Offshore Environmental Effects Monitoring for Deep Panuke

Program Annual Report 2014

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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 natural gas field. The objective of this project is 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.

This documents details 2014 findings for the following analyses:

- Chemical characterization of produced water during production (section 6.1 of the EEMP)
- 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; 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 2014 EEM program include the following:

Produced water chemistry and toxicity

- Results for Nutrients, Majors Ions and Organic Acids have either non-detectable results or results slightly above the RDL. All results were below CCME guidelines where available.
- Except for PAH Naphthalene, Benzene and Toluene results where elevated values were found to be above CCME guidelines; all other parameters (Metals, PAHs, Alkylated Phenols and Hydrocarbons) were below CCME guidelines where available.
- Produced water was tested only once by PFC personnel due to logistical constraints which prevented sampling operations.
- Toxicity tests on produced water were not performed for the same logistical/operational reasons.

Fish habitat alteration:

- Epifauna colonization of WHPS at all well site locations observed had similar species density and assemblages as the 2013 survey. 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*). As in 2013 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 and 2013 surveys, Atlantic cod (*Gadus morhua*) was not present in 2014 at WHPS. Large schools of Gadidae (Either Cod or Pollock) were observed by the ROV crew around the PFC structure.
- 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.

- Blue mussel *Mytilus edulis* continues to be the dominant species at the PFC area and WHPS. Colonization of hydroids was observed on Cuprotect coverage area of the flowlines at F-70.

Marine wildlife observations:

- Eighteen bird strandings were reported. Two storm petrels were unharmed and later released, one gray catbird died in care, and all other birds were found dead.
- Both the supply vessels the M/V Atlantic Condor and the M/V Atlantic Tern reported wildlife sightings in 2014. The M/V Atlantic Condor observed two seals, one whale near the PFC, and various gulls year round. The M/V Atlantic Tern reported observing cormorants, gannets, shearwaters, gulls, seals, whales, sunfish, sea turtles, sharks, dolphins and porpoises.
- As part of the Acadia bird study, ongoing monitoring of bird movements was conducted up to June on the PFC support vessels in 2014. VHF receivers were installed on Deep Panuke in April of 2014, and a dedicated bird observer was on Deep Panuke for the spring migration.
- Ongoing monitoring of oiling rates in beached birds on Sable Island was conducted over the course of 9 surveys carried out between January 1, and November 2014, where 352 beached seabird corpses were collected. Alcids accounted for 54% of the total corpses recovered. Of the six oiled bird corpses found all were alcids. Of the 461 corpses, 184 (52.3%) were complete (>70% of body intact). The oiling rate for all species combined was <3.2%.

Air Quality Monitoring:

- Air emissions were monitored on Sable Island throughout 2014. There was an H_2S emission threshold breach on August 7th, which was likely related to acid gas flaring malfunction on Deep Panuke, but was below health regulation standards. The spikes in H_2S (below notification threshold) seen on June 15 and July 16 were likely due to H_2S acid gas emissions from Deep Panuke by virtue of local wind directional analysis, and the spikes in SO_2, NMHC, BC NO_x, $PM_{2.5}$, and O_3 are not thought to have originated from O&G operations, but rather continental known source regions, *e.g.* wildland fire smoke plumes.
- Systematic flare smoke monitoring was initiated in February 2014, recording flare smoke shade twice a day using the Ringelmann smoke chart. On a scale from zero to five, the

flare was a “0” (no smoke) 74% of the time, a “1” 19% of the time, a “2” 5% of the time, and a “3” 2% of the time.

In accordance with objectives stipulated in the Offshore Production EEMP, it is anticipated that the 2015 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);
- Marine wildlife observations (section 6.6 of EEMP);
- Fish health assessment (section of 6.5 EEMP); and
- Air quality monitoring (section 6.7 of EEMP).

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GLOSSARY OF TERMS

AC	Autoanalysis Colilert
APs	Alkyl Phenols
BC	Black Carbon
BTEX	Benzene, Toluene, Ethylbenzene, Xylene(s)
C	Celsius
CAAQO	Canada Ambient Air Quality Objectives
CCME	Candian Council of Ministers of the Environment
CCR	Central Control Room
CEQG	Canadian Environmental Quality Guidelines
CH_4	Methane
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
CRM	Certified Reference Material
CSR	Comprehensive Study Report
CWS	Canadian Wildlife Service
DIC	Dissolved Inorganic Carbon
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DVD	Digital Video Disc/ Digital Versatile Disc
EA	Environmental Assessment
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

ESRF	Environmental Studies Research Fund
GBBG	Great Black-backed Gulls
GC	Gas Chromatography
GEP	Gas Export Pipeline
GHG	Greenhouse Gases
GPS	Global Positioning System
GVI	General Visual Inspection
HERG	Herring Gulls
H_2S	Hydrogen Sulphide
hr	Hour
HYSPLIT	Hybrid Single Particle Lagrangian Trajectory
IC	Ion Chromatography
ICP	Inductively Coupled Plasma
ISE	Ion Selective Electrode
km	Kilometre
KP	Kilometre Point
L	Litre(s)
LC49	Bioassay Acute Toxicity Analysis
LAT	Lowest Astronomical Tide
LMRS	Low Resolution Mass Spectrometry
LRT	Long-range Transport
m	metre(s)
mg	milligram(s)
mol	Mole (unit)
MODIS	Moderate Resolution Imaging Spectroradiometer
MOPU	Mobile Offshore Production Unit
M&NP	Maritimes & Northeast Pipeline
MS	Mass Spectrometry
MV	Motor Vessel
N	North
NA	Not tested for
NASA	National Aeronautics and Space Administration
NB	New Brunswick
ND	Not Detected

NE	North East
NEB	National Energy Board
NMHC	Non-methane hydrocarbons
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
OES	Optical Emission Spectroscopy
O&G	Oil and Gas
OPR	On-going Precision and Recovery
O_3	Ozone
OWTG	Offshore Waste Treatment Guidelines
OTN	Ocean Tracking Network
PAH	Polynuclear Aromatic Hydrocarbons
PFC	Production Field Centre
pH	Power of Hydrogen
$PM_{2.5}$	Fine airborne particulate matter with a median aerodynamic diameter ≤ 2.5 microns
ppb	Parts per billion
PPMW	Parts per million by weight
PSU	Practical Salinity Units
PTGC	Programmed Temperature Gas Chromatography
RACON	Radar Responder
RADAR	Radio Detection and Ranging
ROV	Remotely Operated Vehicle
QA	Quality Assurance
QC	Quality Control
RDL	Reportable Detection Limit
S^{2-}	Sulphide
SACFOR	Abundance Scale; S-superabundant, A-abundant, C-common, F-frequent, O-occasional, R-rare
SBM	Single Buoy Moorings Inc.

SO_2	Sulphur Dioxide
SOEP	Sable Offshore Energy Project
SSIV	Subsea Isolation Valve
SW	South West
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
US	United States
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
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 natural gas field. 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 2014 report represents the fourth yearly report submitted to Encana.

The 2014 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, MV Atlantic Tern and MV Atlantic Hawk 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; and
- Kingfisher Environmental Health Consultants for Sable Island air quality monitoring.

Table 1-1 provides an overview of the 2014 EEM program including relevant environmental effects monitoring (EEM) components and survey timing. No water quality, sediment or mussel sampling took place in 2014. Baseline testing for these components (with the exception of mussel testing) was conducted in December 2011 prior to production start. Subsequent testing was postponed to wait for steady state production and associated produced water discharges. The sampling program was scheduled for the fall of 2014, as mentioned in Encana's approved 2013 EEM Report (DMMG-X00-RP-EH-90-0003). However, the plant was shut down from September 26 to November 16 for scheduled maintenance and plant optimization. As a result, sampling was rescheduled for December 2014. However, the program could not proceed due to challenging logistical conditions (helicopter issues, vessel schedule and weather conditions). In January 2015, the program was further postponed until spring 2015 because stickleback culture to be used for produced water toxicity testing could no longer be maintained at required health criteria. The other components of the 2014 EEM program were conducted as planned, including produced water chemistry (spring testing); fish habitat alteration; marine wildlife observations and air quality monitoring (see **Table 1-1**).

Table 1-1 Overview of 2014 EEM Program

EEM Component(s)	2014 EEM Program	Survey Timing
Produced water chemistry Section 6.1 of EEMP	Produced water collected on Deep Panuke. Chemical characterization of produced water.	June 2014
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.	April to December 2014
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 February and June 2014.
Oiled Bird Study conducted on Sable Island Section 6.6 of EEMP	Nine surveys for beached seabirds were conducted on Sable Island. Species identification, corpse condition and extent of oiling were recorded for seabird specimens.	Between January and November, 2014
Air Quality 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	Systematic flare smoke monitoring was initiated in 2014 using the Ringelmann smoke chart.	Smoke monitoring twice a day initiated in February 2014.

1.1 DEEP PANUKE BACKGROUND

The Deep Panuke natural gas field is located offshore, 250 km southeast of Halifax, Nova Scotia, approximately 45km to the West of Sable Island in water depths ranging from 42 m to 50 m (**Figure 1.1a**).

The project involves offshore production, processing and transport via a nominal 559 mm (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 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 2014 are as follows:

- 2014 was the second year of production operations at Deep Panuke ("First Gas", or start of steady state production was announced on December 17, 2013). Depending on operational status, production rate varied, with maximum production capability reaching approximately 300 million cubic feet per day.
- An extended shutdown took place September 26 to November 14, 2014, to conduct planned maintenance and plant optimization activities.
- The annual ROV subsea survey took place over the interfield flowlines, wellheads and export pipeline to shore from February 21 to the end of 2014.
- Formation water started to be produced by three wells in 2014, as follows (dates of formation water first detected):
    - H-08 – April 10, 2014
    - F-70 – July 1, 2014
    - M-79A – August 15, 2014
- Only condensed water was produced by D-41 in 2014.

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**.

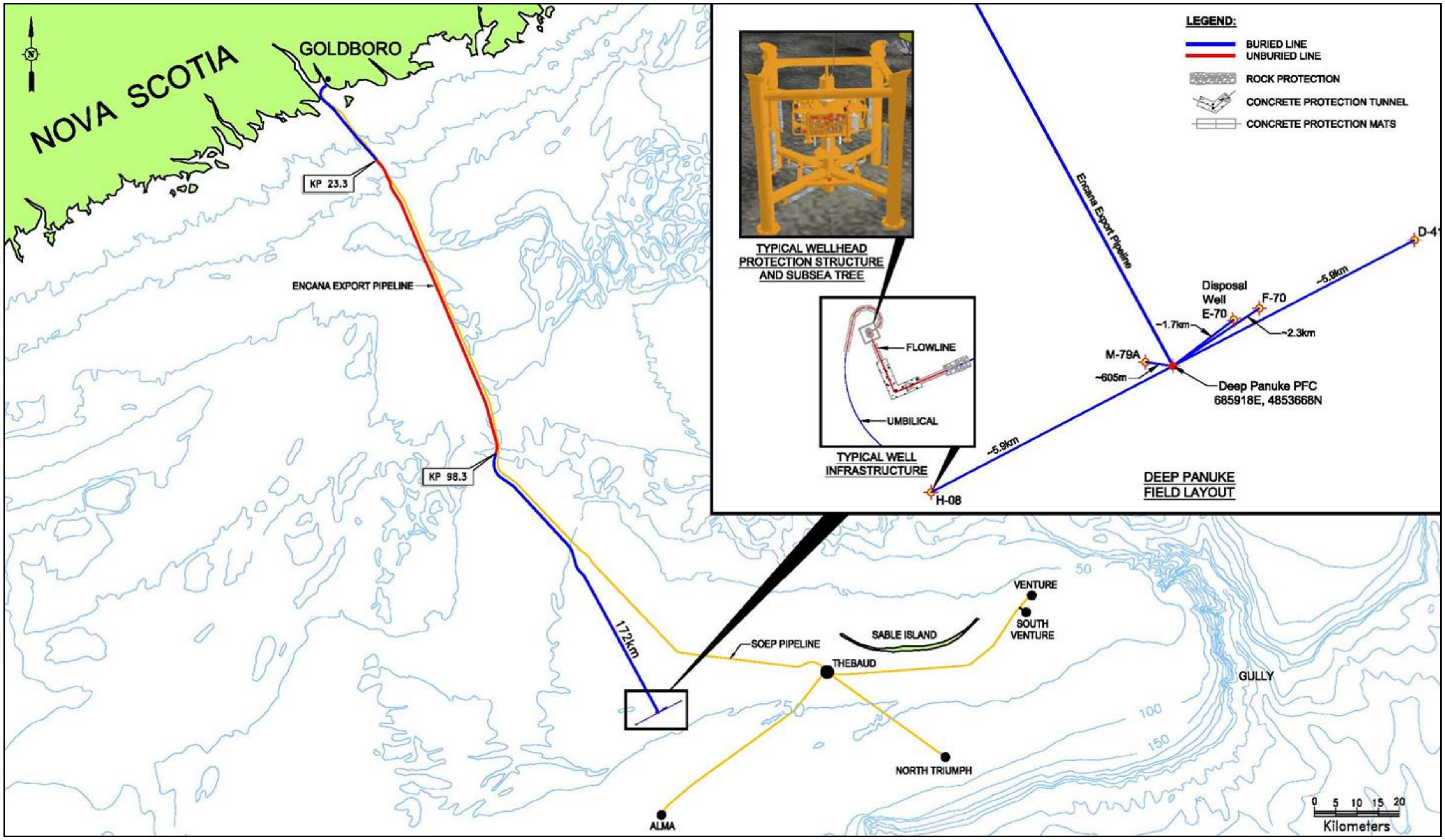


Figure 1.1a Deep Panuke Subsea Production Structures - General Overview (From Offshore Production EEMP - May 21, 2011)

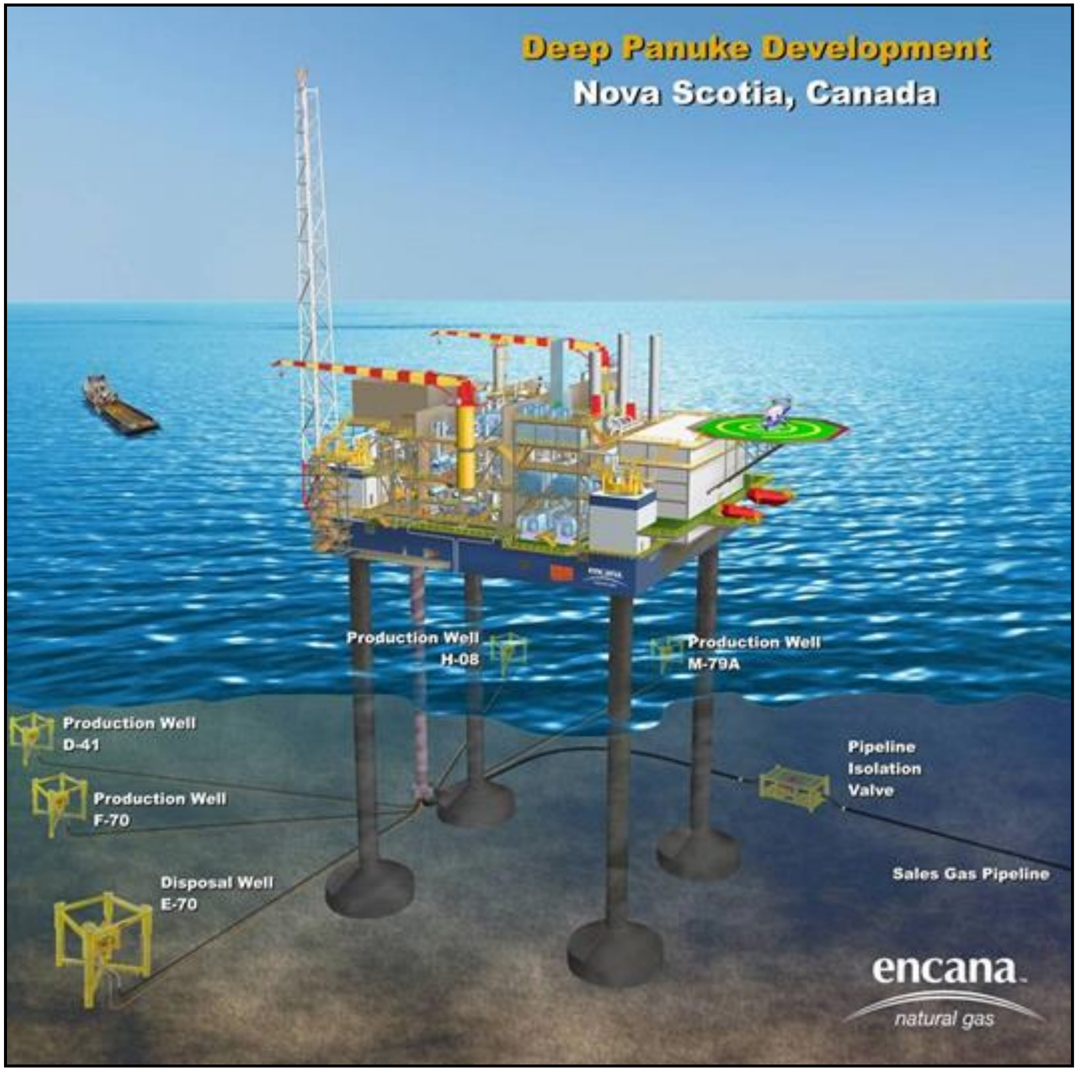


Figure 1.1b Deep Panuke Production Field Centre Rendering (From Offshore Production EEMP - May 21, 2011)

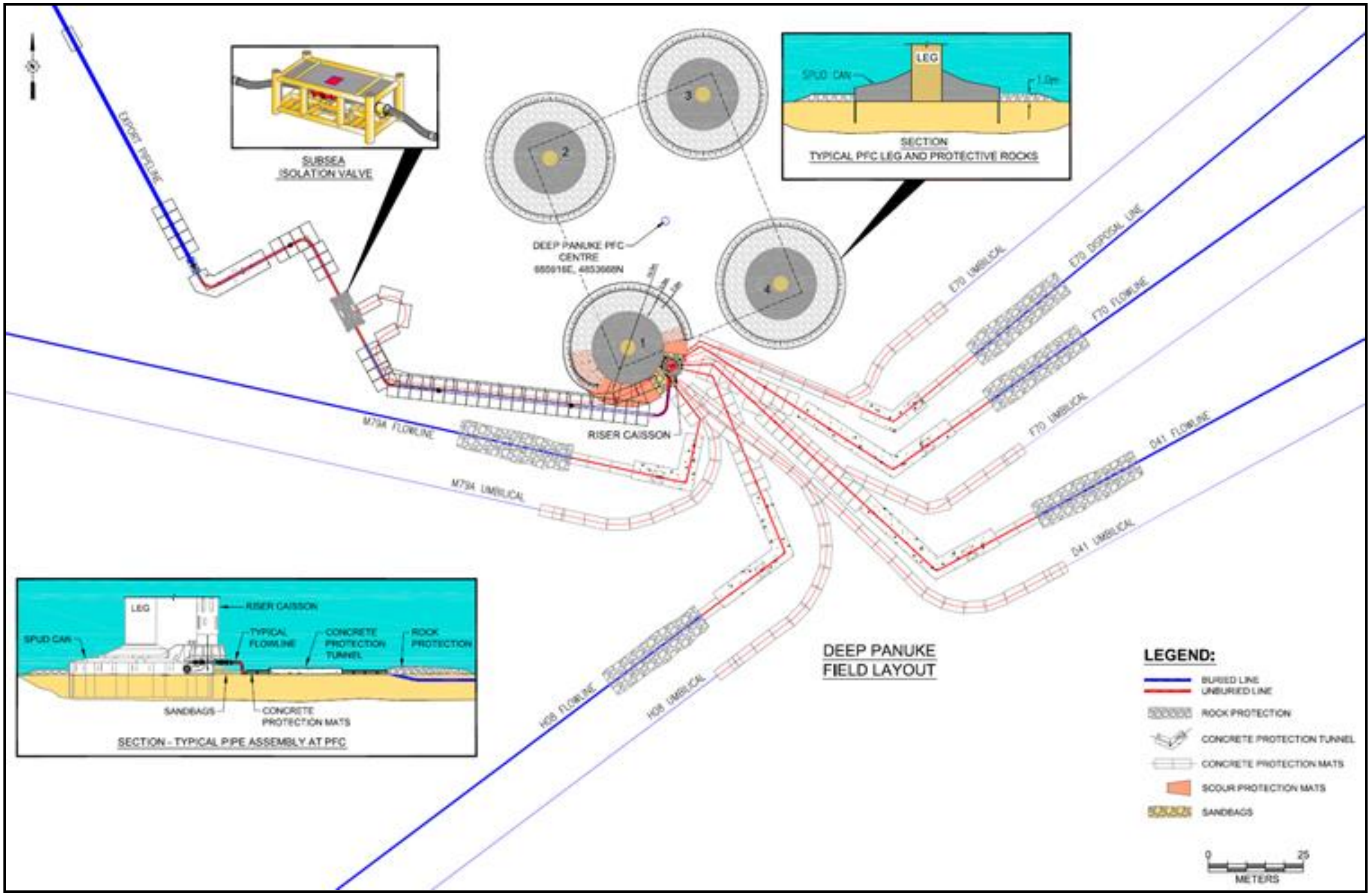


Figure 1.1c Deep Panuke Subsea Production Structures - PFC Area (From Offshore Production EEMP - May 21 2011)

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). Produced water chemistry and toxicity testing are considered environmental compliance monitoring since they are a requirement under the OWTG. They are included together in the EEMP report as they assess the potential impact of contaminants discharged in the marine environment.

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.

The chemical composition of produced water will be analyzed twice yearly for the following parameters:

- metals (aluminium, antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, magnesium, mercury, molybdenum, nickel, selenium, silver, strontium, thorium, tin, uranium, vanadium, zinc);
- non-metals (nitrogen, phosphorus, sulphur, oxygen);
- hydrocarbons: total petroleum hydrocarbons (TPH), poly-aromatic hydrocarbons (PAHs) and alkyl phenols (APs);
- nutrients (nitrate, phosphate, ammonia, organic acids);
- hydrogen sulphide (H_2S);
- salinity;
- pH; and
- temperature.

This list of chemical parameters to test for in produced water has been developed to be consistent with the EEM marine water quality sampling program in order to allow for comparisons between concentrations of the same parameters prior to and after discharge of produced water to the marine environment. As such, the list is expected to evolve based on the results from the marine water quality monitoring program.

Produced water will be tested for toxicity annually. The marine toxicity testing will include the sea urchin fertilization test and at least two other bioassay tests (e.g., early life stage of fish, bacteria, algal species, etc). The tests will be conducted contemporaneously with one of the twice-yearly chemical characterization tests. Besides the Sea Urchin Fertilization test, Dr. Ken Doe of the Environment Canada Toxicology Laboratory in Moncton, NB, recommended the Threespine Stickleback test for the SOEP EEM Program as an indicator of fish toxicity and the Microtox test as an indicator of toxicity at the cellular level.

2.1.2 EEMP Goal

To Examine the potential toxicity of produced water from the Deep Panuke PFC using indicator species and to perform chemical characterization test as per the Deep Panuke Production EPCMP (DMEN-X00-RP-EH-90-0002) [Deep Panuke EA predictions #1, 3, 4, 5 & 6 in Table 3.1]

2.1.3 Objectives

Analyze produced water collected on the Deep Panuke PFC for marine toxicity testing and chemical composition as per the Deep Panuke Production EPCMP (DMEN-X00-RP-EH-90-0002, refer to Section 6.1.1).

Produced water samples will be taken on the PFC (i.e., prior to mixing with seawater system discharge before overboard discharge) to be analyzed for chemistry (twice yearly) and toxicity (annually). If feasible, one of the twice-yearly produced water chemistry samples will be collected the same day as the EEM water quality samples to allow for comparison between concentrations of the tested parameters prior to and after discharge of produced water to the marine environment. If feasible, this sampling will be scheduled during steady state of production operations such that the samples are representative of average conditions. Production data and produced water equipment performance will be recorded at the time of sampling.

2.1.4 Sampling

Due to various logistical constraints (see Section 1), produced water was sampled only once in 2014 for chemical characterization (see **Table 2-1** for sampling details). No toxicity test was performed on the produced water in 2014.

