrations above 2.5 ppb, which is in line with the Venture, South Venture, Thebaud, Deep Panuke (online by July 22nd 2013), and Alma O&G platforms. However, the majority of the on-island combustion sources were purposely located to the East of the air quality monitoring instruments. Therefore, it is possible that the increased NO_x associated with Easterly winds is related to on Island NOx emissions and not the platforms. Further monitoring located between the on-island combustion sources and the Venture platforms under Easterly airflow would be one way to confirm this. In future, source apportionment of VOC species and $PM_{2.5}$ species would offer a robust method to identify the Easterly wind directional dependence of NO_x and associated air pollutants. It is hoped the recently funded ESRF funded project (led by Drs' Gibson and Craig) will be able to identify and quantify the source contribution of the on-island and off-island combustion sources.

Figure 14 shows a pollution rose for SO_2 in 2013. The average SO_2 vector for 2013 was 234˚.

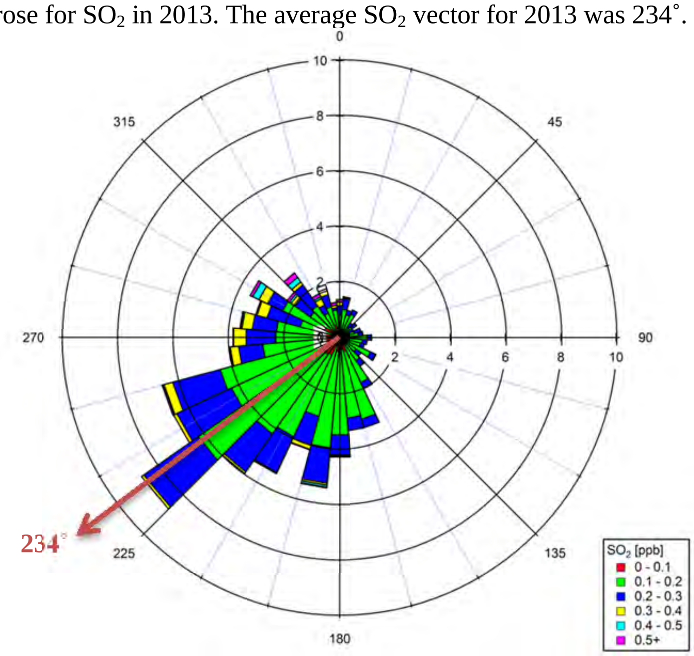


Figure 14. Pollution rose for SO_2 in 2013

The SO_2 pollution roses show a North to North Westerly wind directional dependence for SO_2 concentrations above 0.5 ppb, which not in line with any O&G platforms. As SO_2 is related to the combustion of sulfur containing fuels, the northerly dependence may be either from coal burning power plants in Nova Scotia or ship emissions.

Figure 15 shows a pollution rose for $PM_{2.5}$ in 2013. The average $PM_{2.5}$ vector for 2013 was 244°.

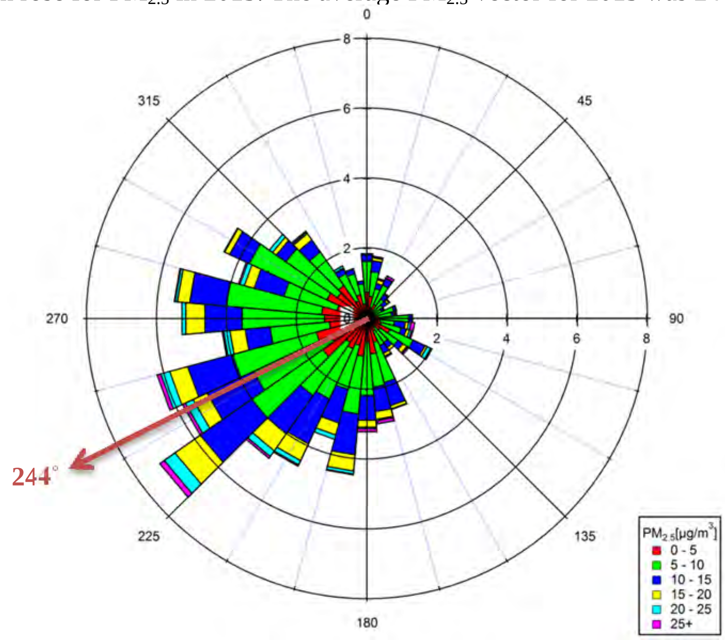


Figure 15. Pollution rose for $PM_{2.5}$ in 2013

The $PM_{2.5}$ pollution rose shown in Figure 15 demonstrates a spread directional dependence from the SW to S and additionally the East for $PM_{2.5}$ concentrations above 25 µg/m^3. The SW and S directions are in line with the Thebaud, Alma, Deep Panuke (online by July 22nd 2013), and North Triumph platforms. To the East are the Venture and South Venture platforms and on-island combustion sources. However, further analysis of air mass back trajectories, facility operations, on-Island operations and $PM_{2.5}$ chemistry is required before associating the $PM_{2.5}$ directional dependence to a particular source. The directional dependence is also approximately in line with the 2013 prevailing wind (256° ~ WSW) from the NA continent and could simply be long-range continental $PM_{2.5}$ sources impacting the Island or sea spray $PM_{2.5}$ during stormy weather.

Figure 16 shows a pollution rose for O_3 in 2013. The average O_3 vector for 2013 was 255°.

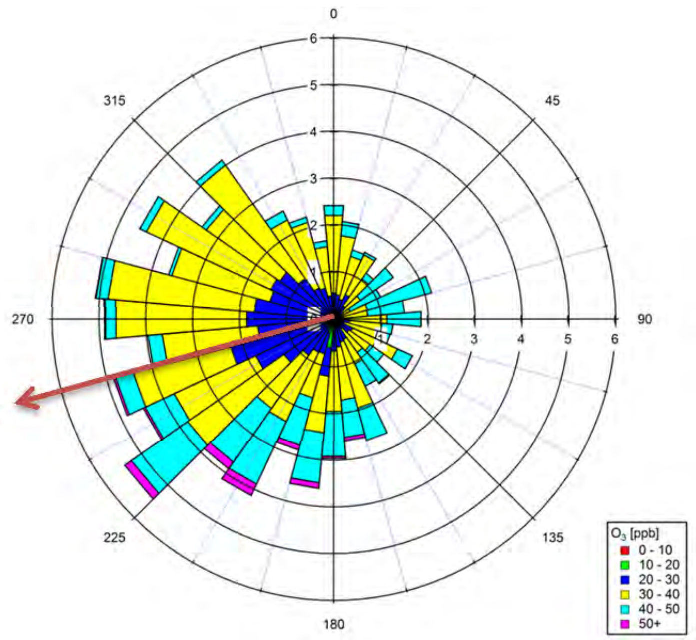


Figure 16. Pollution rose for O_3 in 2013

The pollution rose in 5 shows a spread directional dependence between SW and S directions for O_3 concentrations > 50 ppb. As O_3 is a known LRT air pollutant it is likely not to be related to any O&G production activity.

Figure17 shows a pollution rose for H_2S in 2013. The average H_2S vector for 2013 was 228°.

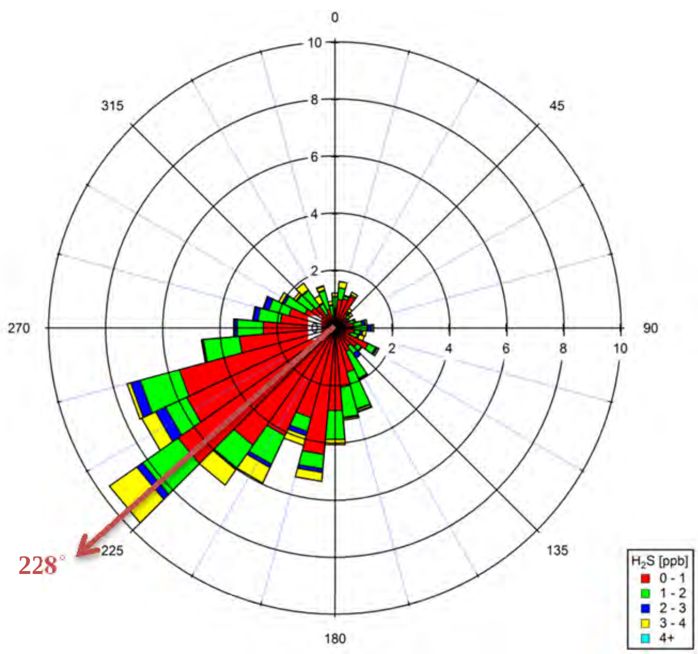


Figure 17. Pollution rose for H_2S in 2013

The pollution rose in Figure 17 shows strong WSW to S directional dependence for H_2S concentrations > 4 ppb, with some Northerly dependence. The WSW to S directions are in line with the Thebaud, Alma, Deep Panuke (online by July 22nd 2013), and North Triumph platforms.

Figure 18 shows a pollution rose for BC in 2013. The average BC vector for 2013 was 241°.

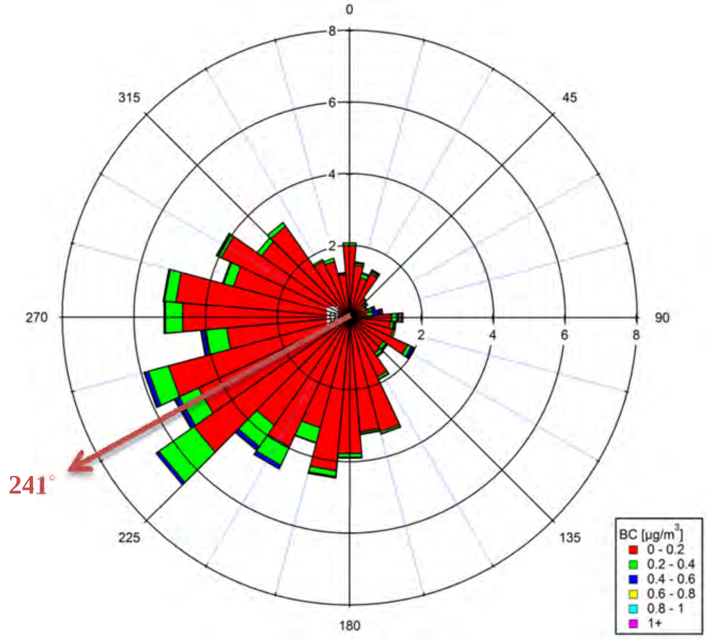


Figure 18. Pollution rose for BC in 2013

The BC pollution rose shown in Figure 18 shows an Easterly directional dependence for BC concentrations above 1 µg/m³. The Easterly direction is in line with the Venture and South Venture O&G platforms, and on-island combustion sources. Further monitoring located between the on-island combustion sources and the Venture platforms under Easterly airflow would be one way to differentiate these sources.