Table 2-1 Produced Water Sampling Details

<table>
<tr><td>Sample Date:</td><td>June 10, 2014 at 7am local time</td></tr>
<tr><td>Type of Sample:</td><td>Produced water samples</td></tr>
<tr><td>Test Sample Locations:</td><td>
<table>
<tr><th>Station</th><th>Time UTC</th><th>Water Depth(m)</th><th>Easting</th><th>Northing</th></tr>
<tr><td>PFC, produced water discharge line sampling point</td><td>11:00</td><td>NA</td><td>686000</td><td>4853691</td></tr>
<tr><td colspan="5">WGS84 UTM Zone 20N</td></tr>
</table>
</td></tr>
<tr><td>Number of Samples/Locations:</td><td>Water was collected on the platform by PFC laboratory personnel. pH and temperature were measured at the time of collection by PFC laboratory personnel.</td></tr>
<tr><td>Equipment:</td><td>Water was collected directly from a produced water outlet located on the PFC and transferred to sampling containers. Containers were put on ice in a cooler and shipped to Halifax by helicopter.</td></tr>
<tr><td>Sample Preparation:</td><td>
<table>
<tr><th>Parameter</th><th>Preservative</th></tr>
<tr><td>Organic acids</td><td>no preservative</td></tr>
<tr><td>Metal scan and Sulphur</td><td>Nitric acid</td></tr>
<tr><td>BTEX/TPH</td><td>Sodium Bisulphate</td></tr>
<tr><td>BTEX/TPH - volatile</td><td>Sodium Bisulphate</td></tr>
<tr><td>Alkylated Phenols</td><td>no preservative</td></tr>
<tr><td>PAHs</td><td>no preservative</td></tr>
<tr><td>Nitrate/ortho-P/Total Nitrogen</td><td>no preservative</td></tr>
<tr><td>Sulphide</td><td>Zn Acetate + NaOH</td></tr>
<tr><td>Total P/Ammonia</td><td>Sulphuric Acid</td></tr>
</table>
</td></tr>
</table>

2.1.5 Analyses

Produced water was analyzed for parameters summarized in **Table 2-2**. Major ions were determined using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES), while trace elements were determined using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS). Nutrients were be determined by a variety of instruments including chromatographs, colorimeters, and spectrophotometers. DIC was measured on an Elemental Analyzer. DOC was measured with a carbon analyzer after high temperature catalytic oxidation.

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

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

Sulphides in water were analyzed using the ion selective Electrode (ISE). The sulphide may be in the form of S2-, HS- or H_2S. Temperature, salinity and DO affect the amount of H_2S found in undissociated form. Sulphide H_2S was determined using SM 4500-S2-G. To calculate H_2S, pH, conductivity and temperature measurements recorded during sampling at the PFC were used.

2.1.5.1 Parameters Analyzed

Table 2-2 Produced Water Parameters Measured

Parameter	Units	RDL	CCME Guidelines	Analysis Method
Nutrients				
Nitrate + Nitrite	$mg \cdot L^{-1}$	0.05	N/A	colorimetry
Nitrate (N)	$mg \cdot L^{-1}$	0.05	1500	colorimetry
Nitrite (N)	$mg \cdot L^{-1}$	0.01	N/A	colorimetry
Nitrogen (Ammonia)	$mg \cdot L^{-1}$	0.01	N/A	colorimetry
Orthophosphate (P)	$mg \cdot L^{-1}$	0.01	N/A	colorimetry
Major Ions				
Phosphorus	$mg \cdot L^{-1}$	0.02	N/A	AC
Sulphide	$mg \cdot L^{-1}$	0.02	N/A	Methylene blue method colorimetry
Organic Acids				
Formic Acid	$mg \cdot L^{-1}$	0.50	N/A	IC
Acetic Acid	$mg \cdot L^{-1}$	1	N/A	IC
Propionic Acid	$mg \cdot L^{-1}$	1	N/A	IC
Butyric Acid	$mg \cdot L^{-1}$	2	N/A	IC

Parameter	Units	RDL	CCME Guidelines	Analysis Method
Trace Metals				
Aluminum (Al)	$\mu g \cdot L^{-1}$	5	N/A	ICP-MS
Antimony (Sb)	$\mu g \cdot L^{-1}$	1	N/A	ICP-MS
Arsenic (As)	$\mu g \cdot L^{-1}$	1	12.5	ICP-MS
Barium (Ba)	$\mu g \cdot L^{-1}$	1	N/A	ICP-MS
Beryllium (Be)	$\mu g \cdot L^{-1}$	1	N/A	ICP-MS
Bismuth (Bi)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Boron (B)	$\mu g \cdot L^{-1}$	50	N/A	ICP-MS
Cadmium (Cd)	$\mu g \cdot L^{-1}$	0.02	0.12	ICP-MS
Calcium (Ca)	$\mu g \cdot L^{-1}$	100	N/A	ICP-MS
Chromium (Cr)	$\mu g \cdot L^{-1}$	1	Hex = 1.5, Tri = 54	ICP-MS
Cobalt (Co)	$\mu g \cdot L^{-1}$	0.40	N/A	ICP-MS
Copper (Cu)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Iron (Fe)	$\mu g \cdot L^{-1}$	50	N/A	ICP-MS
Lead (Pb)	$\mu g \cdot L^{-1}$	0.50	N/A	ICP-MS
Magnesium (Mg)	$\mu g \cdot L^{-1}$	100	N/A	ICP-MS
Manganese (Mn)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Molybdenum (Mo)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Nickel (Ni)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Potassium (K)	$\mu g \cdot L^{-1}$	100	N/A	ICP-MS
Selenium (Se)	$\mu g \cdot L^{-1}$	1	N/A	ICP-MS
Silver (Ag)	$\mu g \cdot L^{-1}$	0.10	N/A	ICP-MS
Sodium (Na)	$\mu g \cdot L^{-1}$	100	N/A	ICP-MS
Strontium (Sr)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Sulphur (S)	$\mu g \cdot L^{-1}$	5000	N/A	ICP-MS
Thallium (Tl)	$\mu g \cdot L^{-1}$	0.10	N/A	ICP-MS
Tin (Sn)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Titanium (Ti)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Uranium (U)	$\mu g \cdot L^{-1}$	0.10	NRG	ICP-MS
Vanadium (V)	$\mu g \cdot L^{-1}$	2	N/A	ICP-MS
Zinc (Zn)	$\mu g \cdot L^{-1}$	5	N/A	ICP-MS
PAH				
Naphthalene	$\mu g \cdot L^{-1}$	0.20	1.4	GC/MS
Benzo(j)fluoranthene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Chrysene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Benzo(b)fluoranthene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Benzo(k)fluoranthene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Benzo(a)pyrene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Perylene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Acenaphthylene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Indeno(1,2,3-cd)pyrene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Dibenz(a,h)anthracene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Benzo(g,h,i)perylene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
2-Methylnaphthalene	$\mu g \cdot L^{-1}$	0.05	N/A	GC/MS
Acenaphthene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Fluorene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
1-Methylnaphthalene	$\mu g \cdot L^{-1}$	0.05	N/A	GC/MS
Benzo(a)anthracene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Phenanthrene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Anthracene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Fluoranthene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
Pyrene	$\mu g \cdot L^{-1}$	0.01	N/A	GC/MS
BTEX-TPH				
Benzene	$mg \cdot L^{-1}$	0.001	110	PTGC
Toluene	$mg \cdot L^{-1}$	0.001	215	PTGC
Ethylbenzene	$mg \cdot L^{-1}$	0.001	25	PTGC
Xylene (Total)	$mg \cdot L^{-1}$	0.002	N/A	PTGC
C_6 - C_{10} (less BTEX)	$mg \cdot L^{-1}$	0.01	N/A	PTGC
$>C_{10}$-C_{16} Hydrocarbons	$mg \cdot L^{-1}$	0.05	N/A	PTGC
$>C_{16}$-C_{21} Hydrocarbons	$mg \cdot L^{-1}$	0.05	N/A	PTGC
$>C_{21}$-$<C_{32}$ Hydrocarbons	$mg \cdot L^{-1}$	0.1	N/A	PTGC
Modified TPH (Tier1)	$mg \cdot L^{-1}$	0.1	N/A	PTGC
Reached Baseline at C_{32}	$mg \cdot L^{-1}$	N/A	N/A	PTGC

Parameter	Units	RDL	CCME Guidelines	Analysis Method
Alkylated Phenols				
Nonylphenol (NP)	$ng \cdot L^{-1}$	10	700	LRMS
4-Nonylphenol monoethoxylate (NP1EO)	$ng \cdot L^{-1}$	50	700	LRMS
4-Nonylphenol diethoxylate (NP2EO)	$ng \cdot L^{-1}$	50	700	LRMS
4-n-Octylphenol (OP)	$ng \cdot L^{-1}$	50	N/A	LRMS
Other Measurements				
pH (field)	pH units		7.0-8.7	Field meter
Temperature	˚C		N/A	Field meter
Salinity	PSU		N/A	Conductivity meter

Note: Mercury analysis was not performed on the Produced Water due to a laboratory error.

2.1.5.2 Analysis QA/QC

- Metals in water: Method Blank, Spike Blank, CRM, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- PAH: Method Blank, Blank Spike, Duplicate Sample, Matrix Spike: 1 per 20 samples, Surrogate for all samples.
- Ammonia in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- NOX/NO2/NO3 in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Ortho-Phos in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Total Phosphorous in water: Method Blank, Spike Blank, Sample Duplicate, Matrix Spike - minimum one each per batch, minimum frequency of 1 every 20 samples
- Organic acids in water: Continuous Calibration Blank, Continuous Calibration Verification, Matrix Spike, - minimum one each per batch, minimum frequency of 1 every 20 samples
- Sulphides in water: Blank Spike, Continuous Calibration Blank, Continuous Calibration Verification, Matrix Spike, - Minimum one each per batch, minimum frequency of 1 every 20 samples
- Alkylated Phenols in water: Blank Spike, Continuous Calibration Blank, OPR (On-going Precision and Recovery) Samples, Matrix Spike, - minimum one each per batch, minimum frequency of 1 every 20 samples
- TPH in soil and water - BTEX/C6-C10 - Method Blank, Blank Spike, Duplicate Sample, Matrix Spike - 1 in 20 - Surrogate for all samples C10-C32 - Method Blank, Blank Spike, Duplicate Sample, Matrix Spike - 1 in 20. Surrogate for all samples

- PAH in soil and water - Method Blank, Blank Spike, Duplicate Sample, Matrix Spike - 1 in 20. Surrogate for all samples

2.1.6 Results

As sample from the PFC produced water discharge line was collected on June 10th 2014 at 7 am (local time). At the time of collection, water pH was 6.88 and water temperature was 64°C. Results for Nutrients, Majors Ions, Organic Acids, Trace Metals, PAHs, Alkylated Phenols and BTEX-TPH carried out by Maxxam and Axys laboratories are summarized in the tables below. Maxxam and Axys water quality data can be found in **Appendix A**. CEQG for marine water quality are included in **Appendix B** and reported in the tables below for all detectable chemical parameters.

- Results for Nutrients, Majors Ions and Organic Acids are shown in **Table 2-3** with either non-detectable results or results slightly above the RDL. All results were below CCME guidelines where available.
- Results for Metals, PAHs, Alkylated Phenols and BTEX-TPH can be found in **Table 2-4**, **Table 2-5**, **Table 2-6** and **Table 2-7** respectively. Except for PAH Naphthalene, Toluene and Benzene results where elevated values were found to be above CCME guidelines; all other parameters were found to be below CCME guidelines where available.

Table 2-3 Water Quality Results: Nutrients, Major Ions and Organic Acids

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Calculated Parameters					
Nitrate (N)	mg/L	ND	0.050	3635054	-
Inorganics					
Nitrate + Nitrite	mg/L	ND	0.050	3643542	-
Nitrite (N)	mg/L	ND	0.010	3643546	-
Nitrogen (Ammonia Nitrogen)	mg/L	46	2.5	3643490	No data
Orthophosphate (P)	mg/L	1.4	0.050	3643540	No data
pH	pH	6.95	N/A	3645198	-
Total Phosphorus	mg/L	4.3	0.10	3643491	No data
Salinity	PSU	71	4.0	3638180	-
Sulphide	mg/L	2.6	0.020	3637274	No data
Miscellaneous Parameters					
Formic Acid	mg/L	ND	50	3642997	-
Acetic Acid	mg/L	ND	100	3642997	-

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Propionic Acid	mg/L	ND	100	3642997	-
Butyric Acid	mg/L	ND	200	3642997	-

* CCME Guidelines only for detected parameters only using Water Quality Guidelines for the Protection of Aquatic Life.
RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

ND = Not detected

N/A = Not Applicable

Table 2-4 Water Quality Results: Trace Metals

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Metals					
Total Aluminum (Al)	ug/L	210	50	3636712	No data
Total Antimony (Sb)	ug/L	ND	10	3636712	No data
Total Arsenic (As)	ug/L	ND	10	3636712	-
Total Barium (Ba)	ug/L	3800	10	3636712	No data
Total Beryllium (Be)	ug/L	ND	10	3636712	-
Total Bismuth (Bi)	ug/L	ND	20	3636712	-
Total Boron (B)	ug/L	49000	5000	3636712	NRG
Total Cadmium (Cd)	ug/L	ND	0.10	3636712	-
Total Calcium (Ca)	ug/L	4200000	1000	3636712	No data
Total Chromium (Cr)	ug/L	ND	10	3636712	-
Total Cobalt (Co)	ug/L	ND	4.0	3636712	-
Total Copper (Cu)	ug/L	ND	20	3636712	-
Total Iron (Fe)	ug/L	ND	500	3636712	-
Total Lead (Pb)	ug/L	ND	5.0	3636712	-
Total Magnesium (Mg)	ug/L	510000	1000	3636712	No data
Total Manganese (Mn)	ug/L	510	20	3636712	No data
Total Molybdenum (Mo)	ug/L	ND	20	3636712	-
Total Nickel (Ni)	ug/L	ND	20	3636712	-
Total Phosphorus (P)	ug/L	5000	1000	3636712	No data (short Term)
Total Potassium (K)	ug/L	280000	1000	3636712	No data
Total Selenium (Se)	ug/L	ND	10	3636712	-
Total Silver (Ag)	ug/L	ND	1.0	3636712	-
Total Sodium (Na)	ug/L	18000000	10000	3636712	No data
Total Strontium (Sr)	ug/L	310000	200	3636712	No data
Total Sulphur (S)	ug/L	170000	50000	3636712	No data
Total Thallium (Tl)	ug/L	2.0	1.0	3636712	No data
Total Tin (Sn)	ug/L	ND	20	3636712	-
Total Titanium (Ti)	ug/L	ND	20	3636712	-
Total Uranium (U)	ug/L	ND	1.0	3636712	-
Total Vanadium (V)	ug/L	ND	20	3636712	-

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Total Zinc (Zn)	ug/L	170	50	3636712	No data

* CCME Guidelines only for detected parameters only using Water Quality Guidelines for the Protection of Aquatic Life.

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

ND = Not detected

NRG = No Recommended Guideline

Table 2-5 Water Quality Results: PAHs

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Polyaromatic Hydrocarbons					
1-Methylnaphthalene	ug/L	200 (1)	1.0	3636652	No data
2-Methylnaphthalene	ug/L	230 (1)	1.0	3636652	No data
Acenaphthene	ug/L	3.3	0.010	3636652	Insufficient data
Acenaphthylene	ug/L	ND (2)	0.10	3636652	-
Anthracene	ug/L	ND (2)	0.40	3636652	-
Benzo(a)anthracene	ug/L	ND (2)	0.20	3636652	-
Benzo(a)pyrene	ug/L	0.012	0.010	3636652	Insufficient data
Benzo(b)fluoranthene	ug/L	0.17	0.010	3636652	No data
Benzo(g,h,i)perylene	ug/L	0.022	0.010	3636652	No data
Benzo(j)fluoranthene	ug/L	0.015	0.010	3636652	No data
Benzo(k)fluoranthene	ug/L	ND	0.010	3636652	-
Chrysene	ug/L	1.7	0.010	3636652	Insufficient data
Dibenz(a,h)anthracene	ug/L	ND	0.010	3636652	-
Fluoranthene	ug/L	2.7	0.010	3636652	Insufficient data
Fluorene	ug/L	55 (1)	0.20	3636652	Insufficient data
Indeno(1,2,3-cd)pyrene	ug/L	ND	0.010	3636652	-
Naphthalene	ug/L	310 (1)	4.0	3636652	1.4
Perylene	ug/L	0.036	0.010	3636652	No data
Phenanthrene	ug/L	56 (1)	0.20	3636652	Insufficient data
Pyrene	ug/L	1.5	0.010	3636652	Insufficient data
Surrogate Recovery (%)					
D10-Anthracene	%	99		3636652	
D14-Terphenyl	%	115		3636652	
D8-Acenaphthylene	%	90		3636652	

* CCME Guidelines only for detected parameters only using Water Quality Guidelines for the Protection of Aquatic Life.

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

ND = Not detected

(1) Elevated PAH RDL(s) due to sample dilution.

(2) Elevated PAH RDL(s) due to matrix / co-extractive interference.

Table 2-6 Water Quality Results: alkylated Phenols

	Units	Produced water	RL	CCME Guidelines *
Alkylphenols				
4-Nonylphenols	ng/L	122	33.2	700
4-Nonylphenols monoethoxylates	ng/L	ND	157	700
4-Nonylphenols diethoxylates	ng/L	ND	13.3	700
Octylphenol	ng/L	ND	49.9	N/A
13C6-4-n-Nonylphenol	% recovery	118%		
13C6-NP2EO	% Recovery	88.4		

RL = Reporting Limit (code): S= Sample Detection Limit

ND = Not detected

N/A = Not Applicable

Table 2-7 Water Quality Results: BTEX-TPH

	Units	Produced water	RDL	QC Batch	CCME Guidelines *
Petroleum Hydrocarbons					
Benzene	mg/L	3.2	0.050	3642551	0.110
Toluene	mg/L	1.3	0.025	3642551	0.215
Ethylbenzene	mg/L	0.049	0.025	3642551	0.250
Xylene (Total)	mg/L	0.39	0.050	3642551	No data
C6 - C10 (less BTEX)	mg/L	ND	0.50	3642551	No data
>C10-C16 Hydrocarbons	mg/L	5.9	0.050	3636573	No data
>C16-C21 Hydrocarbons	mg/L	8.3	0.050	3636573	No data
>C21-<C32 Hydrocarbons	mg/L	5.3	0.10	3636573	No data
Modified TPH (Tier1)	mg/L	20	0.50	3635114	No data
Reached Baseline at C32	mg/L	Yes	N/A	3636573	-
Hydrocarbon Resemblance	mg/L	COMMENT (1)	N/A	3636573	-
Surrogate Recovery (%)					
Isobutylbenzene - Extractable	%	106		3636573	
n-Dotriacontane - Extractable	%	97		3636573	
Isobutylbenzene - Volatile	%	104		3642551	

* CCME Guidelines only for detected parameters only using Water Quality Guidelines for the Protection of Aquatic Life.

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

ND = Not detected

N/A = Not Applicable

(1) Fuel oil fraction.

2.1.7 Summary and Conclusions

- This data set represents produced water levels measured while the PFC was operational;
- Except for elevated Naphtalene (PAH) levels of 310 µg/L (CCME guideline threshold 1.4 µg/L) Benzene levels of 3.2 mg/L (CCME Guideline threshold 0.11 mg/L) and Toluene levels of 1.3 mg/L (CCME Guideline threshold 0.215 mg/L), metal, non-metal, hydrocarbon and nutrient concentrations in the produced water were all found to fall below threshold levels as defined by the Canadian EQG (CCME Guidelines) where available.
- Due to logistical constraints which prevented sampling operations (see Section 1), produced water was tested only once instead of twice and no toxicity tests were performed.

2.2 SEDIMENT CHEMISTRY

2.2.1 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).

2.2.2 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**].

2.2.3 Objectives

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

2.2.4 Sampling

No sampling took place in 2014 (see Section 1).

2.3 SEDIMENT TOXICITY

2.3.1 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.

2.3.2 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** from the Offshore EEMP].

2.3.3 Objectives

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

2.3.4 Sampling

No sampling and laboratory-based sediment toxicity bioassays tests took place in 2014 (see Section 1).

2.4 FISH HABITAT ALTERATION

2.4.1 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.

2.4.2 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**].

2.4.3 Objectives

Assess the extent of fish habitat created by new hard substrate provided by subsea production structures installed for the Deep Panuke natural gas field. Compare species found and coverage of structures to previous years.

2.4.4 Sampling

Collect annual remotely-operated vehicle (ROV) video-camera imagery of 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.

2.4.5 Analysis

2.4.5.1 Subsea Structures

Subsea inspection videos of the wellhead areas (summer and winter 2014) and of the PFC area (summer 2014) were provided on a hard-drive and DVD 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. Data from 2014 was compared to the 2013 video data.

2.4.5.2 Cuprotect Coated Structures

Subsea inspection videos of structures coated with the Cuprotect antifouling products in the PFC riser/spools and wellhead areas (summer 2014) were provided on a hard-drive DVD 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 inspection (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.

2.4.5.3 GEP and Flowlines

Videos of the export pipeline subsea inspection survey (June 2014) 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 2014 survey data (same locations as surveyed in 2011, 2012 and 2013) 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 easily quantifiable.

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, 2012 and 2013 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 23, KP 98 KP 172, 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.

2.4.6 Analysis QA/QC

All identifications were agreed upon by two taxonomists and compared to species from the 2011, 2012 and 2013 reports for reference. All structures shown in the videos were identified using the commentary.

2.4.7 Results

2.4.7.1 Subsea Structures

- Abundances and species present were comparable to the 2013 survey of the WHPS at each location. Like 2013, the 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*.
- Like 2013, zonation was observed occurring on each WHPS in different locations. The bottom zone was mainly colonized by mussel (*Mytilus edulis),* sea cucumbers (*Cucumaria frondosa*) in varying densities, with the crabs (Cancer spp.), and the seastar Asterias vugaris on the surrounding seafloor. The top zone was colonized mainly by blue mussels (*Mytilus edulis*), frilled anemone (*Metridium senile)* and hydroids (Tubularia spp.) (**Tables 2.8-2.11; 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. Percentage cover of marine growth would be closer to 100% had cleaning not occurred. Similar abundances of *Mytilus edulis* and *Metridium senile* were observed in 2014 as 2013. More Tubularia was found in 2014 than 2013, as it appears to be growing with the frilled anemones, on top of blue mussel (**Tables 2.8-2.11; Figure 2.2**).
- Crustaceans included the occasional crab (Cancer sp.), which was usually on the surrounding seafloor. A lobster was observed at the base of a leg at WHPS H-08 in July 2014 **(Figure 2.1a**).

- As in 2013, sculpin (*Myoxocephalus* sp.) was the only fish species observed that lives on the sea bottom on the WHPS in the 2014 survey.
- In the summer 2014 survey of PFC legs, dense mussels (*Mytilus edulis*) were observed over the entire legs, except the few meters near the base. Each leg had patches of dense sea stars (*Asterias vulgaris*) around the midpoint and hydroids (*Tubularia* spp.) were more prevalent around the bottom of the legs, where there were less mussels present. Some of the anemone, *Metridium senile,* were found on each leg on the upper portion (**Table 2.12; Figure 2.3**).
- A wolffish was found at F-70 flowline area under a concrete mattress near the WHPS structure in July of 2014.
- High densities of fish were reported throughout the year on additional ROV surveys around the PFC area. The fish were of the Gadidae family (either pollock, haddock or cod) (Figure 2.10).
- High densities of sea stars were also observed on the surrounding seafloor in the PFC area.
- A shark (likely a porbeagle (*Lamna nasus*)) and a school of amberjacks (*Seriola sp*.) were also observed around the PFC area in December 2014 (Figure 2.10). The porbeagle has been under endangered status according to COSEWIC (Committee on the Status of Endangered Wildlife in Canada) since 2004. The porbeagle remains on the endangered list (which was reassessed and confirmed in 2014) due to by catch in Canadian fisheries and unrecorded mortalities in international fisheries. Porbeagles also mature late and have a low reproductive rate (http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm).

Table 2-8 Summer 2014 Survey of GVI of WHPS compared to 2013 Spring Survey

Wellhead Site	Structure	Fauna	Spring 2013 Abundance	2014 Abundance	2014 Number	Description
E-70	WHPS (Aug)	*Metridium senile*	A	A	-	Mats of sea stars on surrounding seafloor
		Tubularia? spp.	C	S	-	
		Mytilus edulis	S	S	-	Dense mussel and hydroids
		Cancer sp.	-	-	1	Metridium dense in patches
		Cucumaria frondosa	C	C	-	
		Asterias vulgaris	O	A	-	Sea cucumbers on lower parts of the WHPS and surrounding seafloor
		Henricia sp.	-	C	-	

Wellhead Site	Structure	Fauna	Spring 2013 Abundance	2014 Abundance	2014 Number	Description
		Tautogoabrus adspersus	-	-	~70	Cancer sp. On surrounding seafloor
	Seasea Tree (Aug)	*Metridium senile*	-	C	-	Dense marine growth coverage, almost 100%
		Tubularia? spp.	-	S	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	-	A	-	
		Henricia sp.	-	C	-	
		Tautogoabrus adspersus	-	-	20	
F-70	WHPS (Aug)	Porifera (encrusting)	-	R	-	Black and white camera used for GVI- poor visibility Dense mussels and hydroids Sea stars dense on surrounding seafloor Cancer sp. On surrounding seafloor
		Metridium senile	A	S/A	-	
		Tubularia? spp.	F	A	-	
		Hydroids	-	S	-	
		Mytilus edulis	S	S/A	-	
		Cancer sp.	-	-	5	
		Cucumaria frondosa	-	A	-	
		Asterias vulgaris	F	C	-	
		Henricia sp.	-	C	-	
		Hemitripterus sp.	-	-	1	
		Pollachius sp.	-	-	~300	
		Tautogoabrus adspersus	-	-	~100	
		Unidentified fish	-	-	6	
	Subsea Tree (Aug)	*Metridium senile*	-	A	-	
		Tubularia? spp.	-	A	-	
		Mytilus edulis	-	S	-	
		Asterias vulgaris	-	C	-	
		Tautogoabrus adspersus	-	-	~10	

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

Table 2-9 Summer 2014 Survey of GVI of WHPS Compared to Fall 2013 Survey

Wellhead Site	Structure	Fauna	Fall 2013 Abundance	2014 Abundance	2014 Number	Description
M-79A	WHPS (Aug)	*Metridium senile*	A	A	-	*Cucumarina* on bottom 3m of legs
		Tubularia? spp.	C	A	-	
		Campanulariidae? sp.	R	-	-	
		Jellyfish	-	C	-	
		Mytilus edulis	S	S	-	
		Cucumaria frondosa	C	O	-	
		Asterias vulgaris	F	C	-	
		Ophiuroidea	-	R	-	
		Myoxocephalus sp.	O	-	-	

Wellhead Site	Structure	Fauna	Fall 2013 Abundance	2014 Abundance	2014 Number	Description
		Pollachius sp.	A	-	-	
		Tautogoabrus adspersus	A	C	-	
		Unidentified fish	-	C	-	
	Subsea Tree (Aug)	*Tubularia? spp.*	-	S	-	
		Mytilus edulis	-	A	-	
		Asterias vulgaris	-	C	-	
		Henricia sp.	-	C	-	

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

Table 2-10 Winter 2014 Survey of GVI of WHPS Compared to 2013 Spring Survey

Wellhead Site	Structure	Fauna	Spring 2013 Abundance	2014 Abundance	2014 Number	Description
D-41	WHPS (Dec)	Porifiera	-	R	-	*Metridium* dense in patches
		Metridium senile	A	S	-	Hydroids very dense in patches
		Tubularia? spp.	R	S	-	
		Mytilus edulis	S	S	-	Asterias abundant on surrounding seafloor
		Cancer sp.	-	-	1	
		Cucumaria frondosa	C	C	-	2 *Cancer sp*. on surrounding seafloor
		Asterias vulgaris	F	C	-	
		Ophiuroidea	-	O	-	
		Myoxocephalus sp.	-	-	4	
		Tautogoabrus adspersus	-	-	~70	
	Subsea tree (Dec)	*Metridium senile*	F	S	-	*Asterias vulgaris* on top of panel
		Tubularia? spp.	-	A	-	
		Hydoids	-	A	-	
		Mytilus edulis	F	S	-	
		Cucumaria frondosa	O	-	-	
		Asterias vulagaris	O	C	-	
		Tautogoabrus adspersus	-	-	100	

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

Table 2-11 Summer 2014 Survey of GVI of WHPS Compared to 2013 Fall Survey

Wellhead Site	Structure	Fauna	Fall 2013 Abundance	2014 Abundance	2014 Number	Description
H-08	WHPS (Sept)	*Metridium senile*	A	A	-	Video was very short (~3min)
		Tubularia? spp.	F	C	-	
		Mytilus edulis	S	S	-	
		Cucumaria frondosa	R	R	-	
		Asterias vulgaris	F	F	-	
		Myoxocephalus sp.	C	-	-	
		Pollachius sp.	A	S/A	-	

Wellhead Site	Structure	Fauna	Fall 2013 Abundance	2014 Abundance	2014 Number	Description
		Tautogoabrus adspersus	A	F	-	
		Urophysis sp.	-	1	-	

Table 2-12 Summer 2014 Survey of GVI of PFC legs compared to 2013 data

Wellhead site	Structure	Fauna	2013 Abundance	2014 Abundance	2014 Number	Description
PFC	Riser caisson (Jul)	*Mytilus edulis*	-	S	-	Almost 100% mussel coverage
		Metridium senile	-	O	-	
		Asterias vulgaris	-	F	-	*Metridium* only found closer to the surface
		Tautogolabrus adspersus	-	-	25	
		Unidentified fish	-	F		
	SSIV (Apr)	*Campanulariidae? sp.*	C	O	-	Mussels in patches
		Metridium senile		O	-	*Metridium* primarily on top
		Tubularia? spp.	S	C	-	
		Mytilus edulis	A	F	-	Not much marine growth coverage - cleaning?
		Cucumaria frondosa	C	C	-	
		Asterias vulgaris	F	O	-	
		Myoxocephalus sp.	C	-	-	
		Tautogolabrus adspersus	A	-	-	
	PFC Leg 1 (Jul)	*Metridium senile*	F	-	-	Few marine organisms at the base of the leg. -Mussels start a few meters up, increasing in number at the leg gets closer to the surface. - Sea stars are present where mussels star on the leg, but do not continue towards the top. - Some *Metridium* is present closer to the surface. -Cunner were present at the base of leg 1, but not the other legs of the PFC.
		Tubularia? spp.	A	F	-	
		Mytilus edulis	S	A	-	
		Asterias vulgaris	C	C	-	
		Tautogolabrus adspersus	-	C	-	
		Unidentified fish	-	O	-	
	PFC Leg 2 (Jul)	*Metridium senile*	F	F	-	
		Tubularia? spp.	A	F	-	
		Mytilus edulis	S	S	-	
		Myoxocephalus sp.	O	-	-	
		Cucumaria frondosa	R	-	-	
		Asterias vulgaris	C	C	-	
	PFC Leg 3 (Jul)	*Metridium senile*	F	F	-	
		Tubularia? spp.	A	F	-	
		Mytilus edulis	S	S	-	
		Myoxocephalus sp.	O	-	-	
		Cucumaria frondosa	R	-	-	
		Asterias vulgaris	C	C	-	

Wellhead site	Structure	Fauna	2013 Abundance	2014 Abundance	2014 Number	Description
	PFC Leg 4 (Jul)	*Metridium senile*	F	F	-	
		Tubularia? spp.	A	F	-	
		Mytilus edulis	S	S	-	
		Asterias vulgaris	C	F	-	
	Protection tunnel (F-70) (Aug)	*Tubularia?* spp	A	-	-	
		Mytilus edulis	S	-	-	
		Cucumaria frondosa	-	A	-	

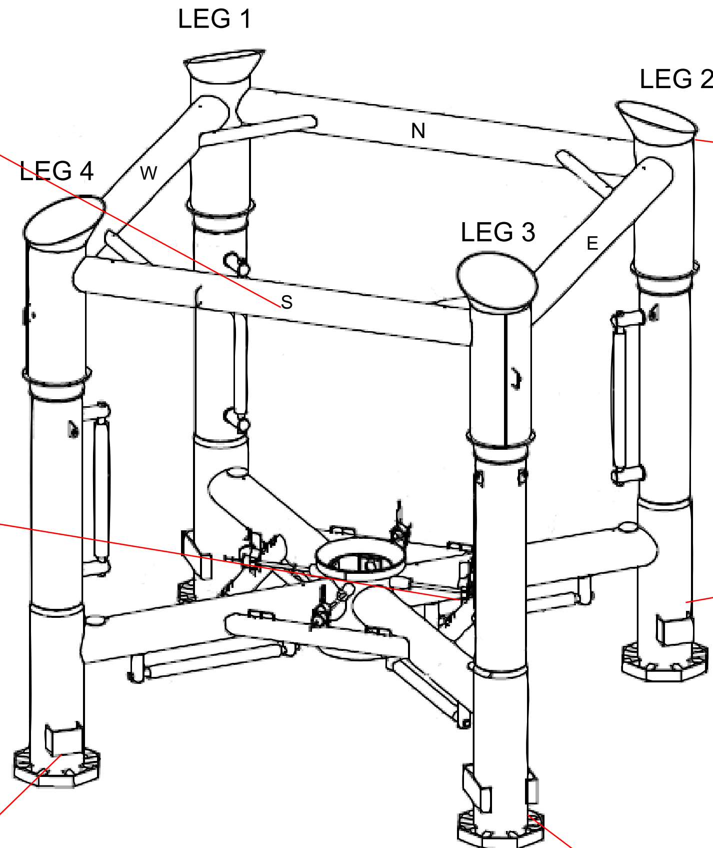
***** Abundance values are based on the SACFOR scale (S = superabundant; A = abundant; C = common; F = frequent; O = occasional; R = rare)

Station H-08


Dense coverage of mussels, hydroids and seastars on the south crossbar between Legs 3 and 4


Dense mussel and hydroid coverage on the lower crossbar between Legs 2 and 3


A lobster at the base of a leg



Wellhead Protection Structure


Frilled anemones, blue mussel, hydroids and cunner at the top of Leg 2.


Blue mussel at the bottom of Leg 2

A school of pollock at the base of Leg 3

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

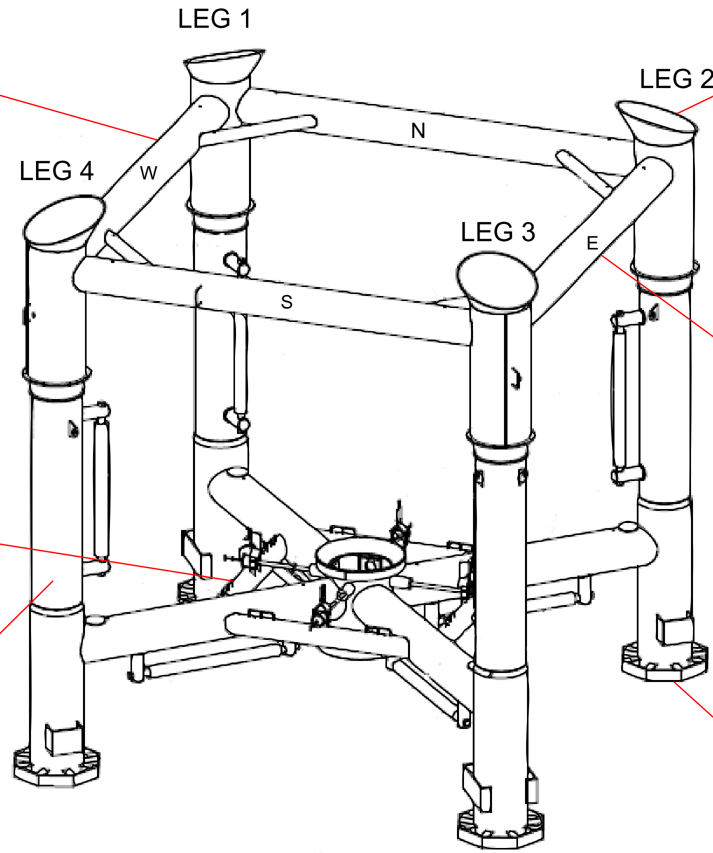
Figure 2.1a

Station M-79A


Dense blue mussel and hydroid coverage on the West horizontal bracket.


Dense blue mussel coverage on HB01-8.


Dense mussels and hydroids, with some frilled anemone, in the middle of Leg 4.



Wellhead Protection Structure


Dense mussels, hydroids and frilled anemones at the top of Leg 2.


East horizontal bracket with blue mussels and hydroids.


A sea cucumber near the bottom of Leg 2. It appears that cleaning has taken place.

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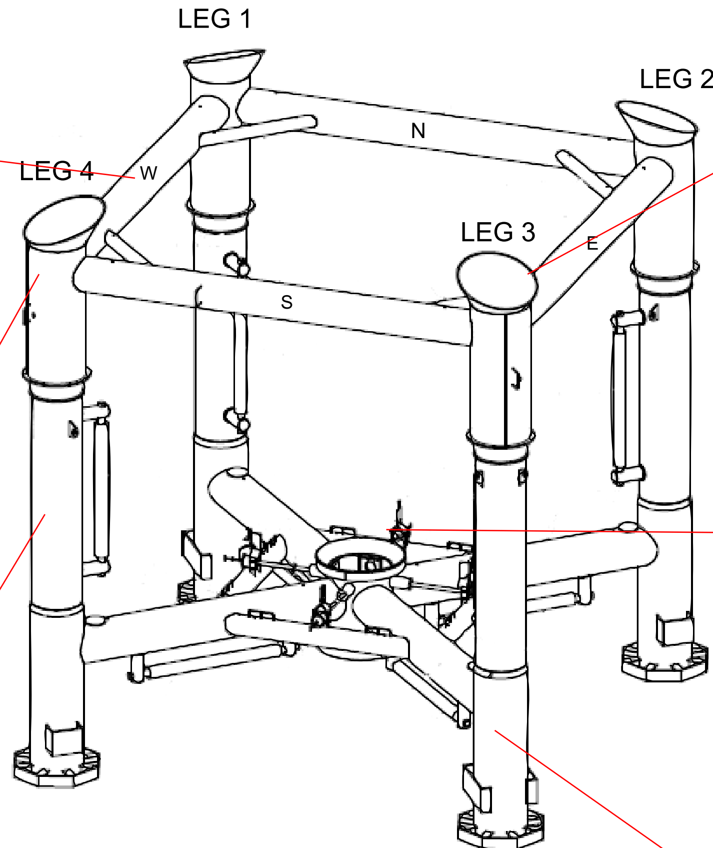
Station F-70

West horizontal bracket

The top of Leg 4,

Hydroids and mussels cover the middle of Leg 4.
A cunner is visible swimming near the structure.



Wellhead Protection Structure

Cunner swim around the top of Leg 3

The subsea tree inside the wellhead protection structure, covered with mussel, sea star and frilled anemones

Dense blue mussels with some frilled anemones near the base of Leg 3, showing Anode 3

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

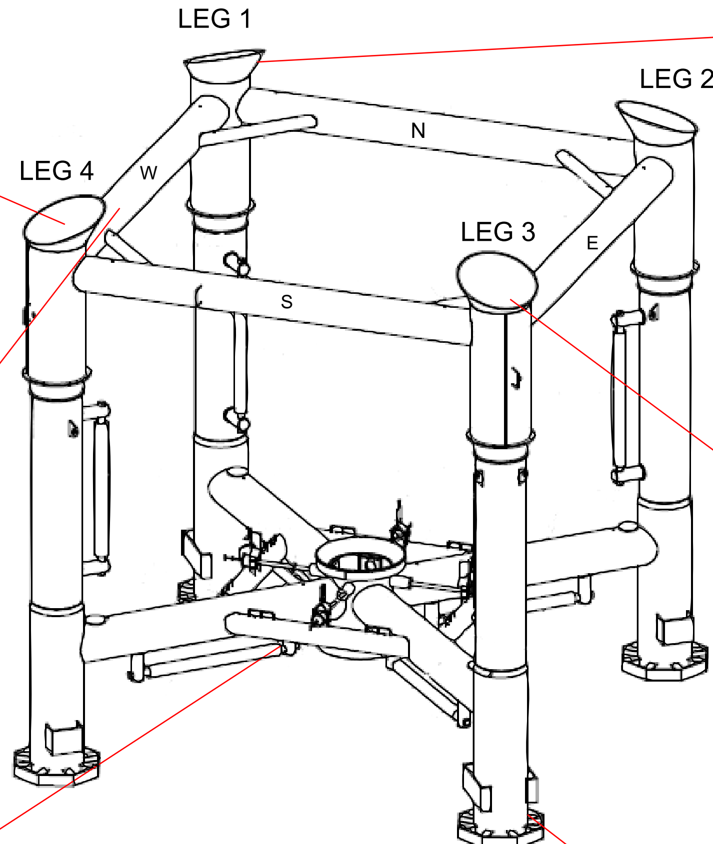
Figure 2.1c

Station D-41

Dense frilled anemones covering the top of Leg 4

Dense hydroids and frilled anemone on the west horizontal brace between Legs 1 and 4

Dense frilled anemones covering the inside of the wellhead protection structure



Wellhead Protection Structure

Dense frilled anemone on the top of Leg 1

Dense patches of frilled anemones at the top of Leg 3

Little marine growth at the base of Leg 3

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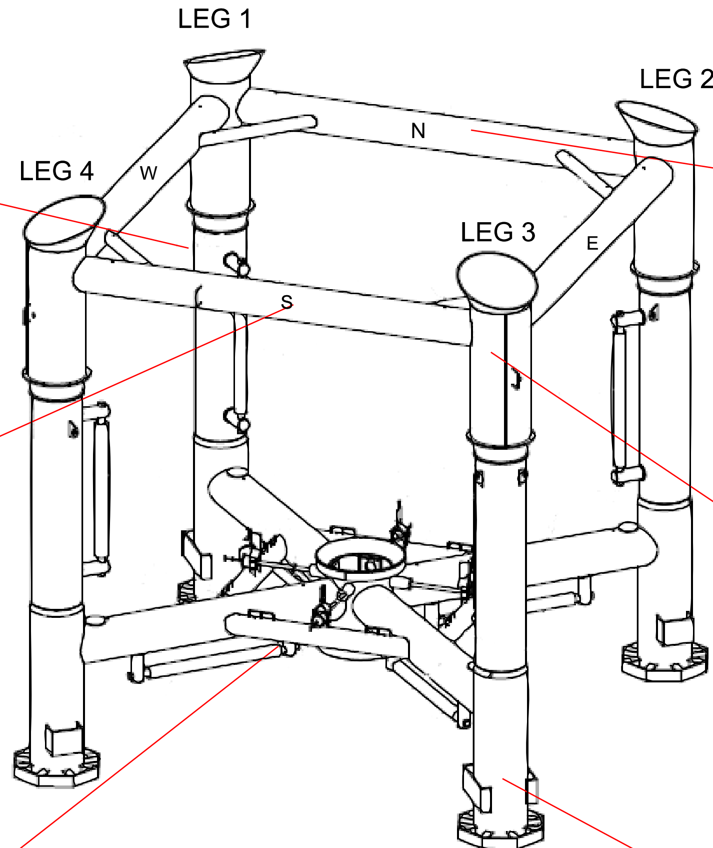
Figure 2.1d Wellhead Protection Structures and Associated Fauna at D-41

Station E-70

Dense frilled anemone and blue mussel at the mid point of Leg 1

Dense mussels on the south crossbar between Legs 3 and 4

Frilled anemone, blue mussels and hydroids on the HB01-7 crossbar



Wellhead Protection Structure

Dense hydroids and blue mussel with some sea stars on the crossbar between Legs 1 and 2

A mix of blue mussels, frilled anemones, sea stars and hydroids near the top of Leg 3

Dense blue mussels with frilled anemones and hydroids near the base of Leg 3

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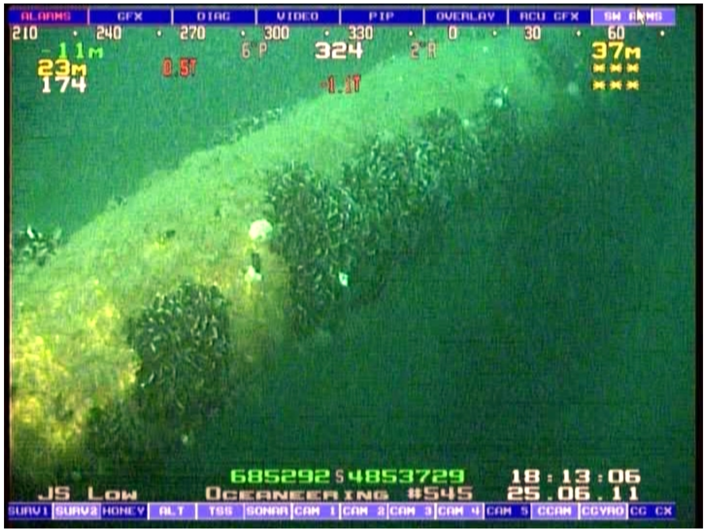
Figure 2.1e Wellhead Protection Structures and Associated Fauna at E-70

Figure 2.1e

2011 Survey

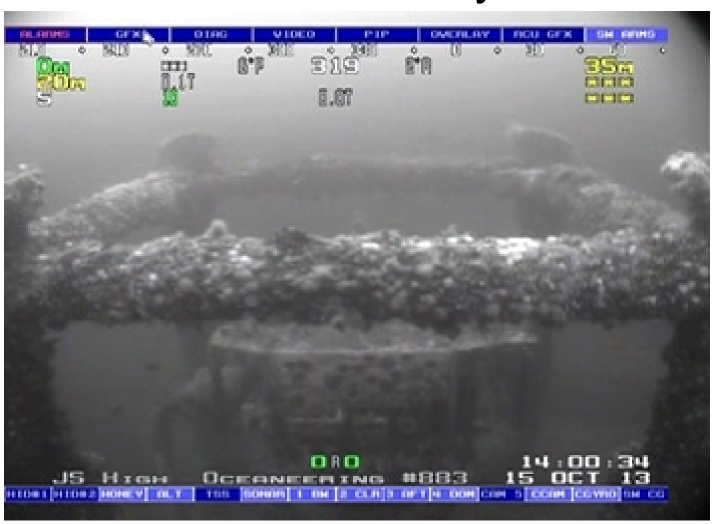


Moderate marine growth on East horizontal bracket at WHPS M-79A in 2011 survey

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

2014 Survey

100% coverage of marine fauna on the East Horizontal Bracket at WHPS M-79A in 2014. Appears to be little change from the 2013 survey.

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Figure 2.2a Comparison of 2011, 2012, 2013 and 2014 Surveys at WHPS M79-A Figure 2.2a

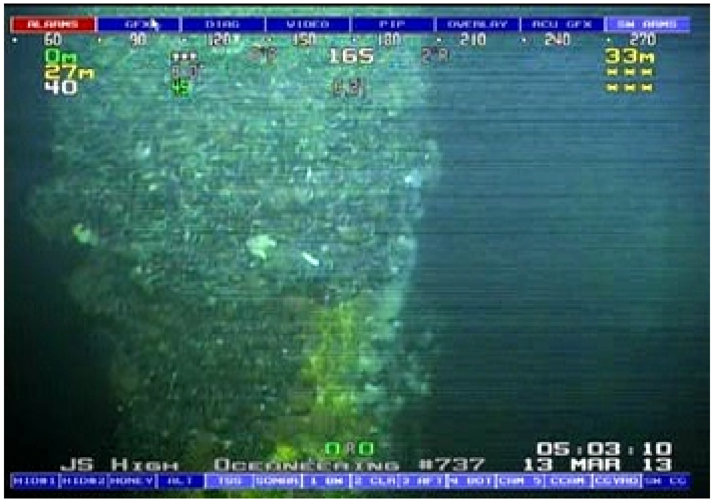
2011 Survey

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.

2014 Survey

Dense mussel coverage, but also additional frilled anemones and hydroids in the 2014 survey.

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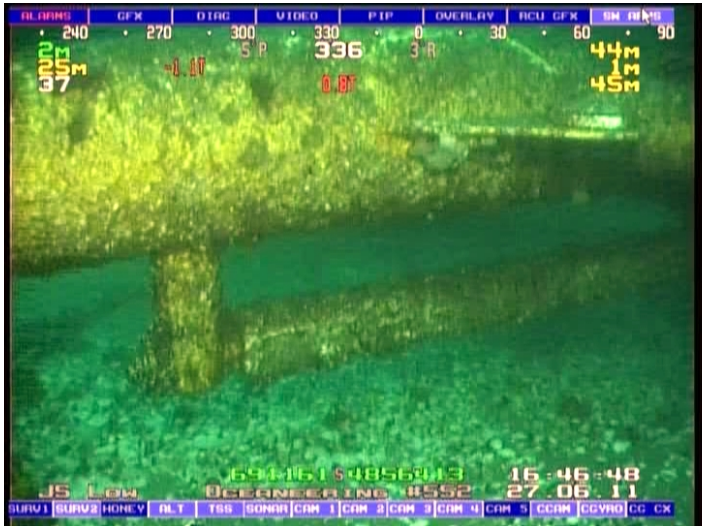
Figure 2.2b Comparison of 2011, 2012, 2013 and 2014 Surveys at WHPS F-70

Figure 2.2b

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.

2014 Survey

Dense mussel coverage on anode An04. Increased numbers of frilled anemones in the 2014 survey, as opposed to sea cucumbers in 2013.

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Figure 2.2c Comparison of 2011, 2012, 2013 and 2014 Surveys at WHPS D-41

Figure 2.2c

2.4.7.2 Cuprotect Coated Structures

- Mussel species, *Mytilus edulis*, were a new species for Cuprotect coated structures and PFC area structures in 2013, and continue to be the dominant species in those areas in the 2014 survey. (**Table 2.13**).
- Dense mussels and some sea stars and hydroids covered most part of PFC structure. Straps on Cuprotect coated structures were the main areas of colonization for species found such as the mussel *Mytilus edulis*, the sea cucumber *Cucumaria frondosa* and hydroid species (**Figure 2.4**). However, near wellhead F-70 there was a hydroid growing on the F4 flange insulation cover where Cuprotect was present, and also many sea cucumbers on the F3 flange insulation cover at F-70. Closing spools at the E-70, F-70 and M79-A wellhead sites had mussel, hydroids, and the sea star *Asterias vulgaris*.
- Like 2013, sculpins were also present, especially at the base of the riser caisson. Cunner were also present, swimming around the base of the riser caisson.