Figure19 shows a pollution rose for CH_4 in 2013. The average CH_4 vector for 2013 was 234°.

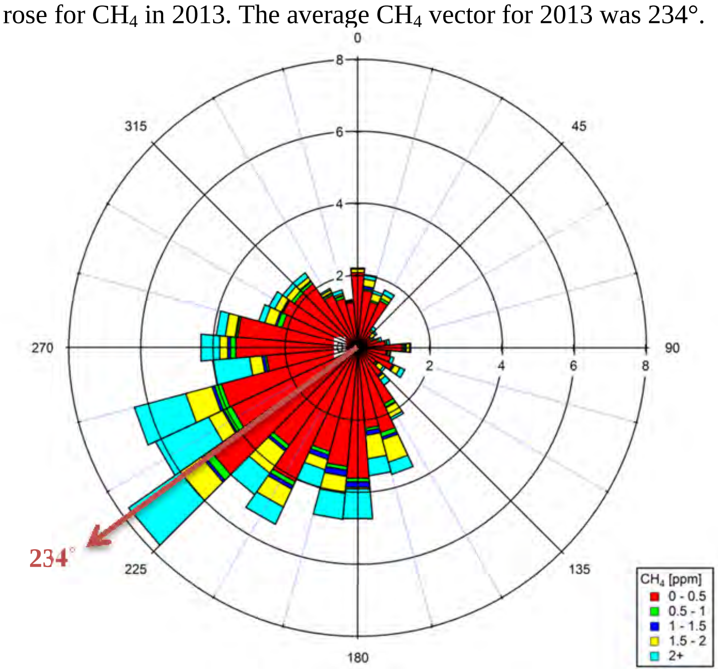


Figure 19. Pollution rose for CH_4 in 2013

The CH_4 pollution rose shown in Figure 19 demonstrates a spread directional dependence from the W to S, for CH_4 concentrations above 2 ppm. The W to S directions are in line with the Thebaud, Alma, Deep Panuke (online by July 22nd 2013), and North Triumph platforms.

Figure 20 shows a pollution rose for NMHC in 2013. The average NMHC vector for 2013 was 234°.

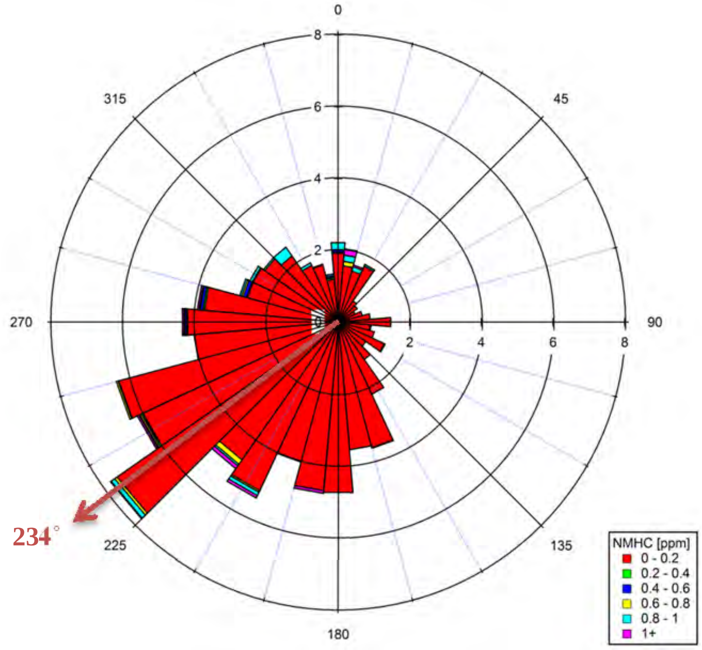


Figure 20. Pollution rose for NMHC in 2013

The NMHC pollution rose shown in Figure 20 demonstrates a spread directional dependence from the SW to SSW, W and N for NMHC concentrations above 1 ppm. The W, and SW to S direction is in line with the Thebaud, Alma, Deep Panuke (online by July 22nd 2013), and North Triumph platforms. There are no platforms to the North.

Figure 21shows a pollution rose for total VOC in 2013. The average total VOC vector for 2013 was 234°.

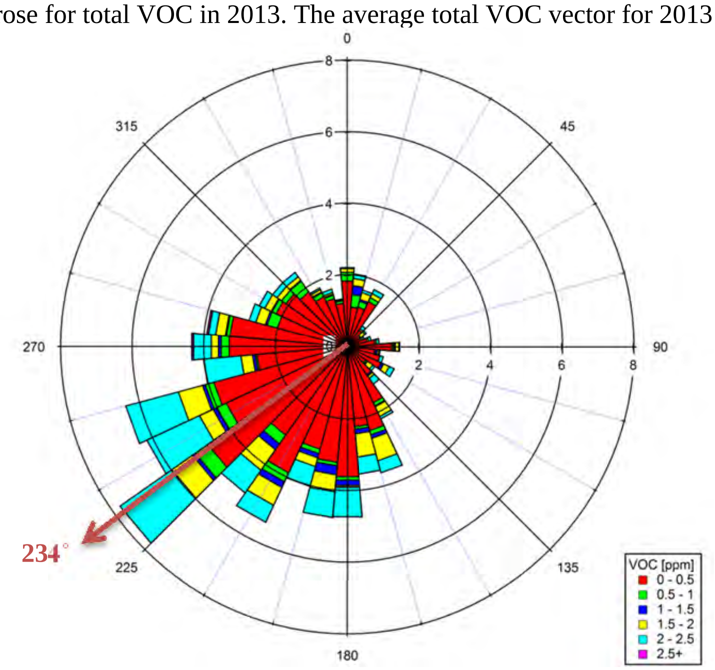


Figure 21. Pollution rose for total VOC in 2013

The total VOC pollution rose shown in Figure 21 demonstrates a spread directional dependence from the W to S directions for total VOC concentrations between 2-2.5 ppm, and a Westerly directional dependence for concentrations above 2.5 ppm. The W to S direction is in line with the Thebaud, Alma, Deep Panuke (online by July 22nd 2013), and North Triumph platforms.

1.6.2 Air Emission Spike Thresholds and Threshold Breaches

Air emission monitoring thresholds values were calculated by Dr. Mark Gibson (Dalhousie University) in consultation with Encana and Exxon Mobil. The threshold values were calculated using extreme value analysis. These thresholds were established for monitoring purposes to identify possible "spikes" in air emissions parameters on Sable Island that could be related to O&G production operations. They are not regulatory thresholds, and are well below any international/Canadian/provincial health impact thresholds (see Table 6). A spike is not a reportable incident but only indicates that an air parameter is above typical background levels. All spikes are investigated to determine if they are related to O&G operations near to Sable Island. Investigations include air mass back-trajectory analysis and pollution rose analysis to determine the long-range and local upwind sources respectively. Table **6** provides the threshold values chosen for the air emission evaluation of O&G operations.

Table 6. Air emission 'spike' thresholds for Sable Island

Metric	**Reference: extreme value analysis (1-hr data period)** [1]	**Suggested threshold value (1-hr)**	**Canada Ambient Air Quality Objectives**
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 µg/m^3	120 µg/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 Q1/2015 (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

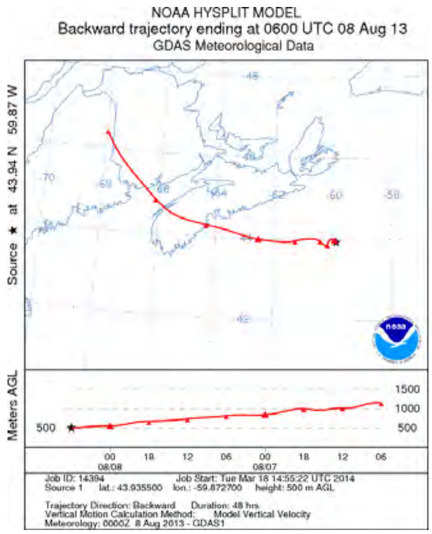
H_2S, the Nova Scotia 1-hr ground-level concentration threshold was used because a CAAQO threshold was not available. The ozone "spike" threshold is higher than the CAAQO threshold because of historical elevated ozone levels in the area.

Table 7 below summarizes the number of hourly spikes that exceeded the selected concentration thresholds.

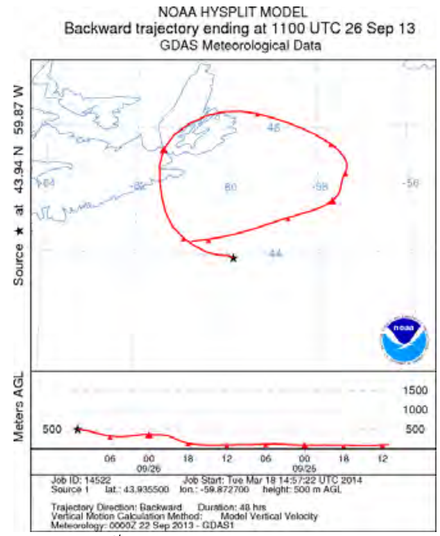
Table 7. Air emission 'spike' thresholds for Sable Island and threshold exceedances in 2013

Metric	Suggested threshold value (1-hr)	Number of spikes over threshold	Total hours over threshold	Date of start of spike	Highest value during spike
NOx	17.0 ppbv	1	1	8 Aug 2013	27.1 ppb
SO_2	6.0 ppbv	0	0		
H_2S (non-QA/QC'd data)	3.11 ppbv	3	211	19 Jun 2013 18 Sep 2013 26 Sep 2013	4 ppb 13.7 ppb 78 ppb
$PM_{2.5}$	168.0 $\mu g/m^3$	0	0		
Ozone	104.0 ppbv	0	0		
Total VOC	TBD in Q1/2015 (ppbv)	0	0		

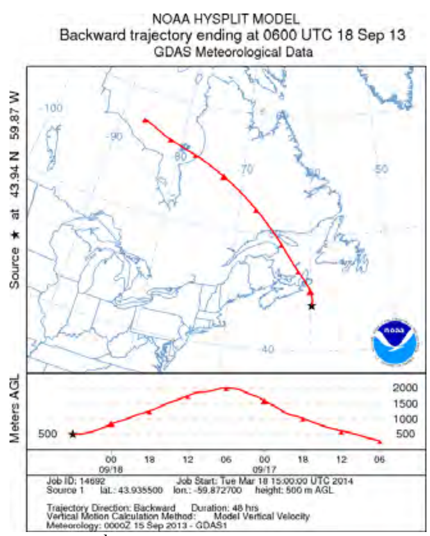
Table 7 shows that there were four events where pollutant concentrations exceeded the selected spike thresholds. There was one NO_X spike event that breached the threshold for one hour. There were three H_2S spike events that breached the threshold for 211 hours in total. However, it is likely the H_2S spikes were due to instrument drift rather than real observations. The NO_x data is also non-QA/QC'd and should be treated tentatively. Figure 22 displays 48-hour back trajectories of the NO_X and H_2S spikes that exceeded the threshold values.