Table 2-13 Cuprotect Coated Structures Summer 2014

Wellhead site	Structure	Fauna	2013 Abundance	2014 Abundance	2014 Number	Description
PFC	Base of Riser Caisson (Jul)	*Tubularia? spp.*	A		-	
		Mytilus edulis	S	S	-	
		Asterias vulgaris	-	F	-	
		Cucumaria frondosa	-	C	-	
		Myoxocephalus sp	C	-	-	
		Tautogolabrus adspersus	-	-	5	
E-70	Closing spool E-70 (Aug)	*Tubularia? spp.*	-	C	-	
		Mytilus edulis	-	C	-	
		Tautogolabrus adspersus	-	-	~20	
F-70	Closing spool F-70 (Aug)	*Metridium senile*	-	C	-	
		Tubularia? spp.	-	C	-	
		Mytilus edulis	-	C	-	
		Asterias vulgaris	-	C	-	
M79-A	Closing spool M79-A (Aug)	*Tubularia? spp.*	-	A	-	
		Mytilus edulis	-	A	-	
		Asterias vulgaris	-	C	-	
F-70	F-70 Flange	*Metridium senile*	-	A	-	100% coverage

Wellhead site	Structure	Fauna	2013 Abundance	2014 Abundance	2014 Number	Description
	(Aug)	*Mytilus edulis*	-	A	-	
F-70	F4 Flange Insulation Cover (F-70) (Aug)	*Tubularia? spp.* *Mytilus edulis* *Cucumaria frondosa*	- - -	C C C	- - -	*Cucumaria* and *Mytilus* mainly on straps. Hydroids are on Cuprotect coated area
F-70	F3 Flange Insulation Cover (F-70) (Aug)	*Cucumaria frondosa*	-	C	-	Some on straps, others on Cuprotect area

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

2013 Survey

2014 Survey

Base of PFC leg 1 with some mussel and sea star coverage.

Less marine growth on the PFC leg in 2014 than 2013. This could be due to cleaning.

Some mussel and sea star coverage mid leg, similar to the base of the leg.

Dense mussle colonization mid leg, with dense patches of sea stars.

Dense mussel patches near the top of the leg, with some possible *Metridium senile.*

Increased mussel coverage (almost 100%) near the top of the leg, with some possible *Metridium senile.*

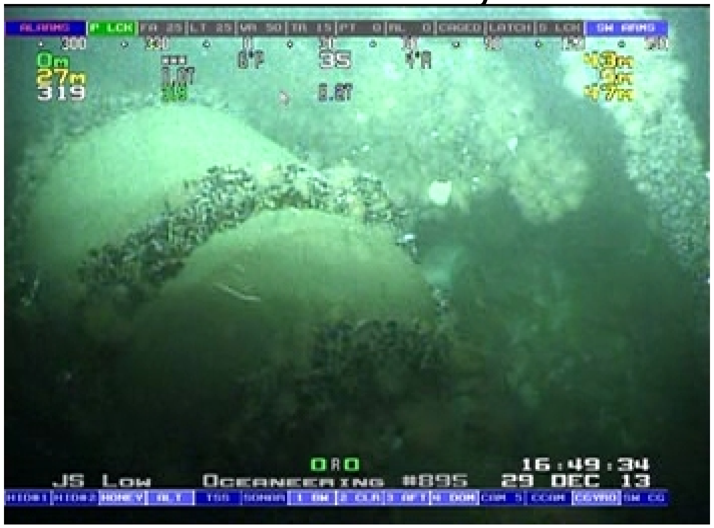
2011 Survey

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

2014 Survey

Growth appears similar to the 2013 insulation cover (only video/photo available of lower riser area from 2014 videos).

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Figure 2.4 Comparison of 2011, 2012, 2013 and 2014 Cuprotect Coated Structures

Figure 2.4

2.4.7.3 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 C, Fish Habitat Alteration Video Assessments; Figures 2.5 to 2.12**);
- Redfish showed an increase in numbers from the 2013 to 2014 survey (14178 in 2013; 18763 in 2014) 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. 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 often created. Depending on how the lights are adjusted on the ROV the base of the pipe is not always visible on video, making fish and other species difficult to see and identify (**Figure 2.7**).
- Numbers of Atlantic cod showed a decrease in numbers from 612 individuals in 2013 to 199 individuals in 2014. This may be due to the migrational nature of the Atlantic cod population on the Scotian Shelf, as the video was recorded in August/September in 2013 and June in 2014. 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. In 2014, 34 unidentified gadoids were found in the analyzed sections of pipe along the GEP (**Figure 2.7**).
- Numbers of flatfish (Pleuronectidae) near the pipeline increased in the 2014 survey (0 in 2013 and 34 in 2014). As flatfish typically cover themselves with sand to blend in with the surrounding substrate video quality could be a factor in reported numbers from year to year (**Figure 2.7**).
- A single Atlantic torpedo ray (*Torpedo nobiliana*) was found in the 2014 survey at KP ~75. A single torpedo ray was also found in the 2012 and 2013 surveys at KP's 48 and 46 respectively (**Figure 2.5**).
- A total of 22 Atlantic wolffish (*Anarhichas lupus*) were found in the 36 sections analyzed of the GEP. In the 2013 survey, no wolffish was found in the 36 analyzed sections, and two were found outside the 23KP-93KP analyzed area. The Atlantic wolffish is notable, as it is considered a species of special concern under the Species at Risk Act. In all wolffish video sightings they appeared to have a burrow at the base of the pipe, or to be swimming along the protected area at the base of the pipe (Figure 2.7).
- Snow crab (*Chionoecetes opilio*) were observed in 33 of 36 videos analyzed, totalling 1352 individuals sighted, which is an increase from the 2013 survey which had 1023

individuals appearing in 28 of the 36 videos. Jonah crab (*Cancer borealis*) were more abundant in 2014, with 1593 total individuals observed compared to 1063 total individuals in 2013. Hermit crab (*Pagurus sp*.) numbers decreased by 75% from 32 in 2013 to 8 in 2014, however, this may be due to video quality, as many hermit crabs are small in size. Northern Stone crab (*Lithodes maja*) numbers decreased by over 35%, having 102 individuals in 2013 and 66 in 2014 (**Figure 2.8**).

- Like past survey years, crustaceans (**Figure 2.8**) were observed on video sitting on top of the pipe and climbing on it. Similarly to the 2013 survey, American lobster was found at the base of the pipe but has not yet been observed on top of, or climbing the pipe in these particular videos.
- Commonly observed sea stars (*Asterias* sp. and *Henricia* sp.) were shown to increase in total numbers by over 100% in 2014 (14940 in 2013, and 35094 in 2014). The small size of many of the sea stars inhabiting the pipeline makes it difficult to obtain exact numbers. Superior video quality in 2012 and 2014 may be a factor in decreased numbers of the 2013 survey. 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, 2013 and 2014 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 increase in echinoderm numbers at KP 73, 83 and 93, and the decrease in echinoderm numbers at KP 63. Due to the small size and abundance of echinoderms. Video quality likely plays a factor in the echinoderm numbers reported from year to year. There was an increase in anthozoa (sea anemones) and crustaceans (mainly due to visible shrimp) at KP 33, and an increase in fish numbers at KP 73 (primarily due to redfish numbers).
- Many dead crabs, or crab exoskeletons from molting were found near the GEP. At least 17 of the 36 videos analyzed had dead crabs present, ranging from 1 to 12 in each video. The majority were Jonah crabs, and only 3 individuals were snow crabs. Piles of rotting debris from dead animals were also found along the GEP (**Figure 2.11**).
- Garbage and debris were also found at the GEP, which seems to act as a barrier that traps garbage. Garbage was found in at least 14 of the 36 videos analysed. The most common item found were beer/soda cans, followed by rubber fishing gloves, glass bottles and rope/other debris (**Figure 2.12**).

- Flowlines from the PFC to the wellheads are mostly buried, either with rock or sand. (**Figure 2.9**). The most abundant species were consistent across all five flowlines. 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” on the SACFOR scale. The majority of the video for the flowlines was of poor quality, so it was difficult to identify to a species or genus level.
- Buried sections of the GEP and flowlines were covered by sand, rock, or a mixture of the two (**Table 2.14**). Species found on the flowlines in 2014 were consistent with those found in the 2013 survey. The main epifauna found on sandy sections of the buried flowlines and GEP were sea stars, sand dollars, and the occasional Jonah crab (*Cancer borealis*) and sculpin or sea raven. Other species found in sandy sections of the buried flowines include flatfish, gadoids (cod, pollock or haddock), and hake. 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, sea cucumbers were super abundant. On concrete mattresses sea cucumbers were also super abundant, as well as concrete protection mattresses, sea cucumbers were super abundant, with occasional sea stars. Uncommon, notable species found on the flowlines were a grey seal found at the H-08 flowline, and a skate found at the F-70 flowline (**Figure 2.9).**
- 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. 2014 video quality was poor due to high amounts of marine snow and decreased our ability to identify other species present other than sea cucumbers on areas of exposed pipe. Buried sections were similar to the flowlines. Sand areas had either sea stars or sand dollars, with the occasional Jonah crab, and rocky areas had sea cucumbers, sea stars and Jonah crabs. Exposed flowlines had abundant sea cucumbers. No notable species were found in these sections of pipe/buried pipe.

Table 2-14 Species abundances along flowlines by substrate type – June 2014

Flowline	Substrate	Species	Abundance
H-08	Sand	Sponge	O
		Clam (?)	R
		Cancer sp.	O
		Shrimp	R
		Sea star	F
		Sand dollar	F
		Sea cucumber	F
		Flatfish	O
		Gadoid	O
		Hake	R
		Sculpin	O
		Unidentified fish	F
		Grey Seal	R
	Rock/Sand	Sponge	R
		Hermit crab	O
		Cancer sp.	O
		Sea star	F
		Sea cucumber	A
		Sculpin	R
		Unidentified fish	O
	Rock	Sponge	F
		Cancer sp.	F
		Hermit crab	R
		Sea star	F
		Sea cucumber	A
		Gadoid	R
		Sculpin	O
		Unidentified fish	F
	Exposed Flowline	Sea cucumber	S
M-79A	Sand	Sponge	R
		Cancer sp.	F
		Sea star	O
		Sea cucumber	R
		Sand dollar	F
		Sculpin	O
		Unidentified fish	O
	Sand/Rock	Cancer sp.	R
		Sea star	F
		Sea cucumber	S
		Unidentified fish	R
	Rock	Cancer sp.	O
		Sea star	O
		Sea cucumber	S
	Exposed Flowline	Sea cucumber	S
F-70	Sand	Sponge	R
		Cancer sp.	O
		Sea star	O
		Sea cucumber	R

Flowline	Substrate	Species	Abundance
		Sand dollar	C
		Flatfish	R
		Gadoid	O
		Sculpin	O
		Skate	O
		Unid fish	F
	Rock/Sand	Sponge	R
		Cancer sp.	O
		Sea star	O
		Sea cucumber	S
		Unidentified fish	O
	Rock	Sea star	O
		Sea cucumber	S
	Exposed Flowline	Sea cucumber	S
	Concrete Mattress	Sea star	O
		Sea cucumber	S
D-41	Sand	Cancer sp.	F
		Sea star	O
		Sea cucumbers	O
		Sand dollar	O
		Hermit crab	R
		Gadoid	R
		Flatfish	O
		Hake	R
		Pollock	R
		Sculpin	O
		Unidentified fish	F
	Rock/Sand	Sponge	R
		Cancer sp.	R
		Hermit crab	R
		Sea star	R
		Sea cucumber	A
	Shell/Rock/Sand	Cancer sp.	O
		Sea star	O
		Sea cucumber	A
		Unidentified fish	R
	Rock	Sponge	R
		Cancer sp.	O
		Hermit crab	R
		Snow crab	R
		Sea star	F
		Sea cucumber	S
		Unidentified fish	R
	Exposed Flowline	Sea cucumber	S
E-70	Sand/Rock	Sea star	O
		Sea cucumber	A
	Rock	Sponge	R
		Sea star	F

Flowline	Substrate	Species	Abundance
		Sea cucumber	O
		Cancer sp.	R
		Sand dollar	C
		Sculpin	O
		Unidentified fish	O
	Rock/Shell	Sea cucumber	S
	Exposed Flowline	Sea cucumber	S

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

2.4.8 Summary and Conclusions

2.4.8.1 Subsea Structures

- Epifauna colonization of WHPS at all well site locations observed varied little from the 2013 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. For example, at WHPS F-70 pollock were present in large numbers in the 2014 summer video survey, compared to the spring 2013 video survey, where no pollock were present. Based on photographs provided from additional ROV surveys throughout the year, there were typically high densities of fish (likely of the family Gadidae) present at the PFC, as well as many sea stars on the surrounding seafloor.
- 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.
- Notable species include a porbeagle and school of amberjacks in the PFC area, a lobster at H-08, and wolfish at F-70.

2.4.8.2 Cuprotect Coated Structures

- The main colonizing species of epifauna on non-Cuprotect coated structures continues to be the blue mussel *Mytilis edulis.* 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 hydroids and sea cucumbers on flange insulation covers at wellhead F-70. Mussels, frilled anemones, sea stars and hydroids were also present on sections of closing spools coming from subsea trees at wellheads.

2.4.8.3 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, hagfish and monkfish;
- Commercial crustaceans observed in the analyzed video were snow crabs, Jonah crabs and American lobsters (snow crab being the most abundant), which is consistent with the 2013 survey;
- Other commercial invertebrates observed include the orange-footed sea cucumber and sea scallop; and
- Notable new species found this year near the pipeline were the Atlantic wolffish and the monkfish. Neither species were found in the sub-sampled part of the GEP between KP 23 and KP 98 in 2013. Wolffish were found in other areas of the pipe, as well as flowlines in the 2013 survey.
- Like past survey years, crustaceans were observed on video sitting on top of the pipe and climbing on it. One American lobster was found next to the pipeline, but lobsters have not been observed climbing the pipe or sitting on top of it in either of the 2013 or 2014 surveys. As the pipe is not a physical barrier for other crustaceans found near the GEP, it is unlikely that it is a physical barrier for lobsters. Studies have also shown that lobsters are capable of climbing over a pipeline (Martec, 2004).
- Dead crustaceans or possible exoskeletons from molting were found along the GEP in 2014.
- Garbage and debris seems to be collecting at a slow rate at the GEP, due to it being a physical barrier.
- Flowlines continue to have a core group of consistent species such as sea stars, sand dollars and Jonah crabs in sandy areas, and sea cucumbers and sea stars in rocky areas. Exposed pipe and flowline is covered in sea cucumbers. Uncommon species were a grey seal found at H-80 and a skate at F-70.

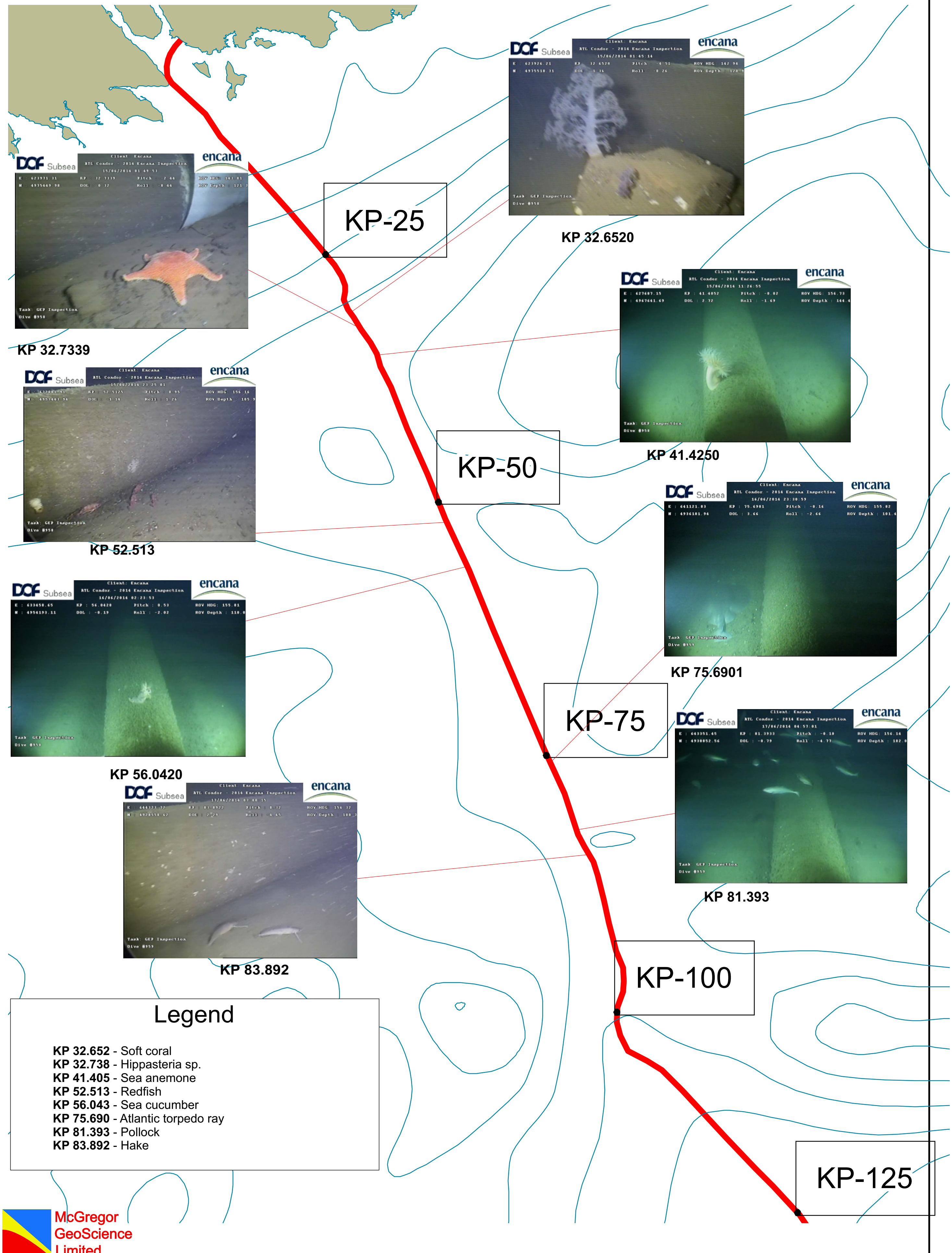

Figure 2.5 Representative Stills from ROV Footage Along GEP Figure 2.5

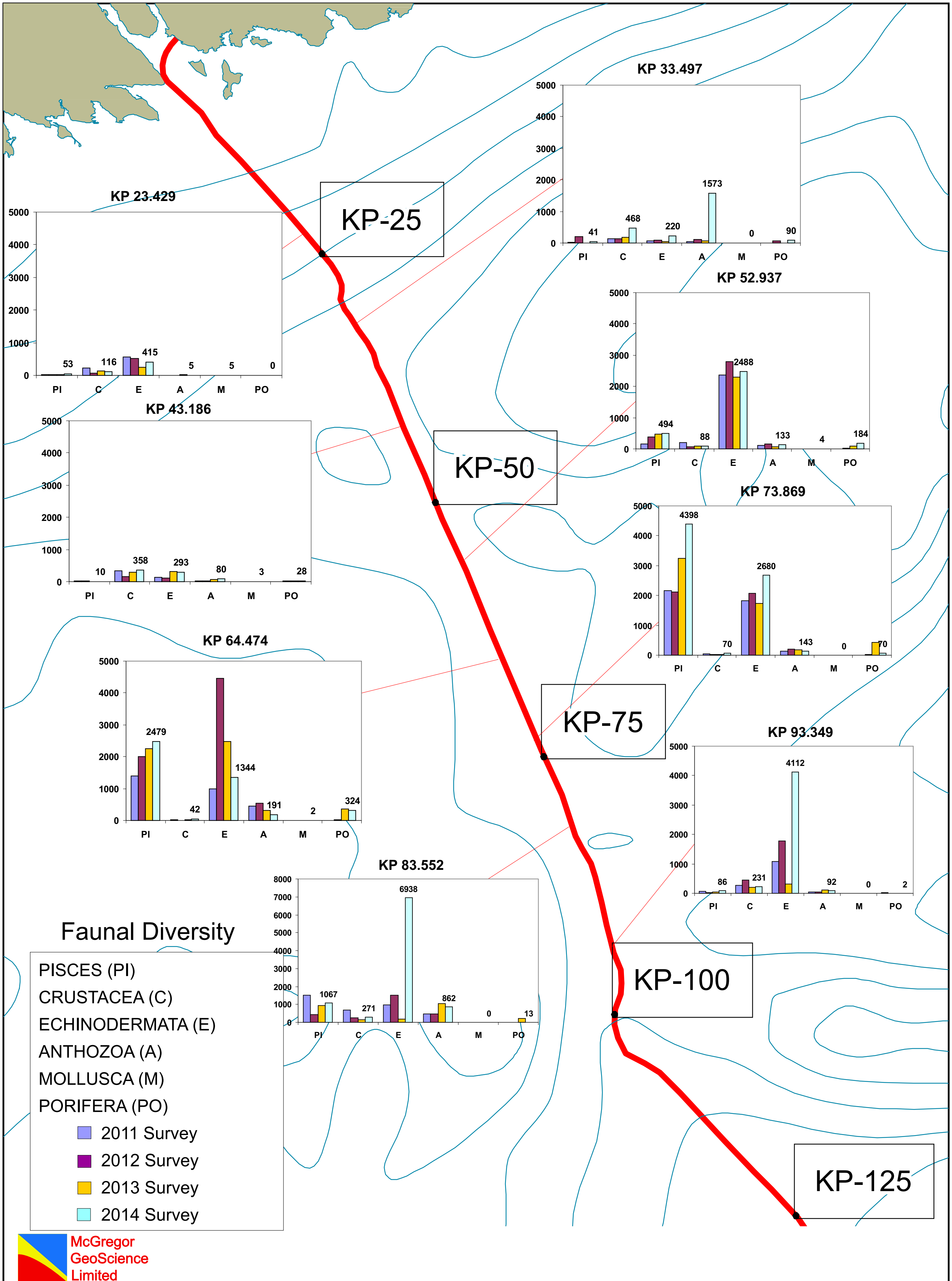

Figure 2.6 Standardized Faunal Composition of Exposed GEP at 10 km Intervals from 2011, 2012, 2013 and 2014 Surveys Figure 2.6

A monkfish at KP 71 along the GEP at a depth of 100m

Atlantic cod and redfish at the base of the GEP at KP 63 at a depth of 102m

A flatfish along the GEP at KP, at a depth of 142m

A wolffish at WHPS H-80

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Figure 2.7 Fish Diversity Along the GEP Pipeline and WHPS

Figure 2.7

A Jonah crab along the GEP at KP 94

An American Lobster at the base of the GEP at KP 55

A snow crab along the GEP at KP 32

A Northern stone crab on the GEP at KP 94

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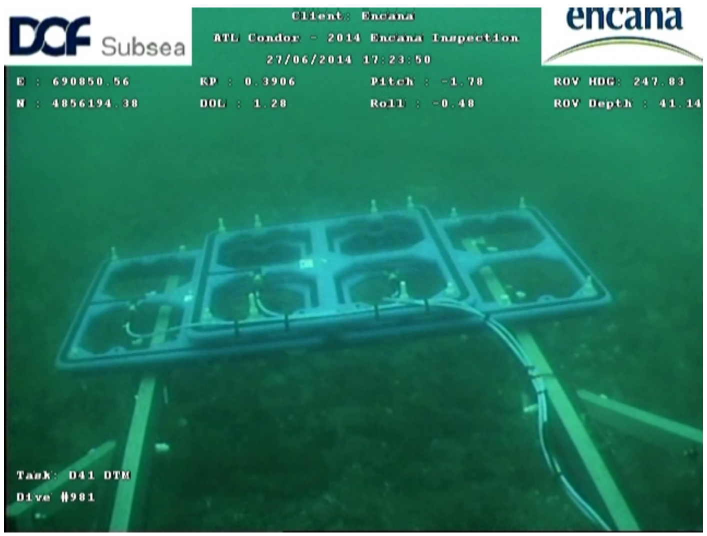
Figure 2.8 Crustacean Diversity Along the GEP

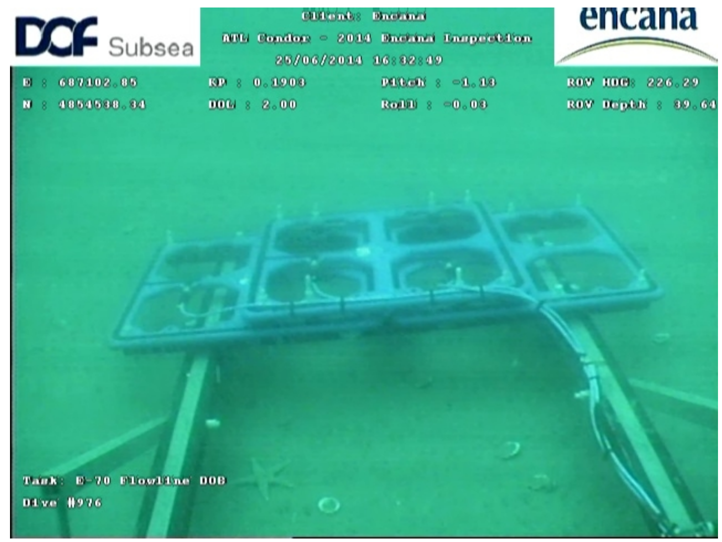
Figure 2.8

A grey seal near the H-08 flowline.

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



Rock dump covering flowline to wellhead D-41 dense sea cucumbers



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

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Figure 2.9 Buried and Exposed Wellhead Flowlines with Associated Fauna

Figure 2.9

A humpback whale near the PFC

White-sided dolphins in the PFC area

Amberjacks around the PFC legs

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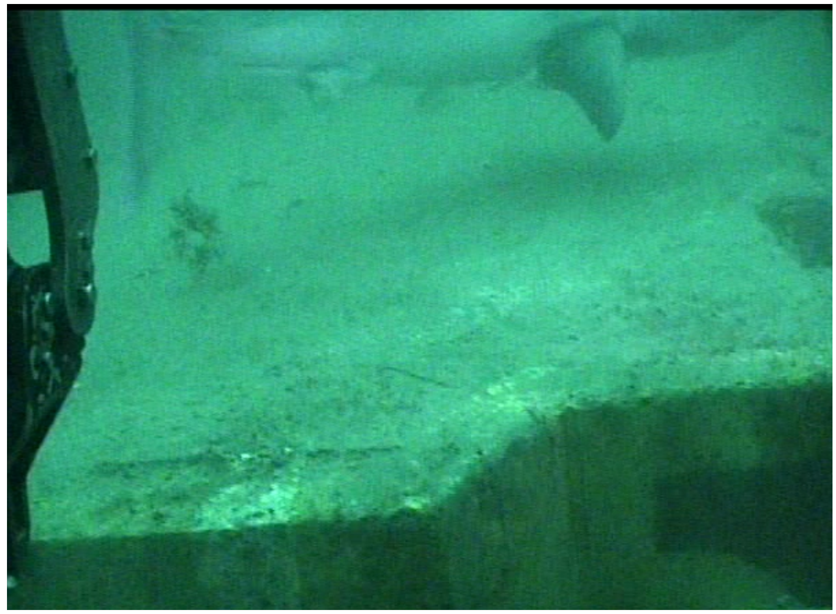
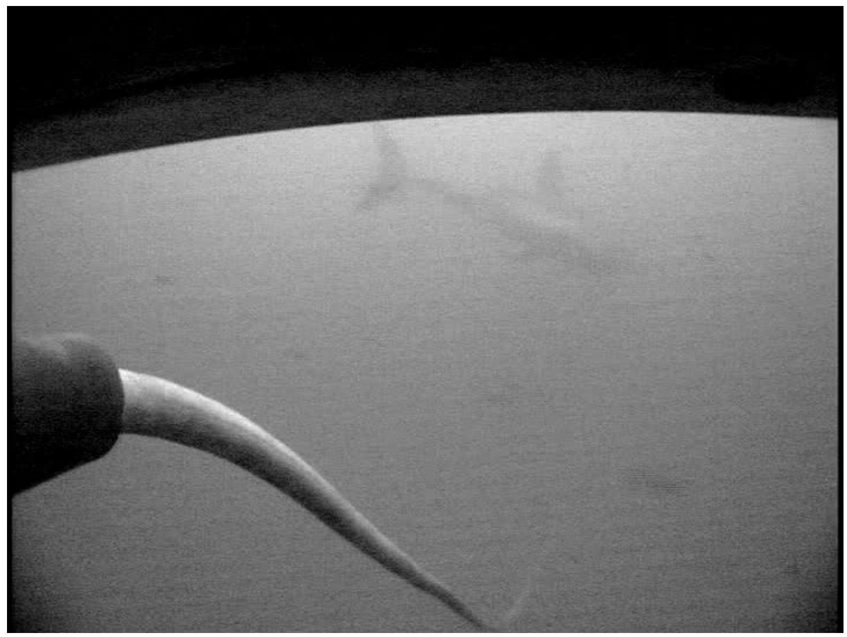
 Notable Wildlife in the PFC Area in 2014 Figure 2.10

A shark (likely a Porbeagle) in the PFC area



A second photograph of the shark in the PFC area



A school of fish gadoids of the family Gadidae (either pollock, cod or haddock)

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Figure 2.10 Notable Wildlife in the PFC Area in 2014 Figure 2.10

Ad dead Jonah crab, or exoskeleton at KP 38 along the GEP

A dead snow crab or exoskeleton at KP 38 along the GEP

Rotting organic material, possibly from a large animal at KP 40 along the GEP

A dead fish along the GEP at KP 86

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Figure 2.11 Dead Species Found Along the GEP in 2014

Figure 2.11

A beer/soda can, the most common piece of garbage along the GEP

A large rope along the GEP

A glass bottle along the GEP

A rubber glove along the GEP

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Figure 2.12 Garbage and Debris Found Along the GEP in 2014

Figure 2.12

2.5 MARINE WILDLIFE OBSERVATIONS

2.5.1 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. To address these questions, Environment Canada started to develop a guidance protocol to handle stranded birds offshore. The final protocol is still pending, and should be finalized in the six months following February 2015. 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.

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 D**). 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. Also, an additional VHF receiver was placed on the Deep Panuke platform in April of 2014.

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 2014) 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 2014. 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.

2.5.2 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**].

2.5.3 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; and
- Identify the oil type/source on feathers of beached seabirds found on Sable Island.

2.5.4 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; and
- Identify the oil type/source on feathers of beached seabirds found on Sable Island.

2.5.5 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 interactions with offshore infrastructure associated with the oil and gas industry of Nova Scotia, Canada Acadia University – Final Report- January 2015 **Appendix D**).

- Oil types observed on feathers from beached seabirds collected on Sable Island were monitored (**Appendix E**);
- A dedicated bird observer (biologist) was present on the PFC during spring migration to identify stranded birds (Appendix F).
- Stranded birds were identified by support vessels. (Appendix F).
- Wildlife seen from the PFC and support vessels was recorded daily (Appendix G).

2.5.6 Parameters Analyzed

Table 2-15 Marine Wildlife Observations in 2014

	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 2014 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)

2.5.7 Results

2.5.7.1 Marine Wildlife Observations

Stranded Seabird Summary

- On-going monitoring for stranded birds was conducted in 2014 on the PFC and support vessels the Atlantic Tern, Atlantic Hawk and the Atlantic Condor. A trained biologist was on the PFC as a dedicated bird observer from April 30 to May 6, 2014 as part of the Acadia bird monitoring research study.
- A total of 18 stranded birds were reported. Species found were Magnolia warblers,

European starlings, Red-winged blackbirds, Leach's storm-petrels, Savannah sparrows, Gray catbirds, American redstarts and Semi-palmated sandpipers.

- Nine Leach's storm-petrels were found, making up half of the stranded birds reported.
- One Gray catbird died in care, and two Leach's storm-petrels were released. All other stranded birds were found dead, and disposed of at sea.
- Unusual observations of non-stranded birds were also recorded. On August 30th, a Brown hawk was observed at the PFC for several day before moving on. A juvenile Peregrine falcon was on the PFC on November 6th, and a Blue heron was spotted from the vessel Atlantic Tern on December 19th.

For complete description of these stranded birds events, refer to the report "Live Seabird – 2014 Salvage Report", **Appendix F**.

Visual Monitoring of Wildlife around the PFC / Vessels Summary

- Both the supply vessels the Atlantic Condor and the Atlantic Tern reported wildlife sightings from January to December of 2014. The Atlantic Hawk and Ryan Leet reported no wildlife sightings from January 2014.
- The Atlantic Condor observed two seals in February, one unidentified whale near the PFC in March, as well as various untagged gulls year round.
- The Atlantic Tern observed a variety of marine wildlife in 2014. Cormorants were observed in May, Gannets from April to May, and shearwaters from May to October. Seals were observed in February and from April to July and September. Whales were observed in February and from April to June, and August and October. A sunfish, sea turtle and sharks were observed in July. Porpoises were observed in July and August and dolphins were seen in August.

For complete details on marine wildlife observed from the supply vessels and PFC, refer to **Appendix G** "2014 Observations from Supply Vessels and PFC of Marine Wildlife".

Acadia Bird Monitoring Research Study Summary

Field studies were conducted up to June 2014 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 596 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) Light-level 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) ~1200 receiver tracking-days in 2012 (including 400 days from supply vessels), and >5000 receiver tracking-days in 2013/2014 (including > 1300 days from supply vessels)

- From 30 April to 07 May 2014, one observer was deployed on the Deep Panuke platform to conduct visual observations of birds during the spring migration period. "Sea Watch" observations documented the relative abundance of seabirds in flight and on the water around the platform: 89% Herring Gull, 8% Northern Fulmar, and less than 1% for each of 5 other species. A "Platform census", conducted three times daily to search for live and dead stranded birds on the platform, found 21 live birds (three of which were subsequently found dead). Fourteen dead birds were found on the platform: 10 were highly decomposed (probably mortalities from the previous year or over winter), 1 was desiccated but not severely decomposed (likely from migration 8 this year), and 3 were fresh mortalities (noted above). Leach's storm-petrels were the most commonly found bird (6 of 14), most of which were oiled and trapped under grated walkway on one of the lower decks. The discovery and documentation of live and dead stranded birds highlight the value of systematic bird surveys aboard platforms to accurately document the timing, species composition, and abundance of strandings.
- Results of the telemetry studies, platform observations, and other available information were used to assess the risk of impacts to study species from offshore oil and gas platforms in Nova Scotia. Terns and Blackpoll Warblers have a low risk of impact due to the limited frequency and low impact of interactions. Leach's Storm-petrels have a low to high risk of impacts (depending on the population) since we demonstrate that Eastern Shore colonies transit through the platform area, this was the most commonly stranded species found dead on the platform, the population appears to be declining in this region and there is uncertainty over total annual mortality estimates associated with oil and gas activities. Gulls have a frequent rate of interaction from a high proportion of the Sable Island breeding colony indicating a "medium" risk for these species. However, no lethal interactions were documented, and the interactions with offshore platforms may be

beneficial in providing food and shelter to individuals. Ipswich Sparrows have a low risk of impact from offshore platforms during fall migration but a high risk of impact during spring migration.

- Deployment of independent bird-radar system was deemed not feasible due to interference associated with PFC RACON system. 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. The use of existing platform radars to detect birds was deemed not feasible at this time for a variety of reasons, the most important being inability to test various digitizing options on an equivalent system on-shore. VHF receivers were installed on the PFC in April 2014. On board testing in May 2014 demonstrated that the installed VHF receiver is capable of detected VHF tags virtually anywhere aboard the Deep Panuke platform.

For complete details on the Acadia bird study, refer to **Appendix D** "Assessment of bird human interactions with the oil and gas industry of Nova Scotia, Canada. Acadia University – Final Report; January 2015".

Sable Island Beached Bird Surveys Summary

- Between January and November, 2014, nine surveys for beached seabirds were conducted on Sable Island, with no surveys during March, September and December.
- During 2014, the corpses and fragments of 352 beached seabird corpses were collected on Sable Island. Aclids accounted for 54% of the total corpses recovered. Of the 461 corpses, 184 (52.3%) 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 (58.8% and 78.6%, respectively). More Northern Fulmars (62.3%) and all Northern Gannets (78.6%) and all shearwaters occurred in summer.
- The overall oiling rate for all species combined (based on complete corpses, Codes 0 to 3) was 3.2% (compared with <0.5% in 2013). A total of six oiled corpses were recovered in 2014, and all were alcids (1 Atlantic Puffin, 3 Thick-billed Murre, 1 murre not identified to species, and 1 Dovekie). The oiling rate for alcids was 7.9% (compared with 0% in 2013).

- The six oiled bird corpses occurred during the first week of February, and samples of oiled feathers were collected from five of the corpses. The samples were determined to be moderately weathered Heavy Fuel Oil most typical of residuals or sludge from fuel tanks.

For complete details on the Sable Island Beached Seabird study, refer to **Appendix E** "2014 Beached Seabird Survey on Sable Island ".

2.5.8 Summary and Conclusions

- Eighteen birds were stranded on PFC support vessels in 2014. Leach's storm petrels made up 50% of the stranded birds found. Other species were Magnolia warblers, European starlings, Red-winged blackbirds, Savannah sparrows, gray catbirds, American redstarts, and semi-palmated sandpipers.
- The 2014 Acadia Bird Study resulted in VHF deployments on 596 birds including Herring Gulls (HERG), Great Black-backed Gulls (GBBG), Common Terns, Arctic Terns, Leach's Storm-petrels, Ipswich Sparrows, and Blackpoll Warblers. A dedicated bird observer was on the Deep Panuke platform during the spring migration of 2014. The main species observed were Herring gulls (89%), and northern Fulmar (8%), and the five other species less than one percent. A platform census for stranded and dead birds was also conducted three times per day. Risk assessment was done for bird-platform interactions, and it was found that Leach's Storm-petrels (Country Island) and Ipswich sparrow (spring migration) were at higher risk of platform interactions. VHF receivers were installed on Deep Panuke in April of 2014, and were able to detect VHF tags from anywhere on the platform.
- Monitoring of oiling rates in beached birds on Sable Island was conducted over the course of 9 surveys carried out between January 1, and November 2014, where 352 beached seabird corpses were collected. Alcids accounted for 54% of the total corpses recovered. Of the six oiled bird corpses found all were alcids. Of the 461 corpses, 184 (52.3%) were complete (>70% of body intact). The oiling rate for all species combined was <3.2%.

2.6 AIR QUALITY MONITORING

2.6.1 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 pollutant spike, 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.

2.6.2 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 natural gas field [EA predictions #14 & 15 in **Table 3.1**]; and
- Provide feedback for continuous improvement in reducing flare and other emissions from the Deep Panuke natural gas field [EA prediction #14 in **Table 3.1**].

2.6.3 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.

2.6.4 Sampling

Flare smoke monitoring:

- Systematic flare smoke monitoring on the PFC started on February 20, 2014 and the flare smoke shade was monitored twice daily (morning and afternoon), assessing it using the Ringelmann smoke chart.

For more details about the flare smoke monitoring, refer to **Appendix H** "2014 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 ($PM_{2.5}$), ozone (O_3), and non-methane hydrocarbons (NMHC) on Sable Island.

For more details about Sable island air quality monitoring, refer to **Appendix I** "2014 Sable Island Air Quality Monitoring".

2.6.5 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 included back-trajectory modeling.

2.6.6 Results

Flare smoke monitoring:

- The Ringlemann smoke chart was used to monitor the flare twice daily on the PFC. On a scale from zero to five, the flare was a “0” 74% of the time, a “1” 19% of the time, a “2” 5% of the time, and a “3” 2% of the time.

Sable Island air quality:

- The following air quality metrics measured on Sable Island in 2014:
  - nitric oxide (NO)
  - nitrogen dioxide (NO_2)
  - nitrogen oxides (NO_x)
  - sulphur dioxide (SO_2)
  - hydrogen sulphide (H_2S)
  - fine airborne particulate matter with a median aerodynamic diameter ≤ 2.5 microns ($PM_{2.5}$)
  - non-methane hydrocarbons (equivalent to the total-volatile organic compound species concentration)
  - black carbon (BC).
- It was found that the average wind vector for 2014 was 252° which is consistent with prevailing winds on the Scotian shelf and advecting over Sable Island. Pollution rose analysis revealed that the average wind directional dependence of the air pollution metrics was as follows: NO_x 252°, SO_2 254°, $PM_{2.5}$ 241°, O_3 251°, H_2S 240°, BC 263° and NMHC 241°. The general agreement between the annual average wind directional dependence with the average wind direction suggests that long-range transport (LRT)

from the continent as the main source of these air pollution metrics on Sable Island. However, some spikes in $PM_{2.5}$ are likely due to sea salt spray on stormy days.

- The most important feature of the air pollution data acquired in 2014 was the recording of a H_2S emission threshold breach of 3.4 ppb (threshold 3.11 ppb) observed at 4 am on August 7 that lasted for 1-hour. After an investigation by facility management it was determined that it was likely related to an issue with acid gas flaring a few hours earlier on Deep Panuke natural gas production platform (Personal communication from Marielle Thillet, Encana, August 14, 2014). This breach is well below any health regulation standard, e.g. Canadian Ambient Air Quality Objective (1-hr average of 30 ppb). There were no other threshold breaches for the remaining air pollutant metrics in 2014.
- The mean (min:max) air pollution metric concentrations observed on Sable Island during 2014 were as follows:

Non methane hydrocarbons	0.001 (0.0 : 0.061) ppm
BC	0.082 (0.0 : 22.34) µg/m^3
SO_2	0.65 (0.1 : 4.3) ppb
NO_x	0.87 (0.0 : 44.1) ppb
$PM_{2.5}$	8.1 (0.0 : 69.0) µg/m^3
O_3	35.8 (15.0 : 65.0) ppb
H_2S	0.68 (0.1 : 3.4) ppb

- 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.
- NOAA HYSPLIT air mass back trajectory system, NASA Aqua and Terra MODIS satellites and the Canadian Wildland Fire Information System were used to further investigate, and aid the identification of spikes in the air pollution metrics (~ 3x standard deviation above the mean). Spikes in NO_x, $PM_{2.5}$, and O_3 originate from known source regions in the Ohio valley, Ontario, Quebec, NE US and Nova Scotia prior to arriving on Sable Island. The spike on August 7 was attributed to acid gas emissions from Deep Panuke natural gas production platform as mentioned above. Spikes in H_2S (below notification threshold) seen on June 15 and July 16 are likely due to H_2S acid gas emissions from Deep Panuke by virtue of local wind directional analysis. Spikes in SO_2 were likely a result of continental outflow from known source regions with possible input

from Deep Panuke and Thebaud due to the local wind crossing these platforms on the day of the spikes. However, attributing SO_2 to the total concentration observed on Sable Island from theses O&G platforms is impossible at present without conducting source apportionment and dispersion modelling efforts (outside the scope of this report). From scrutiny of the NRCan Canadian Wildland Fire Maps online, together with air mass back trajectory analysis, pointed to the spikes seen for BC on April 19, July 13 and July 20 likely being associated with wildland fire smoke plumes advected to Sable Island on these dates. There is intriguing evidence (stagnant marine air flow) that the spikes in NMHC on May 26, June 9 and June 23 through 28 are associated with marine biogenic emissions and neither continental outflow or O&G production operations.

2.6.7 Summary and Conclusions

- The Ringlemann smoke chart was used to monitor the flare twice daily on the PFC. On a scale from zero to five, the flare was a “0” 74% of the time, a “1” 19% of the time, a “2” 5% of the time, and a “3” 2% of the time.
- The following air quality parameters were measured on Sable Island in 2014: NO, NO_2, NO_x, SO_2, H_2S, $PM_{2.5}$, NMHC and BC.
- Hourly spikes above selected thresholds and elevated daily concentrations of air contaminants were analyzed for possible relationship with offshore production activities.
- There was an H_2S emission threshold breach on August 7th, which was likely related to an acid gas flaring malfunction on Deep Panuke, but was below health regulation standards.
- Spikes in H_2S (below notification threshold) seen on June 15 and July 16 are likely due to H_2S acid gas emissions from Deep Panuke by virtue of local wind directional analysis.
- Spikes in SO_2, NMHC, BC NO_x, $PM_{2.5}$, and O_3 are not thought to have originated from O&G operations, but rather continental known source regions, *e.g.* wildland fire smoke plumes.
- 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.

3 ENVIRONMENTAL ASSESSMENT (EA) PREDICTIONS

Table 3-1 EEM Related Environment Assessment (EA) Predictions and 2014 Results

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2014 Plan	2014 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 to be collected twice a year. Chemical characterization to be done twice a year and toxicity testing to be done once a year. Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	Produced water was collected in June of 2014. Chemical parameters measured were all below CCME guidelines, except for PAH-Naphthalene, benzene and toluene. PFC and WHPS had similar species composition amounts of marine growth coverage as 2013.
2	Mortality of benthic organisms due to exposure of the diluted brine plume is unlikely due to the short duration of exposure coupled with the high dilution factor. In the case of limited mortality of benthic organisms, habitat would be re-colonized from adjacent areas.	8.3.4.1	- Marine Benthos	- Sediment Chemistry and Toxicity - Fish Habitat Alteration	Discontinue E-70 cuttings pile monitoring. Continue fish habitat analysis near subsea production structures into 2014 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°C. The temperature anomaly will be a maximum of a 2.5°C upon contact with the seafloor. Beyond 130 m, the temperature anomaly will be less than that 1°C and will fall below 0.4°C at a distance of 500m. The temperature anomalies are not predicted to exceed temperature tolerance thresholds of fish species except in the immediate area (*i.e.*, tens of metres) from the end of pipe discharge. The benthic organisms of the study area are capable of withstanding variable	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 to be collected twice a year. Chemical characterization to be done twice a year and toxicity testing to be done once a year. Marine Water Quality to be performed once a year in conjunction with produced water testing. Sediment chemistry and toxicity to be performed once a year. Fish Health Assessment to be performed once a year (Mussel toxicity) Continue monitoring PFC and WHPS with ROV footage to assess	Produced water was collected in June of 2014. Chemical parameters measured were all below CCME guidelines, except for PAH-Naphthalene, Benzene and Toluene. Due to various logistical and operational reasons sampling of water, sediment, toxicity of produced water and mussel toxicity were not carried out in 2014. PFC and WHPS had similar species composition amounts of marine growth coverage as 2013.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2014 Plan	2014 Results
	temperatures and the predicted 2.5°C temperature anomaly in unlikely to exceed tolerance thresholds of benthic species present.				fish habitat.	
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 to be collected twice a year. Chemical characterization to be done twice a year and toxicity testing to be done once a year. Marine Water Quality to be performed once a year in conjunction with produced water testing. Sediment chemistry and toxicity to be performed once a year. Fish Health Assessment to be performed once a year (Mussel toxicity) Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	Produced water was collected in June of 2014. Due to various logistical and operational reasons sampling of water, sediment, toxicity of produced water and mussel toxicity were not carried out in 2014. PFC and WHPS had similar species composition amounts of marine growth coverage as 2013
5	Treating the produced water at several levels (including continuous polishing) prior to discharge and the rapid dilution of the plume implies that benthic organisms will be exposed to very low concentrations of contaminants that are unlikely to elicit measurable effects.	8.3.4.2	- Marine Benthos	- Produced Water - Chemistry and Toxicity - Marine Water Quality Monitoring - Sediment Chemistry and Toxicity - Fish Habitat Alteration - Fish Health Assessment	Produced water to be collected twice a year. Chemical characterization to be done twice a year and toxicity testing to be done once a year. Marine Water Quality to be performed once a year in conjunction with produced water testing. Sediment chemistry and toxicity to be performed once a year. Fish Health Assessment to be performed once a year (Mussel toxicity) Continue monitoring PFC and WHPS with ROV footage to assess	Produced water was collected in June of 2014. Chemical parameters measured were all below CCME guidelines, except for PAH-Naphthalene, Benzene and Toluene. PFC and WHPS had similar species composition amounts of marine growth coverage as 2013.

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2014 Plan	2014 Results
					fish habitat.	
6	Experimental data pertinent to the toxicity of H2S on fish suggest that the concentrations of H2S that fish will likely be exposed to at Deep Panuke are much less than the concentrations required to cause chronic or acute effects, including at the point of discharge. The full-time "polishing" of produced water on the MOPU and the rapid dilution of the plume will result in fish being exposed to extremely low concentrations of Alkylatedphenols that are unlikely to elicit measurable effects.	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 to be collected twice a year. Chemical characterization to be done twice a year and toxicity testing to be done once a year. Marine Water Quality to be performed once a year in conjunction with produced water testing. Sediment chemistry and toxicity to be performed once a year. Fish Health Assessment to be performed once a year (Mussel toxicity) Continue monitoring PFC and WHPS with ROV footage to assess fish habitat.	Produced water was collected in June of 2014. Chemical parameters measured were all below CCME guidelines, except for PAH-Naphthalene, Toluene and Benzene. Only one AP was detected during testing of produced water. Its level was below CCME guidelines. PFC and WHPS had similar species composition and growth to 2013. Video surveys spanned between April and December of 2014.
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)..

#	*EA Predictions*	*Relevant Section of 2006 EA*	*VEC(s)*	*EEM Component(s)*	*2014 Plan*	*2014 Results*
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. 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 2014. Marine Water Quality to be performed once a year in conjunction with produced water testing. OTN tracking project did not occur in 2014.	Presence of wildlife near the PFC has been observed sporadically but these observations cannot affirm the nature of the attraction (*i.e.* noise, heat, food, shelter/refuge, curiosity, etc.).