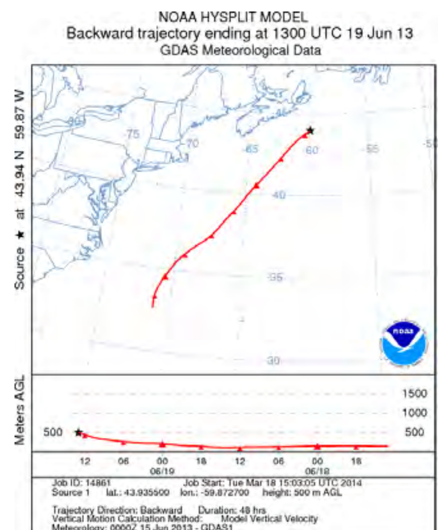
1st highest NO_X (27.1 ppb)



1st highest H_2S (78 ppb)



2nd highest H_2S (13.7 ppb)



3rd highest H_2S (4 ppb)

Figure 22. 2-air mass back trajectories for the NO_X and H_2S spike threshold exceedances for 2013

The back trajectories in Figure 22 reveal four threshold exceedances events in 2013. The back trajectory for the 1st highest NOx on August 8th 2013 comes from the W/NW originating from the mainland. It is therefore unlikely that the NO_x was related to O&G production. The 1st highest H_2S spike on September 26, 2013 does not pass over the vicinities of Thebaud and Deep Panuke platforms and again is unlikely to be related to O&G production. The 2nd highest H_2S concentration has a back trajectory from the Northerly direction which is not in line with any O&G platform. The 3rd highest H_2S concentration on June 19, 2013 has a back trajectory in the SW direction, which passes over the vicinities of the Thebaud, Deep Panuke, and Alma platforms. However, Deep Panuke was not producing during this period and Thebaud and Alma are not sour-gas platforms. Therefore, the H_2S spikes are likely a result of instrument drift and not a result of O&G operations. Neither forest fires were discovered in the back trajectories, nor smog events as satellite images for these dates were unavailable or conditions were cloudy.

1.6.3 Meteorological Analysis

The meteorological data was downloaded from the Environment Canada website (http://climate.weatheroffice.gc.ca/climateData/canada_e.html).

Table 8 provides the descriptive statistics for the meteorological variables for the period January 1, 2013 to December 31 2013.

Table 8. Meteorological Variable Descriptive Statistics for 2013

Variables	n	Mean	Std	Min	25th Pctl	Median	75th Pctl	Max
Temperature (ºC)	8651	8.69	7.51	-11.7	2.5	8.7	15.2	23.3
Dew Point (ºC)	8430	6.01	8.48	-15.2	-0.7	6.7	13.2	21.2
RH (%)	8429	83.10	12.90	42	74	86	94	100
Pressure (kPa)	8649	101.48	0.93	95.94	100.91	101.57	102.12	104.23
Wind speed (m/s)	8662	6.86	3.53	0	4.17	6.11	8.89	26.67
Visibility (km)	8661	9.70	5.46	0	4.8	11.3	15	15

Figure 23 provides a wind rose for 2013. The average wind vector for 2013 was 256°.

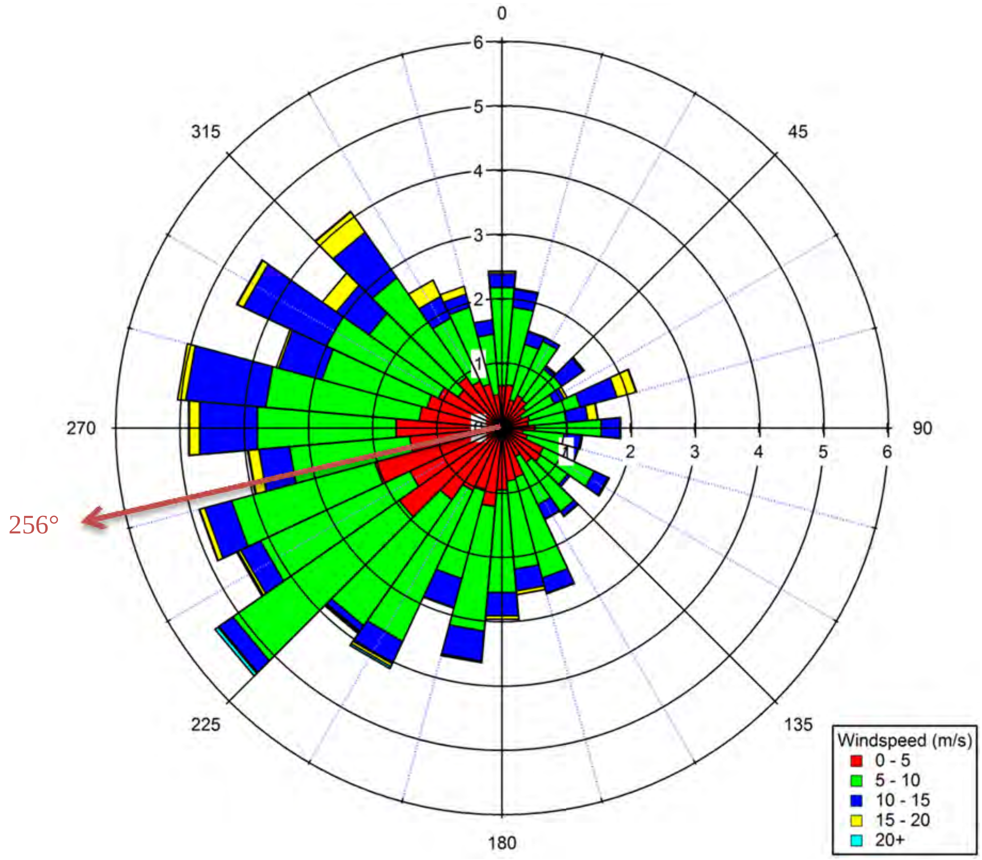


Figure 23. Wind rose for 2013

1.6.4 Investigation of Air Quality Daily Concentrations Above Background

Irrespective of whether there were any air pollution spikes above the threshold levels contained in Table 6, for each year, the concentrations above three standard deviations above the mean of each metric were investigated to determine if the source was related to the O&G production around Sable Island. This was achieved by conducting 2-day air mass back trajectory analysis using the NOAA HYSPLIT product (http://ready.arl.noaa.gov/hysplit-bin/trajasrcm.pl). HYSPLIT was run for elevated episodes during the year that were significantly different from the median background concentration. HYSPLIT was run backwards over 48-hr trajectory. The 48-hr air mass back trajectories can provide evidence for whether the air mass crossed over, and/or in the vicinity of an O&G facility en route to Sable Island, or whether the air mass had tracked from another upwind source region, e.g. NE US or Canadian mainland. InFigure 24 the three 48-hr air mass back trajectories show the track en route to Sable Island (top panel) and the height of the air mass during its trajectory to Sable Island (bottom panel). The latter is important as it provide insight into whether the air mass history was related to upper air or lower boundary layer airflow that crossed over air pollution source regions. Elevated concentrations above the mean background concentrations were found for all pollutants investigated in this report except for O_3, CH_4, and total-VOC as they do not have spikes in their data sets.

Figure 24 provides the back trajectory and concentration associated with the daily average NO_x concentration observed on Sable Island during 2013 that were greater than three standard deviations above the mean. The back trajectories in this investigation section assume the wind direction at 12:00 noon for the daily average concentration. These figures also provide maps of fire locations where applicable from the USDA Active Fire Mapping Program (http://svinetfc6.fs.fed.us/afm/) in Google Earth, and the Canadian Wildland Fire Information System from Natural Resources Canada (http://cwfis.cfs.nrcan.gc.ca/maps/). In addition, MODIS satellite images from the USDA are also included where applicable.

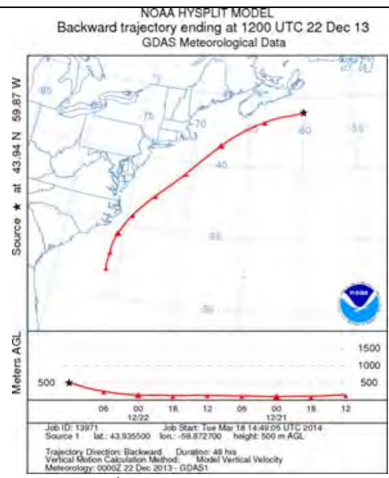
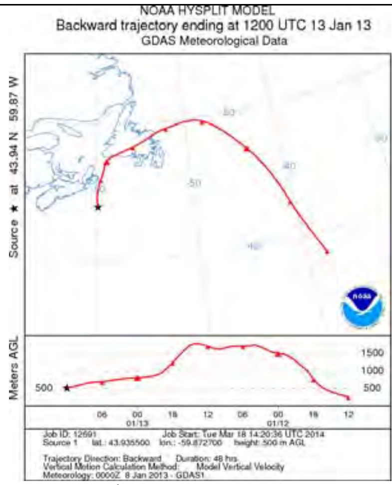
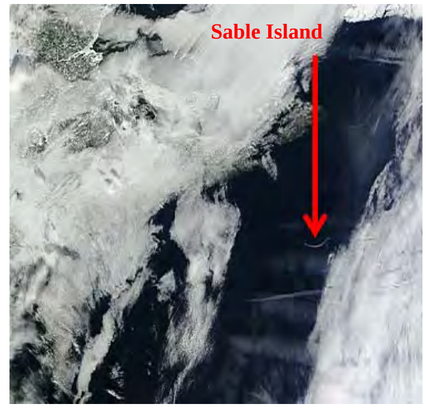
HYSPLIT Back Trajectories	**Fire Maps**	**Satellite Image**
 1st highest 1.09 ppb	NA	No Sable Island satellite image available for this date.

Figure 24. 2-air mass back trajectories for the daily average concentrations above background for NO_X 2013

The back trajectory in Figure 24 reveals that the single NO_x concentration 3-standard deviations from the mean was possibly related to O&G operations. The back trajectory displays that the air parcel was low lying due to a marine inversion prior to reaching Sable Island. It is likely that continental emissions were trapped under the inversion en route to Sable from a SW airflow regime and this being the likely source. As Deep Panuke was not operating during this period it is more likely due to either emissions from the Thebaud platform or LRT from the eastern seaboard of the US. It must be stressed that the NO_x concentration deviations above background are extremely low when compare to Canada Ambient Air Quality Objectives (CAAQO).