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2014 Plan	2014 Results
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 2014.	- The bird monitoring program, Assessment of Bird-Human Interactions at Offshore Installations continued. - In 2014, vessel based VHF receivers were active until June. Risk assessment was done and it was found that Leach's Storm-petrels (Country Island) and Ipswich sparrow (spring migration) were at higher risk of platform interactions.
13	The potential for oiling of birds and/or contamination of their food sources from discharged produced water is unlikely since a sheen, if it did occur, would be very short lived and would be unlikely to produce any oiling of bird plumage.	8.2.4 8.6.4	- Marine Water - Quality - Marine Related - Birds	- Marine Water Quality - Monitoring - Marine Wildlife Observations	Summarize observations and findings from Sable Island Beach Surveys.	3.2% oiling for all species of beached birds found on Sable Island (six oiled alcid corpses in February of 2014). Samples of oiled feathers were collected from five corpses, and the samples were determined to moderately weathered heavy oil fuel most typical residuals or sludge from fuel tanks.
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 monitored as per proposed Sable Island air emissions monitoring plan described in 2012 EEM report. .	One H_2S emission threshold breach, and two H_2S spikes below notification threshold occurred in 2014 that were thought to be due to acid flaring at Deep Panuke. Spikes throughout the year in SO_2, NMHC, BC, NO_x, $PM_{2.5}$ and O_3 are not thought to have originated from 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 monitored as per proposed Sable Island air emissions monitoring plan described in 2012 EEM report.	One H_2S emission threshold breach, and two H_2S spikes below notification threshold occurred in 2014 that were thought to be due to acid flaring at Deep Panuke. Spikes throughout the year in SO_2, NMHC, BC, NO_x, $PM_{2.5}$ and O_3 are not thought to have originated from O&G operations. No breaches of National Air Quality Standards, CAAQO or Canada

#	EA Predictions	Relevant Section of 2006 EA	VEC(s)	EEM Component(s)	2014 Plan	2014 Results
						Wide Standard for any of the air pollution metrics.

4 RECOMMENDED EEM PROGRAM FOR 2015

Table 4-1 Summary of Deep Panuke 2014 Offshore EEMP Sampling Activities, Analysis, and 2015 Recommendations

EEMP Component	2014 Sampling			2014 Analysis		2015 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
Produced Water Chemistry and Toxicity	PFC (prior to mixing with seawater system discharge)	Sampled on the PFC directly from outlet.	Twice annually after First Gas Produced water sampled in once in June 2014.	Water quality composition conducted in June 2014	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters	Continue produced water sampling in 2015; to be collected and analyzed twice a year.
			Annually after First Gas **No Sampling Conducted in 2014**	Toxicity on sea urchin eggs,and threespine stickleback fish, and Microtox test **No Analysis Conducted in 2014**	LC49 bioassay	Start toxicity testing in 2015.
Marine Water Quality Monitoring **No 2014 data**	Triplicate seawater samples at 5 near-field downstream sites and 2 upstream sites along tide direction **No Sampling Conducted in 2014**	Niskin Bottle **No Sampling Conducted in 2014**	In 2011 (prior to First Gas), then annually for the three following years **No Sampling Conducted in 2014**	Water quality composition **No Analysis Conducted in 2014**	Trace metals; BTEX, TPH, PAHs; APs; nutrients; organic acids; major ions and physical parameters **No Analysis Conducted in 2014**	Conduct marine water sampling program in 2015.
Sediment Chemistry and Toxicity **No 2014 data**	9 near-field benthic sampling locations and 2 far-field reference sites **No Sampling Conducted in 2014**	Grab Sample **No Sampling Conducted in 2014**	In 2011 (prior to First Gas and post 2010 drilling and completion activities), then annually for the following three years **No Sampling Conducted in 2014**	Chemical composition **No Analysis Conducted in 2014**	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 2014**	Conduct sediment sampling program in 2015. 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 2014**	Suitable marine amphipod species such as *Rhepoxynius abronius* or *Eohaustoriux estuaries* **No Analysis Conducted in 2014**	Conduct LC49 bioassay in 2015. 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)

EEMP Component	2014 Sampling			2014 Analysis		2015 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
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 2015 with annual ROV footage of wellsites, PFC and pipeline.
Fish Health Assessment **No 2014 data**	Mussels: PFC SW leg Fish: immediate vicinity of PFC and suitable far-field reference sites **No Sampling Conducted in 2014**	Mussels: scraping Fish: angling **No Sampling Conducted in 2014**	Mussels: annually after First Gas Fish: every 3 years after First Gas **No Sampling Conducted in 2014**	Mussels: body burden Fish: enzyme induction, pathology **No Analysis Conducted in 2014**	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 2014**.	Start mussel health assessment in 2015. Fish health assessment to start in 2016.
Marine Wildlife Observations	PFC / vessels	Implementation of Williams and Chardine protocol for stranded birds	As required	Yearly bird salvage report to be submitted to CWS	Species; condition; action taken; fate of bird	Continue into 2015; updated stranded bird handling protocol to be finalized and implemented once regulatory feedback has been received
		Visual monitoring of seabirds, marine mammals and sea turtles around PFC	Opportunistic observations from PFC / vessels	Direct observations	Species, counts and behavioural observations (*e.g.* any congregation of wildlife will be reported)	Continue into 2015; conduct in conjunction with daily deck sweeps for stranded birds
	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	Three-year program (2011 to 2014)	Analysis of radar, transmitters, camera	Specific research/analysis parameters outlined in NSERC proposal	Study completed. Examine feasibility of in-kind contribution to continuing Acadia research; such as redeployment of VHF receivers on PFC and supply vessels.

EEMP Component	2014 Sampling			2014 Analysis		2015 Recommendations
	Location	Type/Method	Frequency/Duration	Type/Method	Parameters	
	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 into 2014.			See above
	Sable Island	Beached bird surveys	Approx. 10 surveys/year	Based on CWS protocol	Oiling rate (standardized approach)	Continue into 2015.
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 2015.
	PFC	Visual observations of flare plume	Continuous during walk-arounds on deck and from video camera looking at the flare			Continue twice daily visual flare plume monitoring using Ringelmann smoke chart.

References

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APPENDICES

APPENDIX A

Maxxam and Axys Produced Water Quality Data 2014

Your C.O.C. #: 473037-01-01

Attention:Stephane Kirchhoff

McGregor GeoScience Limited
177 Bluewater Road
Bedford, NS
CANADA B4B 1H1

Report Date: 2014/07/02
Report #: R3076296
Version: 2

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B497659
Received: 2014/06/10, 10:56

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
TEH in Water (PIRI)	1	2014/06/11	2014/06/11	ATL SOP 00113	Based on Atl. PIRI
Metals Water Total MS (2)	1	2014/06/11	2014/06/12	ATL SOP 00058	Based on EPA6020A
Nitrogen Ammonia - water	1	N/A	2014/06/17	ATL SOP 00015	Based on USEPA 350.1
Nitrogen - Nitrate + Nitrite	1	N/A	2014/06/18	ATL SOP 00016	Based on USGS - Enz.
Nitrogen - Nitrite	1	N/A	2014/06/18	ATL SOP 00017	Based on SM4500-NO2B
Nitrogen - Nitrate (as N)	1	N/A	2014/06/18	ATL SOP 00018	Based on ASTMD3867
Organic Acids Analysis in Water Sample (1, 3)	1	2014/06/14	2014/06/17	CAM SOP-00431	Dionex 031181 Rev.5
PAH in Water by GC/MS (SIM)	1	2014/06/11	2014/06/14	ATL SOP 00103	Based on EPA 8270C
pH (4)	1	N/A	2014/06/18	ATL SOP 00003	Based on SM4500H+B
Phosphorus - ortho	1	N/A	2014/06/18	ATL SOP 00021	Based on USEPA 365.2
VPH in Water (PIRI)	1	2014/06/16	2014/06/18	ATL SOP 00118	Based on Atl. PIRI
Salinity	1	N/A	2014/06/12		SM 2520B
Sulphide (1)	1	N/A	2014/06/11	CAM SOP-00455	SM 4500-S G
ModTPH (T1) Calc. for Water	1	N/A	2014/06/18	N/A	Based on Atl. PIRI
Phosphorus Total Colourimetry	1	2014/06/17	2014/06/20	ATL SOP 00057	Based on EPA365.1

Remarks:

Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Analytics Mississauga
(2) New RDLs in effect due to release of NS Contaminated Sites Regulations. Reduced RDL based on MDL study performance. Low level analytical run checks being implemented.
(3) The organic acids test has been validated in accordance with ISO Guide 17025 requirements. SCC accreditation pending.
(4) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.

Success Through Science®

Your C.O.C. #: 473037-01-01

<u>Attention:Stephane Kirchhoff</u>

McGregor GeoScience Limited
177 Bluewater Road
Bedford, NS
CANADA B4B 1H1

Report Date: 2014/07/02
Report #: R3076296
Version: 2

CERTIFICATE OF ANALYSIS

<u>MAXXAM JOB #: B497659</u>
Received: 2014/06/10, 10:56

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Keri Mackay, Project Manager - Bedford
Email: kmackay@maxxam.ca
Phone# (902)420-0203 Ext:294
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.maxxamanalytics.com

RESULTS OF ANALYSES OF WATER

Maxxam ID		WG0587		
Sampling Date		2014/06/10 07:00		
COC Number		473037-01-01		
	Units	Produced water	RDL	QC Batch
Calculated Parameters				
Nitrate (N)	mg/L	ND	0.050	3635054
Inorganics				
Nitrate + Nitrite	mg/L	ND	0.050	3643542
Nitrite (N)	mg/L	ND	0.010	3643546
Nitrogen (Ammonia Nitrogen)	mg/L	46	2.5	3643490
Orthophosphate (P)	mg/L	1.4	0.050	3643540
pH	pH	6.95	N/A	3645198
Total Phosphorus	mg/L	4.3	0.10	3643491
Salinity	N/A	71	4.0	3638180
Sulphide	mg/L	2.6	0.020	3637274
Miscellaneous Parameters				
Formic Acid	mg/L	ND	50	3642997
Acetic Acid	mg/L	ND	100	3642997
Propionic Acid	mg/L	ND	100	3642997
Butyric Acid	mg/L	ND	200	3642997

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected
N/A = Not Applicable

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ELEMENTS BY ICP/MS (WATER)

Maxxam ID		WG0587		
Sampling Date		2014/06/10 07:00		
COC Number		473037-01-01		
	Units	Produced water	RDL	QC Batch
Metals				
Total Aluminum (Al)	ug/L	210	50	3636712
Total Antimony (Sb)	ug/L	ND	10	3636712
Total Arsenic (As)	ug/L	ND	10	3636712
Total Barium (Ba)	ug/L	3800	10	3636712
Total Beryllium (Be)	ug/L	ND	10	3636712
Total Bismuth (Bi)	ug/L	ND	20	3636712
Total Boron (B)	ug/L	49000	5000	3636712
Total Cadmium (Cd)	ug/L	ND	0.10	3636712
Total Calcium (Ca)	ug/L	4200000	1000	3636712
Total Chromium (Cr)	ug/L	ND	10	3636712
Total Cobalt (Co)	ug/L	ND	4.0	3636712
Total Copper (Cu)	ug/L	ND	20	3636712
Total Iron (Fe)	ug/L	ND	500	3636712
Total Lead (Pb)	ug/L	ND	5.0	3636712
Total Magnesium (Mg)	ug/L	510000	1000	3636712
Total Manganese (Mn)	ug/L	510	20	3636712
Total Molybdenum (Mo)	ug/L	ND	20	3636712
Total Nickel (Ni)	ug/L	ND	20	3636712
Total Phosphorus (P)	ug/L	5000	1000	3636712
Total Potassium (K)	ug/L	280000	1000	3636712
Total Selenium (Se)	ug/L	ND	10	3636712
Total Silver (Ag)	ug/L	ND	1.0	3636712
Total Sodium (Na)	ug/L	18000000	10000	3636712
Total Strontium (Sr)	ug/L	310000	200	3636712
Total Sulphur (S)	ug/L	170000	50000	3636712
Total Thallium (Tl)	ug/L	2.0	1.0	3636712
Total Tin (Sn)	ug/L	ND	20	3636712
Total Titanium (Ti)	ug/L	ND	20	3636712
Total Uranium (U)	ug/L	ND	1.0	3636712
Total Vanadium (V)	ug/L	ND	20	3636712
Total Zinc (Zn)	ug/L	170	50	3636712

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

SEMI-VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		WG0587		
Sampling Date		2014/06/10 07:00		
COC Number		473037-01-01		
	Units	**Produced water**	**RDL**	**QC Batch**
Polyaromatic Hydrocarbons				
1-Methylnaphthalene	ug/L	200 (1)	1.0	3636652
2-Methylnaphthalene	ug/L	230 (1)	1.0	3636652
Acenaphthene	ug/L	3.3	0.010	3636652
Acenaphthylene	ug/L	ND (2)	0.10	3636652
Anthracene	ug/L	ND (2)	0.40	3636652
Benzo(a)anthracene	ug/L	ND (2)	0.20	3636652
Benzo(a)pyrene	ug/L	0.012	0.010	3636652
Benzo(b)fluoranthene	ug/L	0.17	0.010	3636652
Benzo(g,h,i)perylene	ug/L	0.022	0.010	3636652
Benzo(j)fluoranthene	ug/L	0.015	0.010	3636652
Benzo(k)fluoranthene	ug/L	ND	0.010	3636652
Chrysene	ug/L	1.7	0.010	3636652
Dibenz(a,h)anthracene	ug/L	ND	0.010	3636652
Fluoranthene	ug/L	2.7	0.010	3636652
Fluorene	ug/L	55 (1)	0.20	3636652
Indeno(1,2,3-cd)pyrene	ug/L	ND	0.010	3636652
Naphthalene	ug/L	310 (1)	4.0	3636652
Perylene	ug/L	0.036	0.010	3636652
Phenanthrene	ug/L	56 (1)	0.20	3636652
Pyrene	ug/L	1.5	0.010	3636652
Surrogate Recovery (%)				
D10-Anthracene	%	99		3636652
D14-Terphenyl	%	115		3636652
D8-Acenaphthylene	%	90		3636652

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected
(1) Elevated PAH RDL(s) due to sample dilution.
(2) Elevated PAH RDL(s) due to matrix / co-extractive interference.

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Maxxam Job #: B497659
Report Date: 2014/07/02

McGregor GeoScience Limited

ATLANTIC RBCA HYDROCARBONS (WATER)

Maxxam ID		WG0587		
Sampling Date		2014/06/10 07:00		
COC Number		473037-01-01		
	Units	**Produced water**	**RDL**	**QC Batch**
Petroleum Hydrocarbons				
Benzene	mg/L	3.2	0.050	3642551
Toluene	mg/L	1.3	0.025	3642551
Ethylbenzene	mg/L	0.049	0.025	3642551
Xylene (Total)	mg/L	0.39	0.050	3642551
C6 - C10 (less BTEX)	mg/L	ND	0.50	3642551
>C10-C16 Hydrocarbons	mg/L	5.9	0.050	3636573
>C16-C21 Hydrocarbons	mg/L	8.3	0.050	3636573
>C21-<C32 Hydrocarbons	mg/L	5.3	0.10	3636573
Modified TPH (Tier1)	mg/L	20	0.50	3635114
Reached Baseline at C32	mg/L	Yes	N/A	3636573
Hydrocarbon Resemblance	mg/L	COMMENT (1)	N/A	3636573
Surrogate Recovery (%)				
Isobutylbenzene - Extractable	%	106		3636573
n-Dotriacontane - Extractable	%	97		3636573
Isobutylbenzene - Volatile	%	104		3642551

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected
N/A = Not Applicable
(1) Fuel oil fraction.

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	10.7°C

Sample WG0587-01 : Elevated reporting limits for trace metals due to sample matrix.

Organic Acids Analysis: Due to the sample matrix, sample required dilution. Detection limits were adjusted accordingly.

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
3636573	BHR	Matrix Spike	Isobutylbenzene - Extractable	2014/06/11		111	%	30 - 130
			n-Dotriacontane - Extractable	2014/06/11		102	%	30 - 130
			>C10-C16 Hydrocarbons	2014/06/11		81	%	30 - 130
			>C16-C21 Hydrocarbons	2014/06/11		91	%	30 - 130
			>C21-<C32 Hydrocarbons	2014/06/11		97	%	30 - 130
3636573	BHR	Spiked Blank	Isobutylbenzene - Extractable	2014/06/11		103	%	30 - 130
			n-Dotriacontane - Extractable	2014/06/11		109	%	30 - 130
			>C10-C16 Hydrocarbons	2014/06/11		79	%	30 - 130
			>C16-C21 Hydrocarbons	2014/06/11		89	%	30 - 130
			>C21-<C32 Hydrocarbons	2014/06/11		97	%	30 - 130
3636573	BHR	Method Blank	Isobutylbenzene - Extractable	2014/06/11		102	%	30 - 130
			n-Dotriacontane - Extractable	2014/06/11		109	%	30 - 130
			>C10-C16 Hydrocarbons	2014/06/11	ND , RDL=0.050		mg/L	
			>C16-C21 Hydrocarbons	2014/06/11	ND , RDL=0.050		mg/L	
			>C21-<C32 Hydrocarbons	2014/06/11	ND , RDL=0.10		mg/L	
3636652	GTH	Matrix Spike	D10-Anthracene	2014/06/12		90	%	30 - 130
			D14-Terphenyl	2014/06/12		101	%	30 - 130
			D8-Acenaphthylene	2014/06/12		95	%	30 - 130
			1-Methylnaphthalene	2014/06/12		110	%	30 - 130
			2-Methylnaphthalene	2014/06/12		108	%	30 - 130
			Acenaphthene	2014/06/12		100	%	30 - 130
			Acenaphthylene	2014/06/12		107	%	30 - 130
			Anthracene	2014/06/12		99	%	30 - 130
			Benzo(a)anthracene	2014/06/12		105	%	30 - 130
			Benzo(a)pyrene	2014/06/12		97	%	30 - 130
			Benzo(b)fluoranthene	2014/06/12		105	%	30 - 130
			Benzo(g,h,i)perylene	2014/06/12		104	%	30 - 130
			Benzo(j)fluoranthene	2014/06/12		95	%	30 - 130
			Benzo(k)fluoranthene	2014/06/12		91	%	30 - 130
			Chrysene	2014/06/12		107	%	30 - 130
			Dibenz(a,h)anthracene	2014/06/12		95	%	30 - 130
			Fluoranthene	2014/06/12		99	%	30 - 130
			Fluorene	2014/06/12		105	%	30 - 130
			Indeno(1,2,3-cd)pyrene	2014/06/12		100	%	30 - 130
			Naphthalene	2014/06/12		111	%	30 - 130
			Perylene	2014/06/12		98	%	30 - 130
			Phenanthrene	2014/06/12		110	%	30 - 130
			Pyrene	2014/06/12		102	%	30 - 130
3636652	GTH	Spiked Blank	D10-Anthracene	2014/06/12		98	%	30 - 130
			D14-Terphenyl	2014/06/12		129	%	30 - 130
			D8-Acenaphthylene	2014/06/12		110	%	30 - 130
			1-Methylnaphthalene	2014/06/12		107	%	30 - 130
			2-Methylnaphthalene	2014/06/12		107	%	30 - 130
			Acenaphthene	2014/06/12		99	%	30 - 130
			Acenaphthylene	2014/06/12		114	%	30 - 130
			Anthracene	2014/06/12		109	%	30 - 130
			Benzo(a)anthracene	2014/06/12		109	%	30 - 130
			Benzo(a)pyrene	2014/06/12		99	%	30 - 130
			Benzo(b)fluoranthene	2014/06/12		88	%	30 - 130
			Benzo(g,h,i)perylene	2014/06/12		104	%	30 - 130
			Benzo(j)fluoranthene	2014/06/12		97	%	30 - 130

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Benzo(k)fluoranthene	2014/06/12		92	%	30 - 130
			Chrysene	2014/06/12		105	%	30 - 130
			Dibenz(a,h)anthracene	2014/06/12		96	%	30 - 130
			Fluoranthene	2014/06/12		102	%	30 - 130
			Fluorene	2014/06/12		106	%	30 - 130
			Indeno(1,2,3-cd)pyrene	2014/06/12		100	%	30 - 130
			Naphthalene	2014/06/12		104	%	30 - 130
			Perylene	2014/06/12		97	%	30 - 130
			Phenanthrene	2014/06/12		109	%	30 - 130
			Pyrene	2014/06/12		107	%	30 - 130
3636652	GTH	Method Blank	D10-Anthracene	2014/06/12		96	%	30 - 130
			D14-Terphenyl	2014/06/12		103	%	30 - 130
			D8-Acenaphthylene	2014/06/12		90	%	30 - 130
			1-Methylnaphthalene	2014/06/12	ND, RDL=0.050		ug/L	
			2-Methylnaphthalene	2014/06/12	ND, RDL=0.050		ug/L	
			Acenaphthene	2014/06/12	ND, RDL=0.010		ug/L	
			Acenaphthylene	2014/06/12	ND, RDL=0.010		ug/L	
			Anthracene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(a)anthracene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(a)pyrene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(b)fluoranthene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(g,h,i)perylene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(j)fluoranthene	2014/06/12	ND, RDL=0.010		ug/L	
			Benzo(k)fluoranthene	2014/06/12	ND, RDL=0.010		ug/L	
			Chrysene	2014/06/12	ND, RDL=0.010		ug/L	
			Dibenz(a,h)anthracene	2014/06/12	ND, RDL=0.010		ug/L	
			Fluoranthene	2014/06/12	ND, RDL=0.010		ug/L	
			Fluorene	2014/06/12	ND, RDL=0.010		ug/L	
			Indeno(1,2,3-cd)pyrene	2014/06/12	ND, RDL=0.010		ug/L	
			Naphthalene	2014/06/12	ND, RDL=0.20		ug/L	
			Perylene	2014/06/12	ND, RDL=0.010		ug/L	
			Phenanthrene	2014/06/12	ND, RDL=0.010		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Pyrene	2014/06/12	ND , RDL=0.010		ug/L	
3636712	DLB	Matrix Spike	Total Aluminum (Al)	2014/06/11		101	%	80 - 120
			Total Antimony (Sb)	2014/06/11		103	%	80 - 120
			Total Arsenic (As)	2014/06/11		98	%	80 - 120
			Total Barium (Ba)	2014/06/11		100	%	80 - 120
			Total Beryllium (Be)	2014/06/11		107	%	80 - 120
			Total Bismuth (Bi)	2014/06/11		101	%	80 - 120
			Total Boron (B)	2014/06/11		105	%	80 - 120
			Total Cadmium (Cd)	2014/06/11		102	%	80 - 120
			Total Calcium (Ca)	2014/06/11		92	%	80 - 120
			Total Chromium (Cr)	2014/06/11		98	%	80 - 120
			Total Cobalt (Co)	2014/06/11		100	%	80 - 120
			Total Copper (Cu)	2014/06/11		99	%	80 - 120
			Total Iron (Fe)	2014/06/11		105	%	80 - 120
			Total Lead (Pb)	2014/06/11		106	%	80 - 120
			Total Magnesium (Mg)	2014/06/11		109	%	80 - 120
			Total Manganese (Mn)	2014/06/11		103	%	80 - 120
			Total Molybdenum (Mo)	2014/06/11		100	%	80 - 120
			Total Nickel (Ni)	2014/06/11		99	%	80 - 120
			Total Phosphorus (P)	2014/06/11		107	%	80 - 120
			Total Potassium (K)	2014/06/11		101	%	80 - 120
			Total Selenium (Se)	2014/06/11		98	%	80 - 120
			Total Silver (Ag)	2014/06/11		98	%	80 - 120
			Total Sodium (Na)	2014/06/11		NC	%	80 - 120
			Total Strontium (Sr)	2014/06/11		99	%	80 - 120
			Total Sulphur (S)	2014/06/11		98	%	80 - 120
			Total Thallium (Tl)	2014/06/11		101	%	80 - 120
			Total Tin (Sn)	2014/06/11		103	%	80 - 120
			Total Titanium (Ti)	2014/06/11		99	%	80 - 120
			Total Uranium (U)	2014/06/11		107	%	80 - 120
			Total Vanadium (V)	2014/06/11		100	%	80 - 120
			Total Zinc (Zn)	2014/06/11		98	%	80 - 120
3636712	DLB	Spiked Blank	Total Aluminum (Al)	2014/06/11		101	%	80 - 120
			Total Antimony (Sb)	2014/06/11		100	%	80 - 120
			Total Arsenic (As)	2014/06/11		97	%	80 - 120
			Total Barium (Ba)	2014/06/11		100	%	80 - 120
			Total Beryllium (Be)	2014/06/11		103	%	80 - 120
			Total Bismuth (Bi)	2014/06/11		99	%	80 - 120
			Total Boron (B)	2014/06/11		102	%	80 - 120
			Total Cadmium (Cd)	2014/06/11		101	%	80 - 120
			Total Calcium (Ca)	2014/06/11		98	%	80 - 120
			Total Chromium (Cr)	2014/06/11		97	%	80 - 120
			Total Cobalt (Co)	2014/06/11		100	%	80 - 120
			Total Copper (Cu)	2014/06/11		98	%	80 - 120
			Total Iron (Fe)	2014/06/11		104	%	80 - 120
			Total Lead (Pb)	2014/06/11		103	%	80 - 120
			Total Magnesium (Mg)	2014/06/11		107	%	80 - 120
			Total Manganese (Mn)	2014/06/11		100	%	80 - 120
			Total Molybdenum (Mo)	2014/06/11		99	%	80 - 120
			Total Nickel (Ni)	2014/06/11		99	%	80 - 120
			Total Phosphorus (P)	2014/06/11		106	%	80 - 120
			Total Potassium (K)	2014/06/11		100	%	80 - 120
			Total Selenium (Se)	2014/06/11		97	%	80 - 120

Success Through Science®

McGregor GeoScience Limited

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Total Silver (Ag)	2014/06/11		96	%	80 - 120
			Total Sodium (Na)	2014/06/11		101	%	80 - 120
			Total Strontium (Sr)	2014/06/11		99	%	80 - 120
			Total Sulphur (S)	2014/06/11		107	%	80 - 120
			Total Thallium (Tl)	2014/06/11		99	%	80 - 120
			Total Tin (Sn)	2014/06/11		102	%	80 - 120
			Total Titanium (Ti)	2014/06/11		99	%	80 - 120
			Total Uranium (U)	2014/06/11		105	%	80 - 120
			Total Vanadium (V)	2014/06/11		99	%	80 - 120
			Total Zinc (Zn)	2014/06/11		99	%	80 - 120
3636712	DLB	Method Blank	Total Aluminum (Al)	2014/06/11	ND, RDL=5.0		ug/L	
			Total Antimony (Sb)	2014/06/11	ND, RDL=1.0		ug/L	
			Total Arsenic (As)	2014/06/11	ND, RDL=1.0		ug/L	
			Total Barium (Ba)	2014/06/11	ND, RDL=1.0		ug/L	
			Total Beryllium (Be)	2014/06/11	ND, RDL=1.0		ug/L	
			Total Bismuth (Bi)	2014/06/11	ND, RDL=2.0		ug/L	
			Total Boron (B)	2014/06/11	ND, RDL=50		ug/L	
			Total Cadmium (Cd)	2014/06/11	ND, RDL=0.010		ug/L	
			Total Calcium (Ca)	2014/06/11	ND, RDL=100		ug/L	
			Total Chromium (Cr)	2014/06/11	ND, RDL=1.0		ug/L	
			Total Cobalt (Co)	2014/06/11	ND, RDL=0.40		ug/L	
			Total Copper (Cu)	2014/06/11	ND, RDL=2.0		ug/L	
			Total Iron (Fe)	2014/06/11	ND, RDL=50		ug/L	
			Total Lead (Pb)	2014/06/11	ND, RDL=0.50		ug/L	
			Total Magnesium (Mg)	2014/06/11	ND, RDL=100		ug/L	
			Total Manganese (Mn)	2014/06/11	ND, RDL=2.0		ug/L	
			Total Molybdenum (Mo)	2014/06/11	ND, RDL=2.0		ug/L	
			Total Nickel (Ni)	2014/06/11	ND, RDL=2.0		ug/L	
			Total Phosphorus (P)	2014/06/11	ND, RDL=100		ug/L	
			Total Potassium (K)	2014/06/11	ND, RDL=100		ug/L	
			Total Selenium (Se)	2014/06/11	ND, RDL=1.0		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Total Silver (Ag)	2014/06/11	ND , RDL=0.10		ug/L	
			Total Sodium (Na)	2014/06/11	ND , RDL=100		ug/L	
			Total Strontium (Sr)	2014/06/11	ND , RDL=2.0		ug/L	
			Total Sulphur (S)	2014/06/11	ND , RDL=5000		ug/L	
			Total Thallium (Tl)	2014/06/11	ND , RDL=0.10		ug/L	
			Total Tin (Sn)	2014/06/11	ND , RDL=2.0		ug/L	
			Total Titanium (Ti)	2014/06/11	ND , RDL=2.0		ug/L	
			Total Uranium (U)	2014/06/11	ND , RDL=0.10		ug/L	
			Total Vanadium (V)	2014/06/11	ND , RDL=2.0		ug/L	
			Total Zinc (Zn)	2014/06/11	ND , RDL=5.0		ug/L	
3637274	NYS	Matrix Spike [WG0587-04]	Sulphide	2014/06/11		NC	%	80 - 120
3637274	NYS	Spiked Blank	Sulphide	2014/06/11		90	%	80 - 120
3637274	NYS	Method Blank	Sulphide	2014/06/11	ND , RDL=0.020		mg/L	
3637274	NYS	RPD [WG0587-04]	Sulphide	2014/06/11	7.4		%	20
3638180	BBD	QC Standard	Salinity	2014/06/12		101	%	80 - 120
3638180	BBD	Method Blank	Salinity	2014/06/12	ND , RDL=2.0		N/A	
3638180	BBD	RPD [WG0587-02]	Salinity	2014/06/12	0		%	25
3642551	MS3	Matrix Spike	Isobutylbenzene - Volatile	2014/06/16		98	%	70 - 130
			Benzene	2014/06/16		118	%	70 - 130
			Toluene	2014/06/16		115	%	70 - 130
			Ethylbenzene	2014/06/16		113	%	70 - 130
			Xylene (Total)	2014/06/16		113	%	70 - 130
3642551	MS3	Spiked Blank	Isobutylbenzene - Volatile	2014/06/16		102	%	70 - 130
			Benzene	2014/06/16		116	%	70 - 130
			Toluene	2014/06/16		115	%	70 - 130
			Ethylbenzene	2014/06/16		114	%	70 - 130
			Xylene (Total)	2014/06/16		114	%	70 - 130
3642551	MS3	Method Blank	Isobutylbenzene - Volatile	2014/06/16		101	%	70 - 130
			Benzene	2014/06/16	ND , RDL=0.0010		mg/L	
			Toluene	2014/06/16	ND , RDL=0.0010		mg/L	
			Ethylbenzene	2014/06/16	ND , RDL=0.0010		mg/L	
			Xylene (Total)	2014/06/16	ND , RDL=0.0020		mg/L	
			C6 - C10 (less BTEX)	2014/06/16	ND , RDL=0.010		mg/L	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
3642997	FD	Matrix Spike [WG0587-03]	Formic Acid	2014/06/17		106	%	80 - 120
			Acetic Acid	2014/06/17		NC	%	80 - 120
			Propionic Acid	2014/06/17		99	%	80 - 120
			Butyric Acid	2014/06/17		99	%	80 - 120
3642997	FD	Spiked Blank	Formic Acid	2014/06/17		98	%	80 - 120
			Acetic Acid	2014/06/17		103	%	80 - 120
			Propionic Acid	2014/06/17		99	%	80 - 120
			Butyric Acid	2014/06/17		95	%	80 - 120
3642997	FD	Method Blank	Formic Acid	2014/06/17	ND , RDL=0.5		mg/L	
			Acetic Acid	2014/06/17	ND , RDL=1		mg/L	
			Propionic Acid	2014/06/17	ND , RDL=1		mg/L	
			Butyric Acid	2014/06/17	ND , RDL=2		mg/L	
3642997	FD	RPD [WG0587-03]	Formic Acid	2014/06/17	NC		%	20
			Acetic Acid	2014/06/17	NC		%	20
			Propionic Acid	2014/06/17	NC		%	20
			Butyric Acid	2014/06/17	NC		%	20
3643490	ARS	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2014/06/17		99	%	80 - 120
3643490	ARS	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2014/06/17		100	%	80 - 120
3643490	ARS	Method Blank	Nitrogen (Ammonia Nitrogen)	2014/06/17	ND , RDL=0.050		mg/L	
3643491	MCN	Matrix Spike	Total Phosphorus	2014/06/20		113	%	80 - 120
3643491	MCN	Spiked Blank	Total Phosphorus	2014/06/20		111	%	80 - 120
3643491	MCN	Method Blank	Total Phosphorus	2014/06/20	ND , RDL=0.020		mg/L	
3643540	MCY	Matrix Spike	Orthophosphate (P)	2014/06/18		97	%	80 - 120
3643540	MCY	Spiked Blank	Orthophosphate (P)	2014/06/18		101	%	80 - 120
3643540	MCY	Method Blank	Orthophosphate (P)	2014/06/18	ND , RDL=0.010		mg/L	
3643542	MCY	Matrix Spike	Nitrate + Nitrite	2014/06/18		100	%	80 - 120
3643542	MCY	Spiked Blank	Nitrate + Nitrite	2014/06/18		95	%	80 - 120
3643542	MCY	Method Blank	Nitrate + Nitrite	2014/06/18	ND , RDL=0.050		mg/L	
3643546	MCY	Matrix Spike	Nitrite (N)	2014/06/18		97	%	80 - 120
3643546	MCY	Spiked Blank	Nitrite (N)	2014/06/18		97	%	80 - 120
3643546	MCY	Method Blank	Nitrite (N)	2014/06/18	ND , RDL=0.010		mg/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
3645198	KSR	QC Standard	pH	2014/06/18		100	%	80 - 120

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

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Chain Of Custody Record

Page 1 of 2

INVOICE INFORMATION:		Report Information		Project Information	
Company Name	#24189 McGregor GeoScience Limited	Company Name		Quotation #	B43921
Contact Name	Stephane Kirchhoff	Contact Name		P.O. #	
Address	177 Bluewater Road	Address		Project #	
	Bedford NS B4B 1H1			Project Name	
Phone	(902) 420-0313 x Fax (902) 429-7186 x	Phone	Fax	Site #	
Email	skirchhoff@mcgregor-geoscience.com	Email		Sampled By	

Laboratory Use Only

Maxxam Job #	Bottle Order #:
B497659	473037
Chain Of Custody Record	Project Manager
C#473037-01-01	Keri Mackay

Regulatory Criteria:

B497659

* Specify Matrix: Surface/Ground/Tapwater/Sewage/Effluent/Seawater Potable/Nonpotable/Tissue/Soil/Sludge/Metal

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (Please be specific):

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered & Preserved	Lab Filtration Required	Metals Scan (choose TOTAL or DISSOLVED)	RBCA Hydrocarbons in Water	PAH in Water by GC/MS (SIM)	Nitrate (as N)- NO3	Nitrate + Nitrite - NOx	Nitrite - NO2	Nitrogen Ammonia - water	Phosphorus - ortho	Total Phosphorus	Sulphide	Size & # Bottles	Comments / Hazards / Other Required Analysis
1		Produced water	10/6/14	7:00	Prod. Water			X	X	X	X	X	X	X	X	X	X		
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			2014 JUN 10 10:56
10																			

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required:

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
STEPHANE KIRCHHOFF	14/06/10	10:56	TIFFANY MORASH				☐	2, 12, 18	☐ Yes ☐ No

Lab Use Only

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

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Chain Of Custody Record

Page 2 of 2

INVOICE INFORMATION:		Report Information		Project Information		Laboratory Use Only	
Company Name	#24189 McGregor GeoScience Limited	Company Name		Quotation #	B43921	Maxxam Job #	Bottle Order #:
Contact Name	Stephane Kirchhoff	Contact Name		P.O. #		B497659	473037
Address	177 Bluewater Road	Address		Project #		Chain Of Custody Record	Project Manager
	Bedford NS B4B 1H1			Project Name		C#473037-01-02	Keri Mackay
Phone	(902) 420-0313 x Fax: (902) 429-7186 x	Phone	Fax:	Site #			
Email	skirchhoff@mcgregor-geoscience.com	Email		Sampled By			

Regulatory Criteria:

** Specify Matrix: Surface/Ground/Tapwater/Sewage/Effluent/Seawater Potable/Nonpotable/Tissue/Soil/Sludge/Metal

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (Please be specific):

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required:

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtred & Preserved	Lab Filtration Required	pH	Salinity	Organic Acids Analysis in Water Sample	Alkylated Phenols in Water (Sub fr Bed.)							Size & # Bottles	Comments / Hazards / Other Required Analysis
1		Produced water	10/6/14	7:00	Prod Water			X	X	X	X								
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

2014 JUN 10 10:56

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
STEPHANE KIRCHHOFF	14/06/10	10:56	[illegible] TIFFANY [illegible]				☐	2, 12, 18	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

AXYS | Axys Analytical Services Ltd
2045 Mills Road West
SIDNEY, BRITISH COLUMBIA, CANADA V8L 5X2
TEL 250-655-5800 FAX 250-655-5811
www.axysanalytical.com

AXYS Client No.: 4689

Client Address: MAXXAM - Bedford
105 – 200 Bluewater Rd
Bedford, NS, CA, B4B 1G9

The AXYS contact for these data is Cynthia Tomey.

BATCH SUMMARY

Batch ID:	WG47725	***Date:***	30-Jun-2014
Analysis Type:	Alkylphenols	***Matrix Type:***	Aqueous

BATCH MAKEUP

Contract: 4689

Samples:

L21559-1 WG0587-01R\ Produced water

Blank:
WG47725-101

Reference or Spike:
WG47725-102

Duplicate:

Comments:
1. Data are considered final.
2. Data are not blank corrected.

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AXYS METHOD MLA-004 Rev 07

Form 1A
ANALYSIS REPORT

CLIENT SAMPLE NO.
WG0587-01R\ Produced water
Sample Collection:
10-Jun-2014 07:00

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Contract No.:	4689	**Project No.**	B497659
		Lab Sample I.D.:	L21559-1
Matrix:	AQUEOUS	**Sample Size:**	1.05 L
Sample Receipt Date:	11-Jun-2014	**Initial Calibration Date:**	BRACKETING CAL
Extraction Date:	13-Jun-2014	**Instrument ID:**	LR GC/MS
Analysis Date:	18-Jun-2014 **Time:** 19:39:00	**GC Column ID:**	RTX5
Extract Volume (uL):	500	**Sample Data Filename:**	**AP4H0805.D**
Injection Volume (uL):	2.0	**Blank Data Filename:**	AP4H0804.D
Dilution Factor:	N/A	**Opening Cal. Data Filename:** **Closing Cal. Data Filename:**	AP4H0801.D AP4H0811.D
Concentration Units:	ng/L		

This page is part of a total report that contains information necessary for accreditation compliance.
This test is not CALA accredited. Sample results relate only to the sample tested.

COMPOUND	CAS NO.	LAB FLAG [1]	CONC. FOUND	REPORTING LIMIT (RL)[2]	ION ABUND. RATIO	RRT
4-Nonylphenols			122	33.2 (S)		
4-Nonylphenol monoethoxylates		U		157 (S)		
4-Nonylphenol diethoxylates		U		13.3 (S)		
Octylphenol		U		49.9 (S)		

(1) Where applicable, custom lab flags have been used on this report; U = not detected at RL.
(2) Reporting Limit (Code): S = sample detection limit; M = method detection limit; L = lowest calibration level equivalent; Q = contract defined limit.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Peter Chen________

For Axys Internal Use Only [XSL Template: Pest1A.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_L21559-1_Form1A_AP4H0805.D_SJ1758093.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07	**Form 2** **ANALYSIS REPORT**		**CLIENT SAMPLE NO.** **WG0587-01R\ Produced water** **Sample Collection:** **10-Jun-2014 07:00**

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

		Project No.	B497659
Contract No.:	4689	**Lab Sample I.D.:**	L21559-1
Matrix:	AQUEOUS	**Sample Size:**	1.05 L
Sample Receipt Date:	11-Jun-2014	**Initial Calibration Date:**	BRACKETING CAL
Extraction Date:	13-Jun-2014	**Instrument ID:**	LR GC/MS
Analysis Date:	18-Jun-2014 **Time:** 19:39:00	**GC Column ID:**	RTX5
Extract Volume (uL):	500	**Sample Data Filename:**	**AP4H0805.D**
Injection Volume (uL):	2.0	**Blank Data Filename:**	AP4H0804.D
Dilution Factor:	N/A	**Opening Cal. Data Filename:** **Closing Cal. Data Filename:**	AP4H0801.D AP4H0811.D
Concentration Units:	ng absolute		

This page is part of a total report that contains information necessary for accreditation compliance.
This test is not CALA accredited. Sample results relate only to the sample tested.

LABELED COMPOUND	LAB FLAG [1]	SPIKE CONC.	CONC. FOUND	R(%) [2]	ION ABUND. RATIO	RRT
13C6-4-n-Nonylphenol		1000	1180	118	0.11	0.865
13C6-NP2EO		5000	4420	88.4	0.19	1.322

(1) Where applicable, custom lab flags have been used on this report.
(2) R% = percent recovery.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.

Signed: _________Peter Chen________

For Axys Internal Use Only [XSL Template: Pest2.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_L21559-1_Form2_AP4H0805.D_SJ1758093.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 1A

ANALYSIS REPORT

CLIENT SAMPLE NO.
Lab Blank
Sample Collection:
N/A

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Contract No.:	4689	**Project No.**	N/A
		Lab Sample I.D.:	WG47725-101
Matrix:	AQUEOUS	**Sample Size:**	1.00 L
Sample Receipt Date:	N/A	**Initial Calibration Date:**	BRACKETING CAL
Extraction Date:	13-Jun-2014	**Instrument ID:**	LR GC/MS
Analysis Date:	18-Jun-2014 **Time:** 19:04:00	**GC Column ID:**	RTX5
Extract Volume (uL):	500	**Sample Data Filename:**	**AP4H0804.D**
Injection Volume (uL):	2.0	**Blank Data Filename:**	AP4H0804.D
Dilution Factor:	N/A	**Opening Cal. Data Filename:** **Closing Cal. Data Filename:**	AP4H0801.D AP4H0811.D
Concentration Units:	ng/L		

This page is part of a total report that contains information necessary for accreditation compliance.
This test is not CALA accredited. Sample results relate only to the sample tested.

COMPOUND	CAS NO.	LAB FLAG [1]	CONC. FOUND	REPORTING LIMIT (RL)[2]	ION ABUND. RATIO	RRT
4-Nonylphenols		U		3.65 (S)		
4-Nonylphenol monoethoxylates		U		6.79 (S)		
4-Nonylphenol diethoxylates		U		6.66 (S)		
Octylphenol		U		2.08 (S)		

(1) Where applicable, custom lab flags have been used on this report; U = not detected at RL.
(2) Reporting Limit (Code): S = sample detection limit; M = method detection limit; L = lowest calibration level equivalent; Q = contract defined limit.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Peter Chen_________

For Axys Internal Use Only [XSL Template: Pest1A.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_WG47725-101_Form1A_AP4H0804.D_SJ1758091.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 2

ANALYSIS REPORT

CLIENT SAMPLE NO.
Lab Blank
Sample Collection:
N/A

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

		Project No.	N/A
Contract No.:	4689	**Lab Sample I.D.:**	WG47725-101
Matrix:	AQUEOUS	**Sample Size:**	1.00 L
Sample Receipt Date:	N/A	**Initial Calibration Date:**	BRACKETING CAL
Extraction Date:	13-Jun-2014	**Instrument ID:**	LR GC/MS
Analysis Date:	18-Jun-2014 **Time:** 19:04:00	**GC Column ID:**	RTX5
Extract Volume (uL):	500	**Sample Data Filename:**	**AP4H0804.D**
Injection Volume (uL):	2.0	**Blank Data Filename:**	AP4H0804.D
Dilution Factor:	N/A	**Opening Cal. Data Filename:** **Closing Cal. Data Filename:**	AP4H0801.D AP4H0811.D
Concentration Units:	ng absolute		

This page is part of a total report that contains information necessary for accreditation compliance.
This test is not CALA accredited. Sample results relate only to the sample tested.

LABELED COMPOUND	LAB FLAG [1]	SPIKE CONC.	CONC. FOUND	R(%) [2]	ION ABUND. RATIO	RRT
13C6-4-n-Nonylphenol		1000	632	63.2	0.11	0.865
13C6-NP2EO		5000	3750	74.9	0.18	1.322

(1) Where applicable, custom lab flags have been used on this report.
(2) R% = percent recovery.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.

Signed: _________Peter Chen_________

For Axys Internal Use Only [XSL Template: Pest2.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_WG47725-101_Form2_AP4H0804.D_SJ1758091.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 8A
ONGOING PRECISION AND RECOVERY (OPR)

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Contract No.:	4689	**OPR Data Filename:**	**AP4H0802.D**
Matrix:	AQUEOUS	**Lab Sample I.D.:**	WG47725-102
Extraction Date:	13-Jun-2014	**Analysis Date:**	18-Jun-2014 **Time:** 17:53:00

ALL CONCENTRATIONS REPORTED ON THIS FORM ARE CONCENTRATIONS IN EXTRACT, BASED ON 100 uL EXTRACT.

COMPOUND	CAS NO.	LAB FLAG [1]	ION ABUND. RATIO	SPIKE CONC. (ng/mL)	CONC. FOUND (ng/mL)	OPR CONC. LIMITS (ng/mL)	% RECOVERY
4-Nonylphenols				20000	18600	14000 - 26000	93.1
4-Nonylphenol monoethoxylates				101000	98300	50400 - 131000	97.5
4-Nonylphenol diethoxylates				100000	106000	50100 - 150000	106
Octylphenol			0.04	20000	19800	10000 - 26000	99.1

(1) Where applicable, custom lab flags have been used on this report.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Peter Chen________

These pages are part of a larger report that may contain information necessary for full data evaluation. Results reported relate only to the sample tested.

For Axys Internal Use Only [XSL Template: Pest8A.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_WG47725-102_Form8A_SJ1758089.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 8B
ONGOING PRECISION AND RECOVERY (OPR)

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Contract No.:	4689	**OPR Data Filename:**	**AP4H0802.D**
Matrix:	AQUEOUS	**Lab Sample I.D.:**	WG47725-102
Extraction Date:	13-Jun-2014	**Analysis Date:**	18-Jun-2014 **Time:** 17:53:00

ALL CONCENTRATIONS REPORTED ON THIS FORM ARE CONCENTRATIONS IN EXTRACT, BASED ON 100 uL EXTRACT.

LABELED COMPOUND	CAS NO.	LAB FLAG [1]	ION ABUND. RATIO	SPIKE CONC. (ng/mL)	CONC. FOUND (ng/mL)	OPR CONC. LIMITS (ng/mL)	% RECOVERY
13C6-4-n-Nonylphenol			0.11	10000	10200	4000-12000	102
13C6-NP2EO			0.18	50000	40600	5000-65000	81.2

(1) Where applicable, custom lab flags have been used on this report.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Peter Chen________

These pages are part of a larger report that may contain information necessary for full data evaluation. Results reported relate only to the sample tested.

For Axys Internal Use Only [XSL Template: Pest8B.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: AP_ALKYLPHENOLS_AP_WG47725-102_Form8B_SJ1758089.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 4C
BRACKETING CALIBRATION RELATIVE RESPONSES

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Initial Calibration Date:	BRACKETING CAL		
Instrument ID:	LR GC/MS	**GC Column ID:**	RTX5
OPENING CAL Data Filename:	AP4H0801.D	**Analysis Date:**	18-Jun-2014 **Time:** 17:17:00
CLOSING CAL Data Filename:	AP4H0811.D	**Analysis Date:**	19-Jun-2014 **Time:** 00:45:00

COMPOUND	CAS NO.	LAB FLAG [1]	RELATIVE RESPONSE (RR) OPENING CAL	RELATIVE RESPONSE (RR) CLOSING CAL	MEAN RR	RPD [2]
4-Nonylphenols			0.549	0.553	0.551	0.726
4-Nonylphenol monoethoxylates			0.279	0.277	0.278	0.719
4-Nonylphenol diethoxylates			1.00	1.04	1.02	3.53
Octylphenol			1.04	1.02	1.03	1.95

(1) Where applicable, custom lab flags have been used on this report.
(2) QC limits are < 40% RPD.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Anita Lacey________

For Axys Internal Use Only [XSL Template: Pest4C.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: GENERIC-SPECS_ALKYLPHENOLS_GS55173__Form4C_GS55173.html; Workgroup: WG47725; Design ID: 1731]

AXYS METHOD MLA-004 Rev 07

Form 4D
BRACKETING CALIBRATION RELATIVE RESPONSES

AXYS ANALYTICAL SERVICES
2045 MILLS RD., SIDNEY, B.C., CANADA
V8L 5X2 TEL (250) 655-5800 FAX (250) 655-5811

Initial Calibration Date: BRACKETING CAL

Instrument ID: LR GC/MS **GC Column ID:** RTX5

OPENING CAL Data Filename: AP4H0801.D **Analysis Date:** 18-Jun-2014 **Time:** 17:17:00

CLOSING CAL Data Filename: AP4H0811.D **Analysis Date:** 19-Jun-2014 **Time:** 00:45:00

COMPOUND	CAS NO.	LAB FLAG [1]	RELATIVE RESPONSE (RR) OPENING CAL	RELATIVE RESPONSE (RR) CLOSING CAL	MEAN RR	RPD [2]
13C6-4-n-Nonylphenol			0.362	0.382	0.372	5.38
13C6-NP2EO			0.0940	0.0980	0.0960	4.17

(1) Where applicable, custom lab flags have been used on this report.
(2) QC limits are < 40% RPD.