Figure 25 shows the back trajectories and concentrations associated with the daily average SO_2 concentrations observed on Sable Island during 2013 that were greater than 3 standard deviations above the mean. These back trajectories assume the wind direction at 12:00 noon for the daily average concentration. Fire maps and satellite images are included where applicable.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 1st highest 0.58 ppb	No fire maps available for this date.	 Clear skies over Sable Island. Cloudy back trajectory.

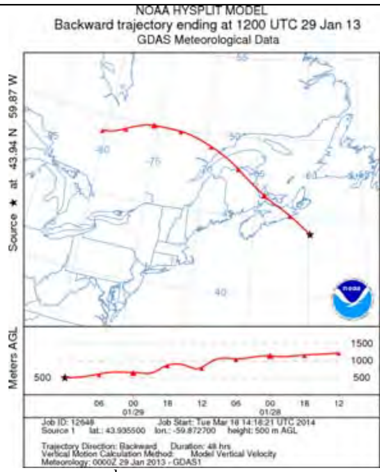
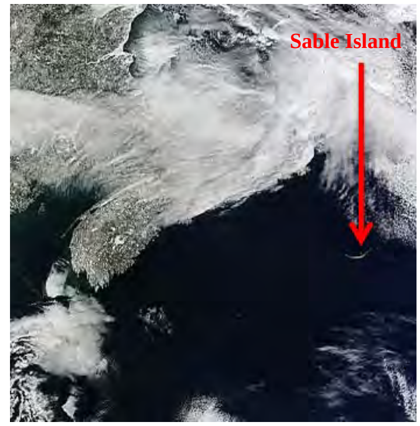
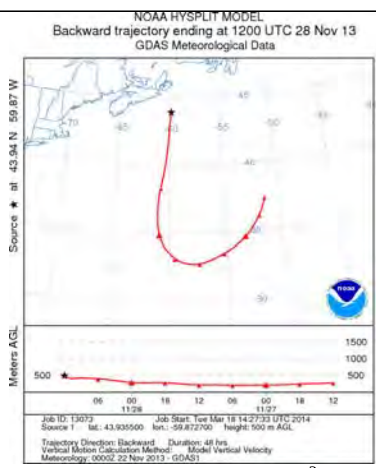
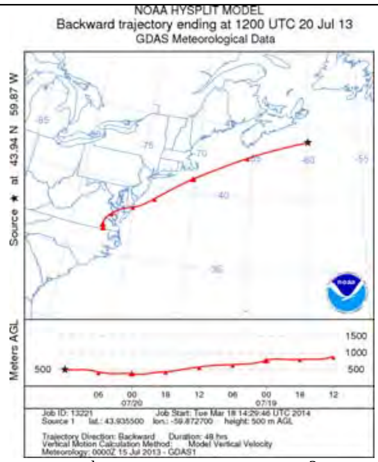
HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 2nd highest 0.38 ppb	No fire maps available for this date.	 Clear skies over Sable Island. Cloudy back trajectory

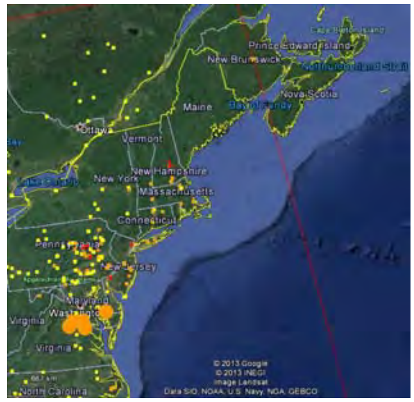
Figure 25. 2-air mass back trajectories for the daily average concentrations above background for SO_2 2013

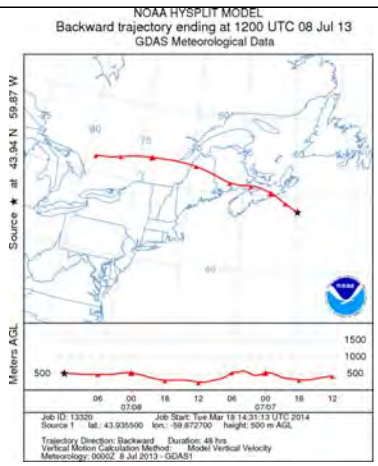
All of the day average SO_2 concentrations are minimal and are not above any concentration restrictions. Upon investigation no fires or smog events were discovered that may have contributed to elevated SO_2 concentration in Sable Island. It can be seen from Figure 25 that the 1st and 2nd highest concentrations do not pass over any of the surrounding Sable Island O&G operations. As SO_2 is related to the combustion of sulfur containing fuels, the northerly dependence may be either from coal burning power plants in Nova Scotia or ship emissions.

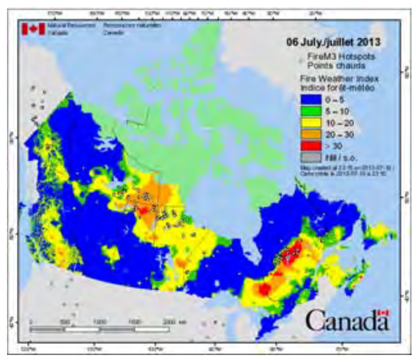
Figure 26 shows the back trajectories and concentrations associated with the daily average $PM_{2.5}$ concentrations observed on Sable Island during 2013 that were greater than 3 standard deviations above the mean. These back trajectories assume the wind direction at 12:00 noon for the daily average concentration. Fire maps and satellite images are included where applicable.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 1st highest 22.79 $\mu g/m^3$	NA	No Sable Island satellite image available for this date.

<table>
<tr><th>HYSPLIT Back Trajectories</th><th>Fire Maps</th><th>Satellite Image</th></tr>
<tr>
<td>

2nd highest 21.03 μg/m³</td>
<td>

USDA: Fires present in back trajectory on July 18, 2013.</td>
<td>
USDA: Cloudy conditions, some fires visible in Virginia (red markers).</td>
</tr>
<tr>
<td>

3rd highest 20.66 μg/m³</td>
<td>

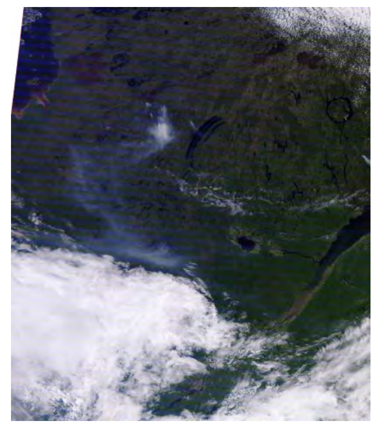
Natural Resources Canada
Numerous fires in Quebec potentially mixing in back trajectory.</td>
<td>
USDA: Quebec fires on July 8th, cloudy conditions on previous dates.</td>
</tr>
</table>

Figure 26. 2-air mass back trajectories for daily average concentrations above background for $PM_{2.5}$ 2013

The 1st highest day average $PM_{2.5}$ is not above the 24-hr NAAQQ of 120 μg/m^3. The back trajectories in Figure 26 reveal that two of the three $PM_{2.5}$ elevated concentration events in 2013 were possibly related to O&G operations. It would appear that the air mass trajectory of the 1st highest average concentrations on November 28, 2013 passed over the vicinity of the North Triumph platform. The air mass trajectory of the 2nd highest average concentration on July 20, 2013 passed over the vicinity of the Deep Panuke and Thebaud platforms. However, further investigation yielded that this event may be contributed by reported fires in Virginia. The air mass trajectory of the 3rd highest average concentration on July 8, 2013 does not have a back trajectory that passes over the vicinity of any O&G platform around Sable Island. It is possible that this event was contributed by continuous forest fires in Quebec in July 2013. It should be noted that it could also be possible that the $PM_{2.5}$ is elevated during all three events due to high sea salt loading. More detailed investigation of O&G operations and the $PM_{2.5}$ chemistry would need to be conducted to confirm this (the latter is out of the scope of this report).

Figure 27 shows the back trajectories and concentrations associated with the daily average H_2S concentrations observed on Sable Island during 2013 that were greater than 3 standard deviations above the mean. These back trajectories assume the wind direction at 12:00 noon for the daily average concentration. Fire maps and satellite images are included where applicable.

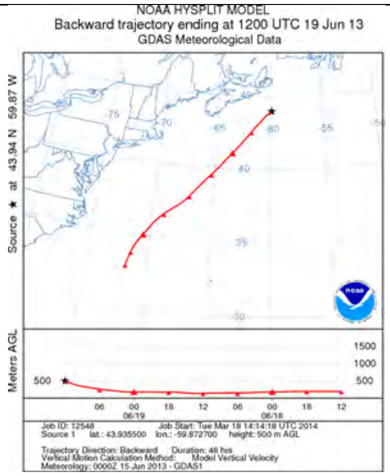
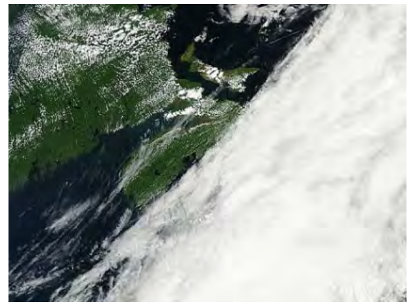
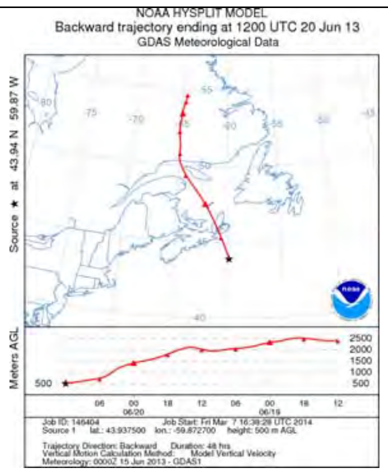
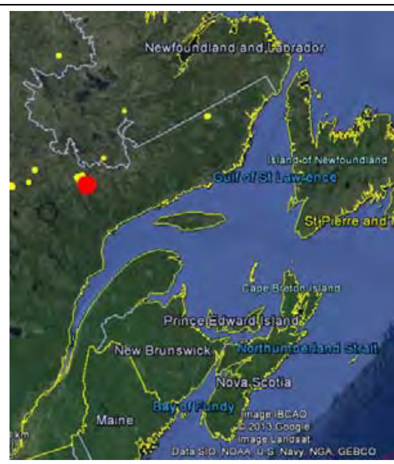
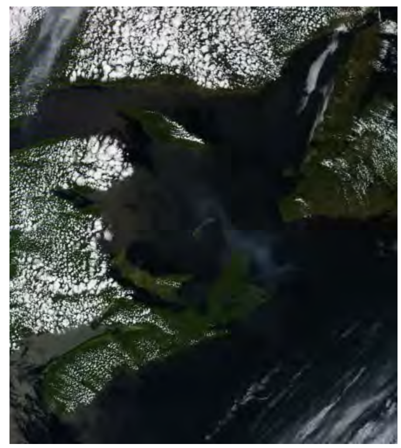
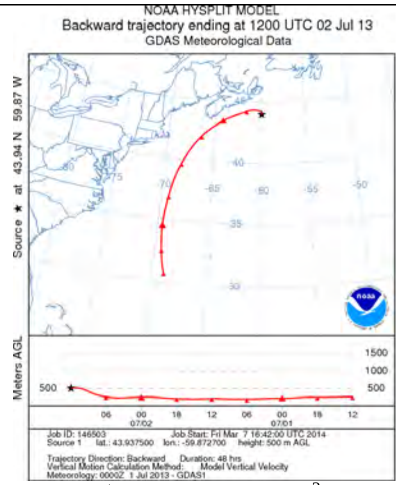
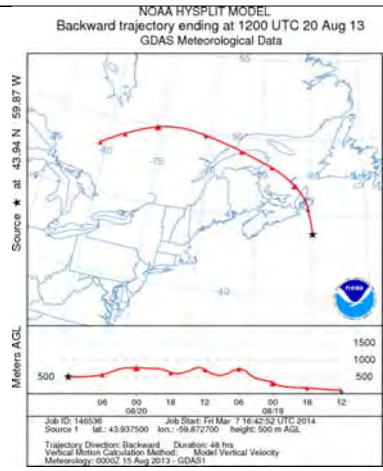
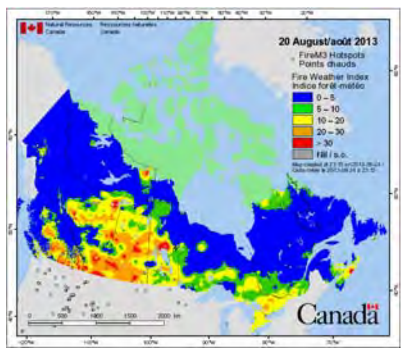
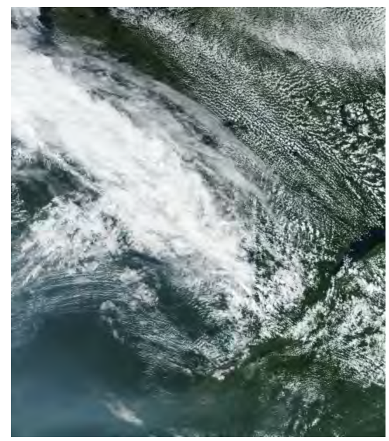
HYSPLIT Back Trajectories	**Fire Maps**	**Satellite Image**
 1st highest 3.75 ppb	NA	 Cloudy conditions over Sable Island. No visibility.
 2nd highest 3.6 ppb	 USDA Hotspots reported in trajectory.	 Smoke still leaving Quebec (top left). Haze passing Cape Breton, June 20th.

Figure 27. 2-air mass back trajectories for the daily average concentrations above background for H_2S 2013

From Figure 27 it can be seen that the highest H_2S average concentration's back trajectory passes over the vicinity of the Thebaud, Deep Panuke and Alma O&G platforms but as the Deep Panuke platform was not producing at the time it is likely that instrument drift that was responsible for this higher than background observation. The 2nd highest average concentration's back trajectory does not pass over any O&G platform, and further investigation yielded that it is likely contributed by a forest fire in Quebec (Deep Panuke again was not producing at that time).

Figure 28 shows the back trajectories and concentrations associated with the daily average BC concentrations observed on Sable Island during 2013 that were greater than 3 standard deviations above the mean. These back trajectories assume the wind direction at 12:00 noon for the daily average concentration. Fire maps and satellite images are included where applicable.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 1st highest 0.45 μg/m^3	NA	 Cloudy conditions over Sable Island. No visibility.
 2nd highest 0.40 μg/m^3	 Natural Resources Canada No hotspots reported in trajectory.	 Haze in Southern QC back trajectory on Aug 19th. Unclear analysis due to cloudy conditions.

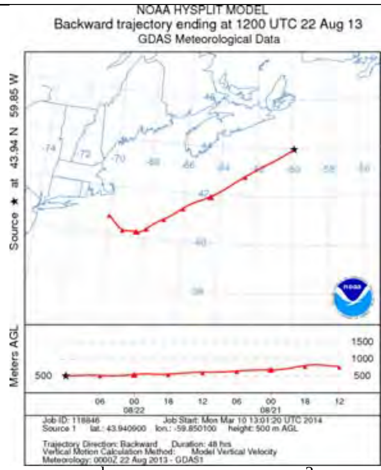
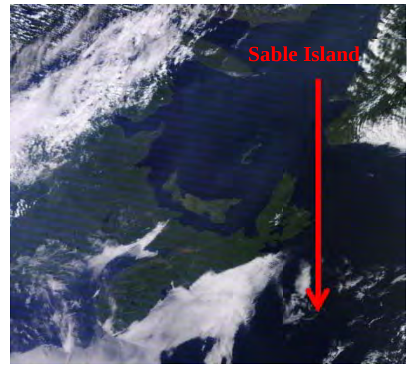
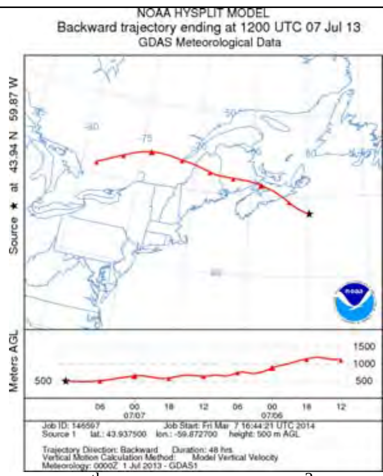
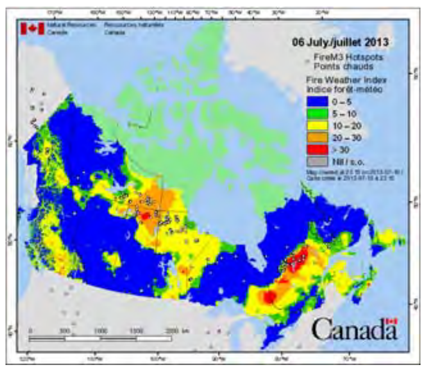
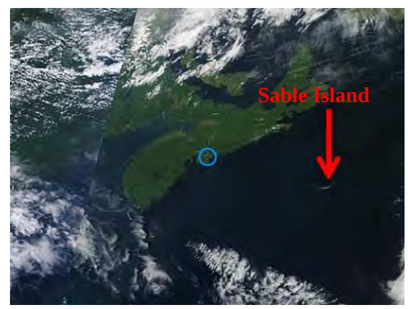
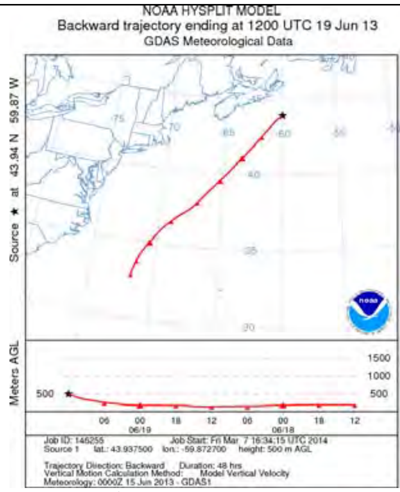
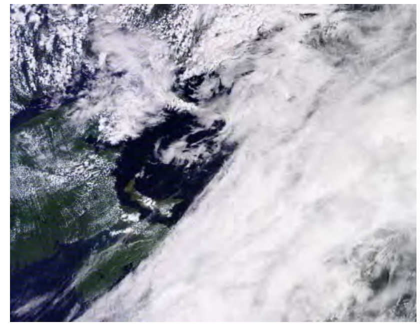
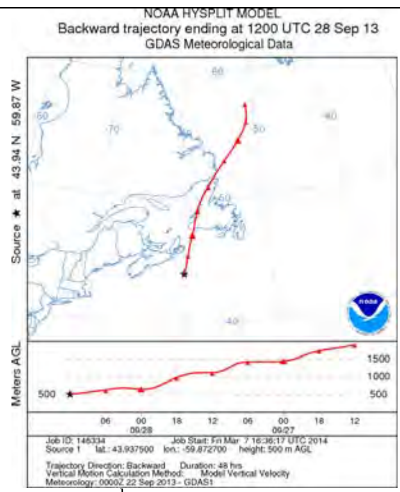
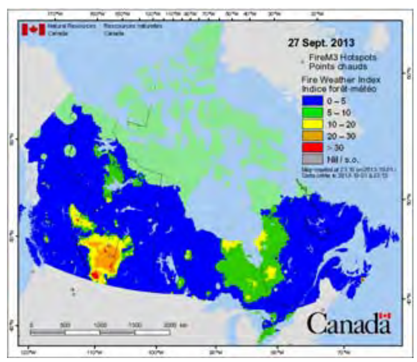
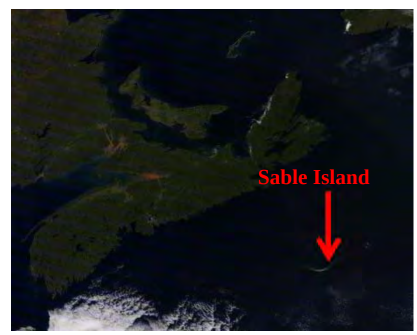
HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 3rd highest 0.40 µg/m³	NA	 Smog approaching Sable Island on Aug 22nd, originating from USA.
 4th highest 0.33 µg/m³	 Natural Resources Canada No hotspots reported in trajectory.	 Clear conditions over Sable Island.

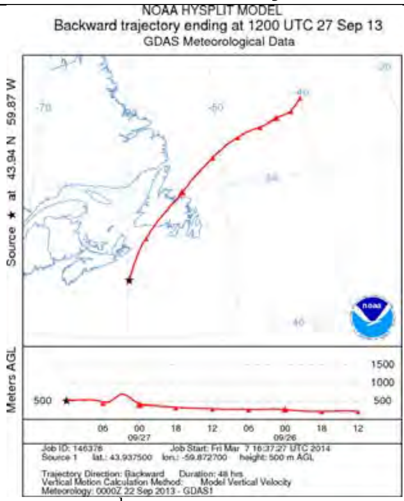
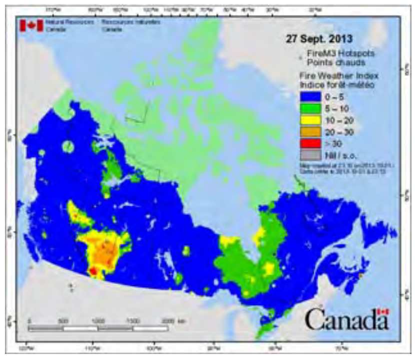
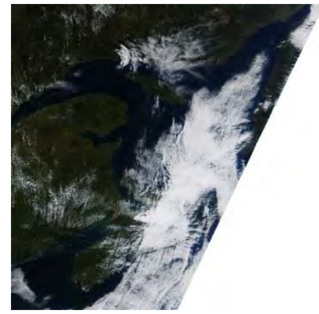
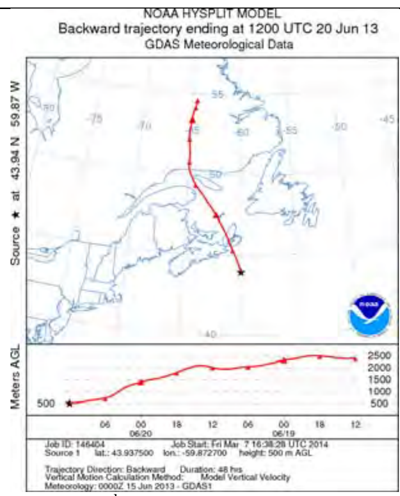
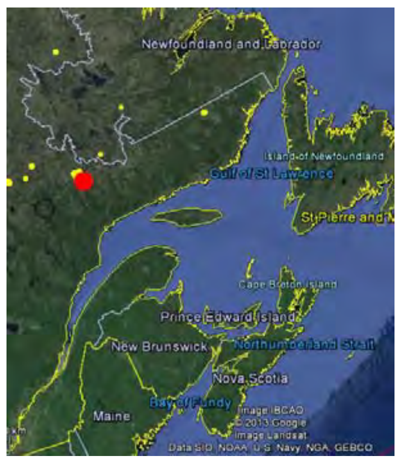
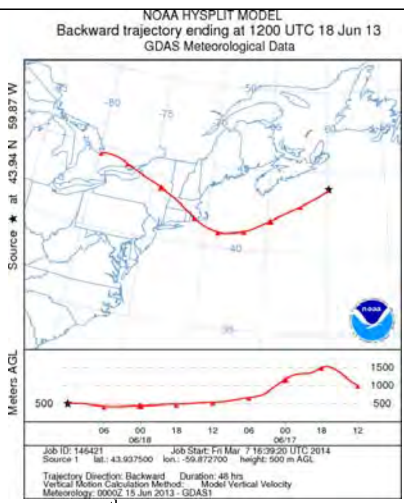
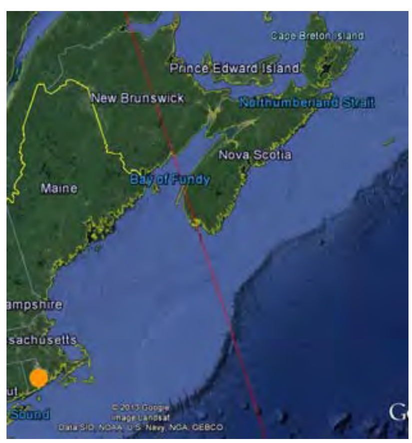
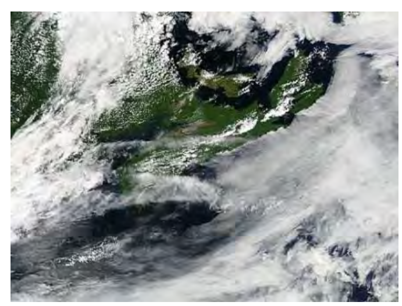
Figure 28. 2-air mass back trajectories for the daily average concentrations above background for BC

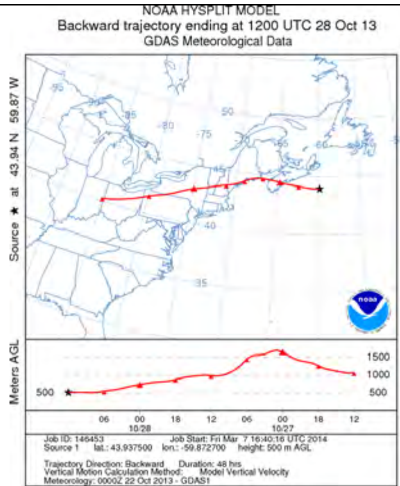
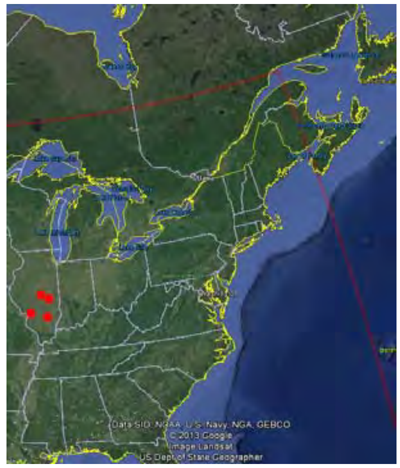
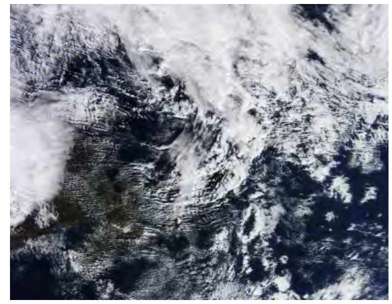
The back trajectories in Figure 28 reveal that none of the BC elevated concentration events were likely related to O&G operations. The 1st, 2nd and 4th highest concentrations' back trajectories do not pass over the vicinity of any O&G platform around Sable Island. The 2nd highest concentration on August 20, 2013 may be due to observed smog traveling through Quebec but cloudy conditions make this analysis unclear.

The 3rd highest concentration's back trajectory passes over the vicinity of the Thebaud, Alma and Deep Panuke platforms on August 22, 2013. Upon further investigation including a 72-hour back trajectory analysis, it was revealed that a large smog mass originating from the United States traveled to Nova Scotia. It appears that this smog mass was carried to Sable Island under a marine inversion.

Figure 29 shows the back trajectories and concentrations associated with the daily average NMHC concentrations observed on Sable Island during 2013 that were greater than 3 standard deviations above the mean. These back trajectories assume the wind direction at 12:00 noon for the daily average concentration. Fire maps and satellite images are included where applicable.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 1st highest 1.03 ppm	NA	 Cloudy conditions over Sable Island. No visibility.
 2nd highest 0.91 ppm	 Natural Resources Canada No hotspots reported in trajectory.	 Clear skies over Sable Island.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 3rd highest 0.87 ppm	 Natural Resources Canada No hotspots reported in trajectory.	 Cloudy conditions and incomplete image. No visibility.
 4th highest 0.79 ppm	 USDA Hotspots reported in trajectory.	 Smoke still leaving Quebec (top left). Haze passing Cape Breton, June 20th.
 5th highest 0.74 ppm	 USDA Hotspot reported in trajectory.	 Cloudy conditions over Sable Island and back trajectory. No visibility.

HYSPLIT Back Trajectories	Fire Maps	Satellite Image
 6th highest 0.34 ppm*	 USDA Multiple fires reported in Illinois on October 26th.	 Cloudy conditions over Sable Island. No visibility.

**This value is not 3 standard deviations above the mean value 0.49. However it is a visible outlier in the daily average timeseries plot for NMHC in Section 1.6.1*

Figure 29. 2-air mass back trajectories for the daily average concentrations above background for NMHC in 2013

Back trajectories in Figure 29 reveal that three of the six NMHC elevated concentration events in 2013 were possibly related to O&G operations, but two of these three events may also be related to mainland wild fires. It would appear that the 1st and 5th highest average concentrations on June 19th and 18th of 2013 passed over the vicinity of the Thebaud, Alma and Deep Panuke platforms. The air mass back trajectory of the 6th highest average concentration on October 28, 2013 passed over the vicinity of the Thebaud and Deep Panuke platforms. All three back trajectories display that their air parcels were low lying due to marine inversion conditions. The 5th and 6th highest NMHC concentrations may have had contributions from wild fires observed under the air mass back trajectory. Cloudy conditions limit pollution source analysis via remote sensing.

The 2nd, 3rd, and 4th highest NMHC concentrations' back trajectories did not align with any O&G platforms around Sable Island. There were no forest fires in line with the 2nd and 3rd back trajectories, and cloudy conditions and incomplete satellite images limit pollution source analysis. For the 4th highest concentration on June 20, 2013 is in line with a forest fire in Quebec.

1.7 NEW INSTRUMENTS ON SABLE ISLAND

Funding from the ESRF for a three-year study "Data display and source apportionment of volatile organic compounds" was approved in February 2011. Dr. Mark Gibson and Dr. Susanne Craig at Dalhousie University are the study leads. The ESRF project will see the deployment of new instruments on Sable Island. The new instruments have been commissioned at Dalhousie University by Dr. Gibson's AFRG and the following instruments were deployed on Sable Island on March 21, 2013: Thermo 55i methane and total non-methane hydrocarbons (total-VOC) analyzer, Thermo 5012 MAAP black carbon analyzer and TSI DustTrak DRX. As of March 25, 2013 the TSI DRX and 55i total-VOC analyzer are collecting data on Sable Island. The Markes International Air Server 3 and Markes Unity 2 thermal desorption-Thermo GC-MS was finally installed at Dalhousie in May 2013. It has been running perfectly since without any malfunctions. This provides comfort for when it will finally be deployed on the Island. However, there is currently not sufficient power on the Island to run the instrument. Parks Canada is aware of the issue and may step in to resolve the power problem. The deployed instruments are connected to a data logger, which in turn is connected to satellite communication on the Island. The data from the deployed instruments is currently being streamed live to a database at Dalhousie University. The data is QA/QC'd on the fly (zero checking and calibration spans removed) with the data being displayed on the following pass word protected website (http://jhopper.peas.dal.ca/users/login.html?next=/). Figure 30 below is a screenshot of the new ESRF funded data display of air emission on Sable Island.

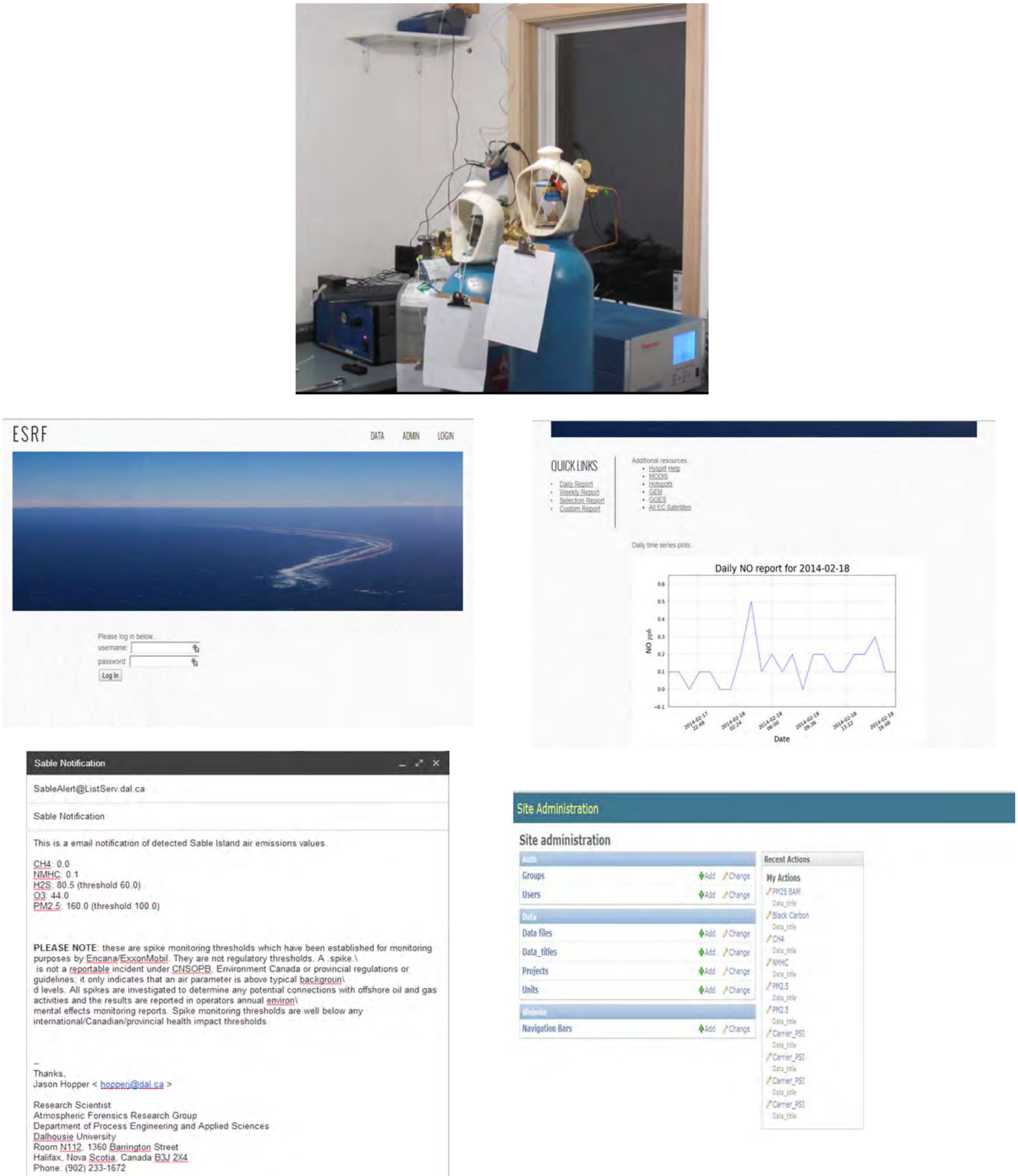


Figure 30. Total VOC and DRC installed on Sable Island and the new ESRF Data display and reporting website. First top image: Total VOC and DRX installed on Sable Island. Remaining four images: (top left) ESRF login page, (top right) link to 24-hr data plots updated in real time and additional data, (bottom left) sample alert email, (bottom right) custom

settings for email alerts and data reports.

The website is currently displaying daily and weekly time series plots of SO_2, H2S, O_3, wind speed, wind direction temperature, methane (CH_4), total non-methane hydrocarbons (NMHC), black carbon and $PM_{2.5}$. A user with access privileges can download data from the website for any or all of the pollutants and for any or all data ranges that they desire. Users can also upload data to the website for dissemination amongst the ESRF project partners.

Other additional air quality instruments include a second Markes International Unity 2 thermal desorption unit coupled to a Thermo 1300 Trace gas chromatograph (GC) which in turn is coupled to a Thermo ISQELITE quadrupole mass spectrometer (MS). This new TD-GC-MS is being used to analyze thermal desorption tubes samples of daily VOC species from the Island. The Vice President of Thermo Fisher Scientific sanctioned the mass spectrometer as in-kind support for the ESRF study, an in-kind value of $87,000. Together, the 1-hr and daily VOC species and the total-NMHC will be used to determine the source apportionment of natural and made VOC and aerosol emissions impacting Sable Island. Other instruments that will be placed on Sable Island (ETA Q3/4 2014) and include a TSI 3031 ultrafine particle monitor and the TSI aerodynamic particle sizer (APS). As of February 22, 2014 the negotiations with NRCan regarding the TSI instruments are almost complete.

1.7.1 Size-resolved particle number concentrations

The TSI 3031 Ultrafine Monitor and the TSI 3321 Aerodynamic Particle Sizer will be utilized to measure the size-resolved particle number counts between 0.01 and 20 μm. The 3031 and 3321 will be housed in the Environment Canada Air Chemistry building on Sable Island with the respective inlets passing to the outside of the building to sample the ambient air. The 3031 and the 3321 particle number concentration data will be streamed to the data display website.

1.7.2 TSI DRX PM_{10}, $PM_{4.0}$, $PM_{2.5}$ and PM_1

Figure 31. TSI DustTrak DRX Desktop 8533

A TSI DustTrak DRX Desktop 8533 was deployed on March 25, 2013 for the continuous, near real-time measurement of PM_{10}, $PM_{4.0}$, $PM_{2.5}$ and PM_1. The DRX concentration measurement ranges from 1 to 150,000 $\mu g/m^3$.

The DRX is easy to maintain and requires one annual service. The TSI DRX is housed in the Environment Canada Air Chemistry building on Sable Island with a sampling pipe passing through the roof to sample ambient air. The instrument has an autozero module to prevent zero drift, and a three-year service and repair agreement to ensure its operation throughout the period of the project. Due to TSI's proprietary nature of the DRX's software, only the $PM_{2.5}$ data channel can be streamed to the data display. The PM_{10}, $PM_{4.0}$ and PM_1 will be uploaded to the data display periodically.

1.7.3 Thermo MAAP 5012 black carbon analyzer

Figure 32. Thermo Model 5012 Multi-Angle Absorption Photometer (MAAP) black carbon analyzer

The Thermo Model 5012 Multi-Angle Absorption Photometer (MAAP) (aethalometer) is being used to measure the concentration of black carbon (BC) associated with the $PM_{2.5}$ size fraction. The BC content of the $PM_{2.5}$ is provided in near real-time by simultaneously measuring the optical absorption and scattering of light by the particles collected on a collection filter tape. The combination of optical absorption and scattering of light techniques provides a more precise measurement of the BC content of ambient $PM_{2.5}$ than absorption alone. The 5012 detection limit is 20 ng/m^3 over a 30 min averaging period and therefore ~ 10 ng/m^3 over a 1-hr integration period. The 5012 is housed in the Environmental Air Chemistry building as of March 21, 2013. The sampling inlet utilizes a flange to pass through the roof of the building. The instrument will be provided with a 3-year warranty and annual service agreement. Data from the 5012 is being streamed to the data display.

1.7.4 55i Methane and Total Non-methane Hydrocarbon (VOC) Analyser

Figure 33. 55i Thermo Scientific Methane and Total Non-methane Hydrocarbon (VOC) Analyzer

The 55i Thermo Scientific Methane and Total Non-methane Hydrocarbon (VOC) analyzer provides real time measurements of methane and non-methane hydrocarbons using a back flush chromatography system. Samples are automatically collected using a pump at pre-set time intervals. The air sample is then injected into the column along with an inert carrier gas, where different chemicals within the sample are separated based on retention time. Exiting chemicals are then measured using a flame ionization detector (FID) by measuring the signal generated and relating it through comparison with calibrant gases of known concentrations.

1.8 DISCUSSION

Wind rose analysis showed that the average wind vectors for 2013 was 256° which is consistent with prevailing winds in the NE Atlantic (Gibson et al., 2009a, Gibson et al., 2013b). The SO_2, $PM_{2.5}$, and O_3 are the only data sets in this report that have been QA/QC'd. Therefore the analysis discussed for the non-QA/QC'd pollutants are not reliable. However, there is likelihood that the dates for elevated daily average pollutant concentrations are accurate.

The NO_X pollution roses showed Westerly directional dependence for concentrations above 2.5 ppb, and there was one recorded concentration spike that breached the selected 17.0 ppb 1-hr threshold. The air mass back trajectory for this spike revealed it came from the Westerly/ North Westerly direction, which discounts O&G production as the source. There was only one NO_X elevated daily average that was three standard deviations above the mean daily average values. A back trajectory revealed that it may have originated from O&G operations to the WSW. As Deep Panuke was not operating during this period it is likely due to either emissions from the Thebaud platform or LRT from the eastern seaboard of the US. It is important to note that the NO_X recorded data analyzed in this report is incomplete and has not yet been QA/QC'd.

The SO_2 pollution roses showed a Northerly directional dependence for concentrations above 0.5 ppb, which is not in line with any O&G an operation around Sable Island. Two pollution events were found three standard deviations above the mean concentration; however their back trajectories revealed that they did not originate from O&G operations. The analysed SO_2 data set was QA/QC'd but is incomplete from September to December. The non-QA/QC'd data suggests there was a pulsed fluorescence data drift for the SO_2 analyser.

The $PM_{2.5}$ pollution rose displayed an Easterly and South Westerly to Southerly directional dependence for concentrations greater than 25 µg/m^3, which is in line with all O&G platforms around Sable Island. Three elevated daily average concentrations were found to be three standard deviations above the mean concentration. The 1st highest concentration of 22.79 µg/m^3 on November 28, 2013 had a back trajectory over the North Triumph platform. Elevated $PM_{2.5}$ concentrations could also be a consequence of sea salt spray and further investigations of the $PM_{2.5}$ chemistry and/or O&G operations would need to be conducted to confirm this. The installation of an Aerodyne, Aerosol Chemical Speciation Monitor for the real time measurement of Na, Cl, NH_4, SO_4 and organic components would resolve this issue. However, these instruments cost $180,000 and approximately $10,000/year in consumables to operate.

The O_3 pollution rose for 2013 revealed a South Westerly to Southerly directional dependence for average daily concentrations above 50 ppb. This is in line with the Thebaud, Deep Panuke, Alma, and North Triumph platforms. There were no daily average O_3 pollution concentrations greater than three standard deviations above the mean in 2013. As O_3 is a regional secondary air pollutant and closely associated to long range transport it is unlikely that the local O&G production had any influence on the three elevated concentrations seen in 2013.

H_2S pollution rose analysis showed a distinct South Westerly wind directional dependence which is in line with the Thebaud, Deep Panuke and Alma O&G platforms. There were three recorded spikes that breached the selected 3.11 ppb 1-hr threshold. However, two of these spikes did not pass over the vicinities of O&G platforms and the 3rd spike happened before Deep Panuke started producing and Thebaud and Alma are not sour-gas platforms. Therefore it is likely that these three H_2S spikes are a result of instrument drift rather than real observations.

The BC pollution rose for 2013 had an average concentration vector of 241˚ which is in line with the Thebaud, Deep Panuke, and Alma platforms. There were four daily average concentrations that were three standard deviations above the mean concentration. The 3rd highest daily average concentration had a back trajectory that passed over the vicinities of O&G platforms to the South West, but it is possible that a smog mass may have contributed to this concentration. It is important to note that the BC recorded data analyzed in this report is incomplete and has not yet been QA/QC'd.

The CH_4 pollution rose shows a strong South Westerly directional dependence for concentrations above 2 ppm. The NMHC pollution rose showed a Northery, Westerly and South to South Westerly directional dependence for concentrations above 1 ppm. The total VOC pollution rose showed a Westerly to Southerly directional dependence for concentrations between 2-2.5 ppm, and a Westerly directional dependence for concentrations above 2.5 ppm. The

Westerly and South to South Westerly directions are in line with the Thebaud, Deep Panuke, Alma, and North Triumph platforms. There were zero daily average CH_4 and total VOC concentrations that were three standard deviations above the mean concentration. There were six daily average NMHC concentrations that were three standard deviations above the mean concentration. Three of these six events had back trajectories passing over O&G platforms around Sable Island but two of these three events were likely contributed to by fires. The 1st highest daily average NMHC concentration of 1.03 ppm on June 19, 2013 had a back trajectory that passed over the vicinities of the Thebaud, Deep Panuke, and Alma platforms. It is important to note that the CH_4, NMHC, and total VOC recorded data sets analyzed in this report are incomplete and have not yet been QA/QC'd.

1.9 CONCLUSIONS

The most important feature of the air pollution data acquired in the 2013 year was one event where the NO_X emissions 'spike' threshold (1-hr period) was exceeded and likely not a result of O&G operations. The back trajectory for the NO_X spike of 27.1 ppb revealed it came from the Westerly/North Westerly direction, which eliminates O&G operations as the source. The three H_2S spikes investigated are likely due to instrument drift rather than O&G operations.

A logbook on the Island that keeps a record of incineration events would help identify whether the NO_x spike was due to incineration practices or emissions for the Venture platforms.

The 1st highest daily average $PM_{2.5}$ concentration of 22.79 µg/m^3 on November 28, 2013 had a back trajectory to the South, which is in line with the North Triumph platform. Elevated $PM_{2.5}$ concentrations may also be a consequence of sea salt spray and further investigations of the $PM_{2.5}$ chemistry and/or O&G operations would need to be conducted to confirm this.

There were no breaches of the National Air Quality Standards, Canada Ambient Air Quality Objectives (CAAQO) or Canada Wide Standard for any of the air pollution metrics contained in this report.

1.10 RECOMMENDATIONS

It is recommend that further monitoring be conducted for NO_x, H_2S, SO_2, BC and $PM_{2.5}$ between the on-island combustion sources and the Venture platforms under Easterly airflow. This would confirm whether the Easterly wind directional dependence for NO_x, $PM_{2.5}$ and BC were due to on-Island emission sources or O&G production.

It is recommended that a log book is kept on the Island to record when trash is incinerated. It would be a simple matter to then look through the log book to see if any of the NO_x, $PM_{2.5}$ or BC spikes are on days when trash was burned.

It is recommended that real time $PM_{2.5}$ chemical composition be monitored on Sable Island. This would allow immediate source identification and provide threshold breach alerts rather than waiting for over a year for data to become available. In addition, the $PM_{2.5}$ chemical data currently available is only collected once every 6th days so transient and episodic episodes may be missed. Therefore, it is recommended that an instrument such as an Aerodyne Chemical Speciation Monitor (real-time chloride, organic matter, sulfate, nitrate and ammonium) be added to Sable Island's air quality monitoring program to provide real time $PM_{2.5}$ chemical composition surveillance. The recently deployed $PM_{2.5}$ black carbon, size-resolved particle number and total VOCs managed would complement these measurements. Together, these measurements would provide a full suite of air pollutants to optimize the identification of local and LRT sources and to alert O&G facility operators to any incidences of air quality threshold breaches. It is recommend that gas generators for (H_2 and N_2) be purchased to maintain the continuous un-interrupted operations of the Thermo 55i total-VOC and total-non-methane hydrocarbon analyzer.

1.11 REFERENCES

BROWNELL, D. K., MOORE, R. M. & CULLEN, J. J. 2010. Production of methyl halides by Prochlorococcus and Synechococcus. *Global Biogeochem. Cycles,* 24**,** GB2002.

CNSOPB 1990. Annual Report. 22.

CNSOPB 2013. Encana's Deep Panuke Project.

GANTT, B., NICHOLAS, M., ZHANG, Y. & XU, J. 2010. The effect of marine isoprene emissions on secondary organic aerosol and ozone formation in the coastal United States. *Atmospheric Environment,* 44**,** 115-121.

GIBSON, M. D., GUERNSEY, J. R., BEAUCHAMP, S., WAUGH, D., HEAL, M. R., BROOK, J. R., MAHER, R., GAGNON, G. A., MCPHERSON, J. P., BRYDEN, B., GOULD, R. & TERASHIMA, M. 2009a. Quantifying the Spatial and Temporal Variation of Ground-level Ozone in the Rural Annapolis Valley, Nova Scotia, Canada using Nitrite-impregnated Passive Samplers. *Journal of the Air & Waste Management Association,* 59**,** 310-320.

GIBSON, M. D., HEAL, M. R., BACHE, D. H., HURSTHOUSE, A. S., BEVERLAND, I. J., CRAIG, S. E., CLARK, C. F., JACKSON, M. H., GUERNSEY, J. R. & JONES, C. 2009b. Using Mass Reconstruction along a Four-Site Transect as a method to interpret PM10 in West-Central Scotland, United Kingdom. *Journal of the Air and Waste Management Association,* 59**,** 1429-1436.

GIBSON, M. D., HEAL, M. R., LI, Z., KUCHTA, J., KING, G. H., HAYES, A. & LAMBERT, S. 2013a. The spatial and seasonal variation of nitrogen dioxide and sulfur dioxide in Cape Breton Highlands National Park, Canada, and the association with lichen abundance. *Atmospheric Environment,* 64**,** 303-311.

GIBSON, M. D., KUNDU, S. & SATISH, M. 2013b. Dispersion model evaluation of PM2.5, NOx and SO2 from point and major line sources in Nova Scotia, Canada using AERMOD Gaussian plume air dispersion model. *Atmospheric Pollution Research,* 4**,** 157-167.

GIBSON, M. D., PIERCE, J. R., WAUGH, D., KUCHTA, J. S., CHISHOLM, L., DUCK, T. J., HOPPER, J. T., BEAUCHAMP, S., KING, G. H., FRANKLIN, J. E., LEAITCH, W. R., WHEELER, A. J., LI, Z., GAGNON, G. A. & PALMER, P. I. 2013c. Identifying the sources driving observed PM2.5 temporal variability over Halifax, Nova Scotia, during BORTAS-B. *Atmos. Chem. Phys.,* 13**,** 7199-7213.

GREENHORSESOCIETY 2012. Sable Island Greenhorse Society.

INKPEN, T., HINGSTON, M., WAUGH, D., KEAST, S., MCPHERSON, J., WORTHY, D. & FORBES, G. 2009. Sable Island Air Monitoring Program Report: 2003-2006 *Meteorological Service of Canada* Atlantic Region Science Technical Report

MONKS, P. S., GRANIER, C., FUZZI, S., STOHL, A., WILLIAMS, M. L., AKIMOTO, H., AMANN, M., BAKLANOV, A., BALTENSPERGER, U., BEY, I., BLAKE, N., BLAKE, R. S., CARSLAW, K., COOPER, O. R., DENTENER, F., FOWLER, D., FRAGKOU, E., FROST, G. J., GENEROSO, S., GINOUX, P., GREWE, V., GUENTHER, A., HANSSON, H. C., HENNE, S., HJORTH, J., HOFZUMAHAUS, A., HUNTRIESER, H., ISAKSEN, I. S. A., JENKIN, M. E., KAISER, J., KANAKIDOU, M., KLIMONT, Z., KULMALA, M., LAJ, P., LAWRENCE, M. G., LEE, J. D., LIOUSSE, C., MAIONE, M., MCFIGGANS, G., METZGER, A., MIEVILLE, A., MOUSSIOPOULOS, N., ORLANDO, J. J., O'DOWD, C. D., PALMER, P. I., PARRISH, D. D., PETZOLD, A., PLATT, U., PÖSCHL, U., PRÉVÔT, A. S. H., REEVES, C. E., REIMANN, S., RUDICH, Y., SELLEGRI, K., STEINBRECHER, R., SIMPSON, D., TEN BRINK, H., THELOKE, J., VAN DER WERF, G. R., VAUTARD, R., VESTRENG, V., VLACHOKOSTAS, C. & VON GLASOW, R. 2009. Atmospheric composition change – global and regional air quality. *Atmospheric Environment,* 43**,** 5268-5350.

PALMER, P. I., PARRINGTON, M., LEE, J. D., LEWIS, A. C., RICKARD, A. R., BERNATH, P. F., DUCK, T. J., WAUGH, D. L., TARASICK, D. W., ANDREWS, S., ARUFFO, E., BAILEY, L. J., BARRETT, E., BAUGUITTE, S. J. B., CURRY, K. R., CARLO, P. D., CHISHOLM, L., DAN, L., DRUMMOND, J. R., FORSTER, G., FRANKLIN, J. E., GIBSON, M. D., GRIFFIN, D., HELMIG, D., HOPKINS, J. R., HOPPER, J. T., JENKIN, M. E., KINDRED, D., KLIEVER, J., BRETON, M. L., MATTHIESEN, S., MAURICE, M., MOLLER, S., MOORE, D. P., ORAM, D. E., O'SHEA, S. J., OWEN, R. C., PAGNIELLO, C. M. L. S., PAWSON, S., PERCIVAL, C. J., PIERCE, J. R., PUNJABI, S., PURVIS, R. M., REMEDIOS, J. J., ROTERMUND, K. M., SAKAMOTO, K. M., STRAWBRIDGE, K. B., STRONG, K., TAYLOR, J., TRIGWELL, R., TERESZCHUK, K. A., WALKER, K. A., WEAVER, D., WHALEY, C. & YOUNG, J. C. 2013. Quantifying the impact of BOReal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites (BORTAS) experiment: design, execution and science overview. *Atmos. Chem. Phys.,* 13**,** 6239-6261.

PALMER, P. I. & SHAW, S. L. 2005. Quantifying global marine isoprene fluxes using MODIS chlorophyll observations. *Geophys. Res. Lett.*, 32**,** L09805.
WAUGH, D., INKPEN, T., HINGSTON, M., KEAST, S., MCPHERSON, J., WORTHY, D. & FORBES, G. 2010. Sable Island Air Monitoring Program Report No: 2003-2006. *Environmental Studies Research Funds,* Report No. 181**,** 1-56.