These data are validated and reported as accurate and in accord with AXYS Analytical Services Ltd. ISO17025 compliant quality assurance processes.
Signed: _________Anita Lacey________

For Axys Internal Use Only [XSL Template: Pest4D.xsl; Created: 30-Jun-2014 14:44:52; Application: XMLTransformer-1.13.65;
Report Filename: GENERIC-SPECS_ALKYLPHENOLS_GS55173__Form4D_GS55173.html; Workgroup: WG47725; Design ID: 1731]

AXYS Analytical Services Ltd. - Accreditation Summary

ACC-101 R12

Matrix and Accrediting Body

Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp: CALA	Serum: CALA	Solids: CALA	Solids: California DPH	Solids: Florida DOH	Solids: Minnesota DOH	Solids: New Jersey DEP	Solids: New York DOH	Solids: Virginia DGS	Solids: Washington DE	Solids: Maine DOH	Tissue: CALA	Tissue: Florida DOH	Tissue: Minnesota DOH	Tissue: New Jersey DEP	Tissue: Virginia DGS	Urine: CALA	Water: CALA	Water, Drinking: Florida DOH	Water, Drinking: Minnesota DOH	Water, Drinking: New Jersey DEP	Water, Non-Potable: California DPH	Water, Non-Potable: Florida DOH	Water, Non-Potable: Minnesota DOH	Water, Non-Potable: New Jersey DEP	Water, Non-Potable: New York DOH	Water, Non-Potable: Virginia DGS	Water, Non-Potable: Washington DE	Water, Non-Potable: Maine DOH
BPA and MPE	4,4'-dihydroxy-2,2-diphenylpropane (Bisphenol A) (BPA)	AXYS MLA-059	MLA-059																	Y												
	Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	AXYS MLA-059	MLA-059																	Y												
	Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP)	AXYS MLA-059	MLA-059																	Y												
	Mono-(3-carboxypropyl) phthalate (MCPP)	AXYS MLA-059	MLA-059																	Y												
	Mono-2-ethylhexyl phthalate (MEHP)	AXYS MLA-059	MLA-059																	Y												
	Mono-benzyl phthalate (MBzP)	AXYS MLA-059	MLA-059																	Y												
	Mono-butyl phthalate (MBP) (n + iso)	AXYS MLA-059	MLA-059																	Y												
	Mono-cyclohexyl phthalate (MCHP)	AXYS MLA-059	MLA-059																	Y												
	Mono-ethyl phthalate (MEP)	AXYS MLA-059	MLA-059																	Y												
	Mono-iso-nonyl phthalate (MiNP)	AXYS MLA-059	MLA-059																	Y												
	Mono-methyl phthalate (MMP)	AXYS MLA-059	MLA-059																	Y												
HBCDD	alpha-hexabromocyclododecane (a-HBCDD)	AXYS MLA-070	MLA-070		Y																											
	beta-hexabromocyclododecane (b-HBCDD)	AXYS MLA-070	MLA-070		Y																											
	gamma-hexabromocyclododecane (g-HBCDD)	AXYS MLA-070	MLA-070		Y																											
OC Pesticides	2,4'-DDD	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
	2,4'-DDE	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
	2,4'-DDT	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
	4,4'-DDD	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	4,4'-DDE	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	4,4'-DDT	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Aldrin	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	

AXYS Analytical Services Ltd. - Accreditation Summary

ACC-101 R12

				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Alpha-HCH	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Beta-HCH	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Chlordane, technical	EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y															Y	Y		
	cis-Chlordane (alpha-Chlordane)	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 8270	MLA-007											Y															Y			Y
	cis-Nonachlor	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
	Delta-HCH	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																										Y	Y		Y
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y					Y																				
		EPA 8081	MLA-007								Y			Y																		
	Dieldrin	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endosulphan I	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endosulphan II	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y

AXYS Analytical Services Ltd. - Accreditation Summary

ACC-101 R12

				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endosulphan sulphate	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endrin	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endrin aldehyde	AXYS MLA-007	MLA-007			Y															Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Endrin Ketone	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 8081	MLA-007								Y																					
	Gamma-HCH (Lindane)	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Heptachlor	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 8270	MLA-007				Y				Y	Y		Y																		
	Heptachlor epoxide	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																						Y				Y	Y		Y
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Hexachlorobenzene	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 8270	MLA-007				Y				Y	Y		Y																		
		EPA 1625	MLA-007																						Y				Y	Y		
	Hexachlorobutadiene	AXYS MLA-028	MLA-028																												Y	
	Methoxychlor	AXYS MLA-007	MLA-007		Y	Y									Y						Y											

AXYS Analytical Services Ltd. - Accreditation Summary

ACC-101 R12

Matrix and Accrediting Body

Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp CALA	Serum CALA	Solids CALA	Solids California DPH	Solids Florida DOH	Solids Minnesota DOH	Solids New Jersey DEP	Solids New York DOH	Solids Virginia DGS	Solids Washington DE	Solids Maine DOH	Tissue CALA	Tissue Florida DOH	Tissue Minnesota DOH	Tissue New Jersey DEP	Tissue Virginia DGS	Urine CALA	Water CALA	Water, Drinking Florida DOH	Water, Drinking Minnesota DOH	Water, Drinking New Jersey DEP	Water, Non-Potable California DPH	Water, Non-Potable Florida DOH	Water, Non-Potable Minnesota DOH	Water, Non-Potable New Jersey DEP	Water, Non-Potable New York DOH	Water, Non-Potable Virginia DGS	Water, Non-Potable Washington DE	Water, Non-Potable Maine DOH
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 608	MLA-007																										Y	Y		
		SM6630B	MLA-007																						Y							
		EPA 8081	MLA-007				Y				Y	Y		Y																		
	Mirex	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 8270	MLA-007																						Y				Y	Y		Y
	Oxychlordane	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
	Toxaphene	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-028	MLA-028												Y																Y	
	trans-Chlordane (gamma-Chlordane)	AXYS MLA-007	MLA-007		Y	Y									Y						Y											
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
		EPA 8270	MLA-007				Y				Y			Y															Y			Y
	trans-Nonachlor	AXYS MLA-007	MLA-007		Y	Y									Y																	
		AXYS MLA-028	MLA-028		Y	Y									Y						Y										Y	
PAH	1,2,6-Trimethylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	1,2-Dimethylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	1,4,6,7-Tetramethylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	1,7-Dimethylfluorene	AXYS MLA-021	MLA-021			Y															Y											
	1,7-Dimethylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	1,8-Dimethylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	1-Methylchrysene	AXYS MLA-021	MLA-021			Y															Y											
	1-Methylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	1-Methylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	2,3,5-Trimethylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	2,3,6-Trimethylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	2,4-Dimethyldibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	2,6-Dimethylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											
	2,6-Dimethylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	2/3-Methyldibenzothiophenes	AXYS MLA-021	MLA-021			Y															Y											
	2-Methylanthracene	AXYS MLA-021	MLA-021			Y															Y											
	2-Methylfluorene	AXYS MLA-021	MLA-021			Y															Y											
	2-methylnaphthalene	AXYS MLA-021	MLA-021			Y															Y											

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Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp: CALA	Serum: CALA	Solids: CALA	Solids: California DPH	Solids: Florida DOH	Solids: Minnesota DOH	Solids: New Jersey DEP	Solids: New York DOH	Solids: Virginia DGS	Solids: Washington DE	Solids: Maine DOH	Tissue: CALA	Tissue: Florida DOH	Tissue: Minnesota DOH	Tissue: New Jersey DEP	Tissue: Virginia DGS	Urine: CALA	Water: CALA	Water, Drinking: Florida DOH	Water, Drinking: Minnesota DOH	Water, Drinking: New Jersey DEP	Water, Non-Potable: California DPH	Water, Non-Potable: Florida DOH	Water, Non-Potable: Minnesota DOH	Water, Non-Potable: New Jersey DEP	Water, Non-Potable: New York DOH	Water, Non-Potable: Virginia DGS	Water, Non-Potable: Washington DE	Water, Non-Potable: Maine DOH
		EPA 8270	MLA-021								Y																					
	2-Methylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	3,6-Dimethylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	3-Methylfluoranthene/ Benzo(a)fluorene	AXYS MLA-021	MLA-021			Y															Y											
	3-Methylphenanthrene	AXYS MLA-021	MLA-021			Y															Y											
	5,9-Dimethylchrysene	AXYS MLA-021	MLA-021			Y															Y											
	5/6-Methylchrysenes	AXYS MLA-021	MLA-021			Y															Y											
	7-Methylbenzo(a)pyrene	AXYS MLA-021	MLA-021			Y															Y											
	9/4-Methylphenanthrenes	AXYS MLA-021	MLA-021			Y															Y											
	Acenaphthene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Acenaphthylene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Anthracene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Benz[a]anthracene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Benzo[a]pyrene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Benzo[b]fluoranthene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		Y
	Benzo[e]pyrene	AXYS MLA-021	MLA-021			Y									Y						Y											
	Benzo[ghi]perylene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Benzo[j/k]fluoranthenes	AXYS MLA-021	MLA-021												Y						Y											
	Benzo[k]fluoranthene	AXYS MLA-021	MLA-021																		Y											
		EPA 8270	MLA-021								Y			Y																		

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Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp CALA	Serum CALA	Solids CALA	Solids California DPH	Solids Florida DOH	Solids Minnesota DOH	Solids New Jersey DEP	Solids New York DOH	Solids Virginia DGS	Solids Washington DE	Solids Maine DOH	Tissue CALA	Tissue Florida DOH	Tissue Minnesota DOH	Tissue New Jersey DEP	Tissue Virginia DGS	Urine CALA	Water CALA	Water, Drinking Florida DOH	Water, Drinking Minnesota DOH	Water, Drinking New Jersey DEP	Water, Non-Potable California DPH	Water, Non-Potable Florida DOH	Water, Non-Potable Minnesota DOH	Water, Non-Potable New Jersey DEP	Water, Non-Potable New York DOH	Water, Non-Potable Virginia DGS	Water, Non-Potable Washington DE	Water, Non-Potable Maine DOH
		EPA 1625	MLA-021																						Y				Y	Y		Y
	Biphenyl	AXYS MLA-021	MLA-021			Y															Y											
	C1-Acenaphthenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Benz(a)anthracenes/chrysenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Benzofluoranthenes/ Benzopyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Biphenyls	AXYS MLA-021	MLA-021			Y															Y											
	C1-Dibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	C1-Fluoranthenes/Pyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Fluorenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Naphthalenes	AXYS MLA-021	MLA-021			Y															Y											
	C1-Phenanthrenes/Anthracenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Benz(a)anthracenes/Chrysenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Benzofluoranthenes/ Benzopyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Biphenyls	AXYS MLA-021	MLA-021			Y															Y											
	C2-Dibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	C2-Fluoranthenes/Pyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Fluorenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Naphthalenes	AXYS MLA-021	MLA-021			Y															Y											
	C2-Phenanthrenes/Anthracenes	AXYS MLA-021	MLA-021			Y															Y											
	C3-Benz(a)anthracenes/Chrysenes	AXYS MLA-021	MLA-021			Y															Y											
	C3-Dibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	C3-Fluoranthenes/Pyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C3-Fluorenes	AXYS MLA-021	MLA-021			Y															Y											
	C3-Naphthalenes	AXYS MLA-021	MLA-021			Y															Y											
	C3-Phenanthrenes/Anthracenes	AXYS MLA-021	MLA-021			Y															Y											
	C4-Benz(a)anthracenes/Chrysenes	AXYS MLA-021	MLA-021			Y															Y											
	C4-Dibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	C4-Fluoranthenes/Pyrenes	AXYS MLA-021	MLA-021			Y															Y											
	C4-Naphthalenes	AXYS MLA-021	MLA-021			Y															Y											
	C4-Phenanthrenes/Anthracenes	AXYS MLA-021	MLA-021			Y															Y											
	Chrysene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Dibenz[ah]anthracene	AXYS MLA-021	MLA-021			Y									Y						Y											

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Dibenzo[ah]anthracene	EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Dibenzothiophene	AXYS MLA-021	MLA-021			Y															Y											
	Fluoranthene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Fluorene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Indeno[1,2,3-cd]pyrene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Naphthalene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Perylene	AXYS MLA-021	MLA-021			Y									Y						Y											
	Phenanthrene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Pyrene	AXYS MLA-021	MLA-021			Y									Y						Y											
		EPA 8270	MLA-021				Y				Y	Y		Y																		
		EPA 1625	MLA-021																						Y				Y	Y		
	Retene	AXYS MLA-021	MLA-021			Y															Y											
Parabens	Benzylparaben (Benzyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
	Butylparaben (n-Butyl 4-hydroxybenzoate and isobutyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
	Ethylparaben (Ethyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
	Isopropylparaben (Isopropyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
	Methylparaben (Methyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
	n-Propylparaben (Propyl 4-hydroxybenzoate)	AXYS MLA-064	MLA-064																	Y												
PBDPE	BDE 10 2,6-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 100 2,2',4,4',6-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 105 2,3,3',4,4'-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 11 3,3'-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 116 2,3,4,5,6-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	

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				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	BDE 119 2,3',4,4',6-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 12 3,4-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 126 3,3',4,4',5-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 13 3,4'-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 140 2,2',3,4,4',6'-hexabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 15 4,4'-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 153 2,2',4,4',5,5'-hexabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 154 2,2',4,4',5',6-hexabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 155 2,2',4,4',6,6'-hexabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 166 2,3,4,4',5,6-hexabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 17 2,2',4-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 181 2,2',3,4,4',5,6-heptabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 190 2,3,3',4,4',5,6-heptabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 206 2,2',3,3',4,4',5,5',6-nonabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 207 2,2',3,3',4,4',5,6,6'-nonabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 208 2,2',3,3',4,5,5',6,6'-nonabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 209 Decabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 25 2,3',4-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 28 2,4,4'-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 30 2,4,6-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 35 3,3',4-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 37 3,4,4'-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 47 2,2',4,4'-tetrabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 49 2,2',4,5'-tetrabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 66 2,3',4,4'-tetrabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 7 2,4-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 75 2,4,4',6-tetrabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 77 3,3',4,4'-tetrabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 8 2,4'-dibromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 85 2,2',3,4,4'-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE 99 2,2',4,4',5-pentabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE-183 2,2',3,4,4',5',6-heptabromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
	BDE-33 2',3,4-tribromodiphenylether	EPA 1614	MLA-033		Y	Y									Y						Y										Y	
PCB	PCB 1 2-Chlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	

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Matrix and Accrediting Body

Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
				CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 10 2,6-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 100 2,2',4,4',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 101 2,2',4,5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 101/90/89	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 102 2,2',4,5,6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 103 2,2',4,5',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 104 2,2',4,6,6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 105 2,3,3',4,4'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 105/127	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 106 2,3,3',4,5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 107 2,3,3',4',5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 107/109	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 108 2,3,3',4,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 109 2,3,3',4,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 11 3,3'-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 110 2,3,3',4',6-Pentachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 111 2,3,3',5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 112 2,3,3',5,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 113 2,3,3',5',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 114 2,3,4,4',5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 115 2,3,4,4',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 116 2,3,4,5,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 117 2,3,4',5,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 118 2,3',4,4',5-Pentachlorobiphenyl	AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 118/116	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 119 2,3',4,4',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 12 3,4-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 120 2,3',4,5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 121 2,3',4,5',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 122 2,3,3',4',5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 123 2,3',4,4',5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 124 2,3',4',5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 125 2,3',4',5',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 126 3,3',4,4',5-Pentachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 127 3,3',4,5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 128 2,2',3,3',4,4'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 129 2,2',3,3',4,5-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 13 3,4'-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 130 2,2',3,3',4,5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 131 2,2',3,3',4,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 131/142	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 132 2,2',3,3',4,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 133 2,2',3,3',5,5'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 134 2,2',3,3',5,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 134/143	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 135 2,2',3,3',5,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 136 2,2',3,3',6,6'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 137 2,2',3,4,4',5-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 138 2,2',3,4,4',5'-Hexachlorobiphenyl	AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 138/163/164	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 139 2,2',3,4,4',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 14 3,5-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 140 2,2',3,4,4',6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 141 2,2',3,4,5,5'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 142 2,2',3,4,5,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 143 2,2',3,4,5,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 144 2,2',3,4,5',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 144/135	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 145 2,2',3,4,6,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	

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Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
				CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 146 2,2',3,4',5,5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 147 2,2',3,4',5,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 148 2,2',3,4',5,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 149 2,2',3,4',5',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 149/139	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 15 4,4'-Dichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 150 2,2',3,4',6,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 151 2,2',3,5,5',6-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 152 2,2',3,5,6,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 153 2,2',4,4',5,5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 154 2,2',4,4',5,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 155 2,2',4,4',6,6'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 156 2,3,3',4,4',5-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 157 2,3,3',4,4',5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 158 2,3,3',4,4',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 158/160	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 159 2,3,3',4,5,5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 16 2,2',3-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 16/32	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 160 2,3,3',4,5,6-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 161 2,3,3',4,5',6-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 162 2,3,3',4',5,5'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 163 2,3,3',4',5,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 164 2,3,3',4',5',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 165 2,3,3',5,5',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 166 2,3,4,4',5,6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 167 2,3',4,4',5,5'-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 168 2,3',4,4',5',6-Hexachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 169 3,3',4,4',5,5'-Hexachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 17 2,2',4-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 170 2,2',3,3',4,4',5-Heptachlorobiphenyl	AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 170/190	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 171 2,2',3,3',4,4',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 172 2,2',3,3',4,5,5'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 172/192	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 173 2,2',3,3',4,5,6-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 174 2,2',3,3',4,5,6'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 174/181	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 175 2,2',3,3',4,5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 176 2,2',3,3',4,6,6'-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 177 2,2',3,3',4,5',6'-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 178 2,2',3,3',5,5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 179 2,2',3,3',5,6,6'-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 18 2,2',5-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 180 2,2',3,4,4',5,5'-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 181 2,2',3,4,4',5,6-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 182 2,2',3,4,4',5,6'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 183 2,2',3,4,4',5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 184 2,2',3,4,4',6,6'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 185 2,2',3,4,5,5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 186 2,2',3,4,5,6,6'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 187 2,2',3,4',5,5',6-Heptachlorobiphenyl	AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 187/182	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 188 2,2',3,4',5,6,6'-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 189 2,3,3',4,4',5,5'-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 19 2,2',6-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 190 2,3,3',4,4',5,6-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 191 2,3,3',4,4',5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 192 2,3,3',4,5,5',6-Heptachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 193 2,3,3',4',5,5',6-Heptachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 194 2,2',3,3',4,4',5,5'-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 195 2,2',3,3',4,4',5,6-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 196 2,2',3,3',4,4',5,6'-Octachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 196/203	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 197 2,2',3,3',4,4',6,6'-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 198 2,2',3,3',4,5,5',6-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 199 2,2',3,3',4,5,5',6'-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 2 3-Chlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 20 2,3,3'-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 200 2,2',3,3',4,5,6,6'-Octachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 201 2,2',3,3',4,5',6,6'-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 202 2,2',3,3',5,5',6,6'-Octachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 203 2,2',3,4,4',5,5',6-Octachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 204 2,2',3,4,4',5,6,6'-Octachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 205 2,3,3',4,4',5,5',6-Octachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 206 2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 207 2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 208 2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y		Y						Y							Y	Y	Y	Y	
	PCB 209 Decachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 21 2,3,4-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 22 2,3,4'-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 23 2,3,5-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 24 2,3,6-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 24/27	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 25 2,3',4-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 26 2,3',5-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 27 2,3',6-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 28 2,4,4'-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 29 2,4,5-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 3 4-Chlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 30 2,4,6-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 31 2,4',5-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 32 2,4',6-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 33 2,3',4'-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 33/20/21	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 34 2,3',5'-Trichlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 35 3,3',4-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 36 3,3',5-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 37 3,4,4'-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 38 3,4,5-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 39 3,4',5-Trichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 4 2,2'-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 40 2,2',3,3'-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 41 2,2',3,4-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 41/71/64/68	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 42 2,2',3,4'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 42/59	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 43 2,2',3,5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 44 2,2',3,5'-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 45 2,2',3,6-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 46 2,2',3,6'-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 47 2,2',4,4'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 47/48/75	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 48 2,2',4,5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 49 2,2',4,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 49/43	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 5 2,3-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	

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Matrix and Accrediting Body

Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp: CALA	Serum: CALA	Solids: CALA	Solids: California DPH	Solids: Florida DOH	Solids: Minnesota DOH	Solids: New Jersey DEP	Solids: New York DOH	Solids: Virginia DGS	Solids: Washington DE	Solids: Maine DOH	Tissue: CALA	Tissue: Florida DOH	Tissue: Minnesota DOH	Tissue: New Jersey DEP	Tissue: Virginia DGS	Urine: CALA	Water: CALA	Water, Drinking: Florida DOH	Water, Drinking: Minnesota DOH	Water, Drinking: New Jersey DEP	Water, Non-Potable: California DPH	Water, Non-Potable: Florida DOH	Water, Non-Potable: Minnesota DOH	Water, Non-Potable: New Jersey DEP	Water, Non-Potable: New York DOH	Water, Non-Potable: Virginia DGS	Water, Non-Potable: Washington DE	Water, Non-Potable: Maine DOH
	PCB 50 2,2',4,6-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 51 2,2',4,6'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 52 2,2',5,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 52/73	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 53 2,2',5,6'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 54 2,2',6,6'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 55 2,3,3',4-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 56 2,3,3',4'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 56/60	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 57 2,3,3',5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 58 2,3,3',5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 59 2,3,3',6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 6 2,3'-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 60 2,3,4,4'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 61 2,3,4,5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 62 2,3,4,6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 63 2,3,4',5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 64 2,3,4',6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 65 2,3,5,6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 66 2,3',4,4'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 66/80	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 67 2,3',4,5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 68 2,3',4,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 69 2,3',4,6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 7 2,4-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 70 2,3',4',5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 70/76	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 71 2,3',4',6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 72 2,3',5,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 73 2,3',5',6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 74 2,4,4',5-Tetrachlorobiphenyl	AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 74/61	AXYS MLA-007	MLA-007			Y									Y						Y											

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				Matrix and Accrediting Body: Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 75 2,4,4',6-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 76 2,3',4',5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 77 3,3',4,4'-Tetrachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 78 3,3',4,5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 79 3,3',4,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 8 2,4'-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 8/5	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 80 3,3',5,5'-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 81 3,4,4',5-Tetrachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 82 2,2',3,3',4-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 83 2,2',3,3',5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 83/108	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 84 2,2',3,3',6-Pentachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 85 2,2',3,4,4'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 85/120	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 86 2,2',3,4,5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 87 2,2',3,4,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y				Y	Y	Y	Y	Y	Y						Y							Y	Y	Y	Y	
	PCB 87/115/116	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 88 2,2',3,4,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 89 2,2',3,4,6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 9 2,5-Dichlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y		Y						Y								Y	Y	Y	
	PCB 90 2,2',3,4',5-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 91 2,2',3,4',6-Pentachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 92 2,2',3,5,5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 93 2,2',3,5,6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 94 2,2',3,5,6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 95 2,2',3,5',6-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 95/93	AXYS MLA-007	MLA-007			Y									Y						Y											
	PCB 96 2,2',3,6,6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 97 2,2',3,4',5'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 97/86	AXYS MLA-007	MLA-007			Y									Y						Y											

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Matrix and Accrediting Body

				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	PCB 98 2,2',3,4',6'-Pentachlorobiphenyl	EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB 99 2,2',4,4',5-Pentachlorobiphenyl	AXYS MLA-007	MLA-007			Y									Y						Y											
		AXYS MLA-901	MLA-901		Y																											
		EPA 1668	MLA-010		Y	Y					Y	Y	Y	Y	Y						Y								Y	Y	Y	
	PCB Aroclor 1016	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1221	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1232	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1242	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1248	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1254	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB Aroclor 1260	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 625	MLA-007																						Y				Y	Y		Y
		EPA 1668	MLA-010								Y																		Y			
		EPA 8270	MLA-007				Y				Y	Y																				
	PCB congeners, total	EPA 1668	MLA-010								Y																		Y			
	Total Dichlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											

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Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp	Serum	Solids								Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
				CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Heptachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Hexachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Monochlorobiphenyls	EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Nonachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Octachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Pentachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Polychlorinated biphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
	Total Tetrachlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	Total Trichlorobiphenyls	AXYS MLA-007	MLA-007			Y									Y						Y											
		EPA 1668	MLA-010		Y	Y									Y						Y											
	PCB Aroclor 1268	AXYS MLA-007	MLA-007			Y									Y						Y											
PCDDF	1,2,3,4,6,7,8-HpCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,4,6,7,8-HpCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,4,7,8,9-HpCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,4,7,8-HxCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,4,7,8-HxCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,6,7,8-HxCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,6,7,8-HxCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,7,8,9-HxCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	1,2,3,7,8,9-HxCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,7,8-PeCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	1,2,3,7,8-PeCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	2,3,4,6,7,8-HxCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	2,3,4,7,8-PeCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	2,3,7,8-TCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	2,3,7,8-TCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	OCDD	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	OCDF	EPA 8290	MLA-017				Y	Y		Y	Y	Y				Y		Y	Y							Y			Y	Y		
		EPA 1613	MLA-017	Y	Y	Y							Y	Y	Y						Y				Y	Y		Y	Y	Y	Y	Y
	Total HpCDD	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total HpCDF	EPA 8290	MLA-017					Y				Y				Y		Y	Y							Y				Y		Y
		EPA 1613	MLA-017											Y											Y	Y						
	Total HxCDD	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total HxCDF	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total PeCDD	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total PeCDF	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total TCDD	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y
	Total TCDF	EPA 8290	MLA-017					Y		Y		Y				Y		Y	Y							Y				Y		
		EPA 1613	MLA-017											Y											Y	Y						Y

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
PFC	Perfluorobutanesulfonate (PFBS)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorobutanoate (PFBA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorodecanoate (PFDA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorododecanoate (PFDoA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluoroheptanoate (PFHpA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorohexanesulfonate (PFHxS)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorohexanoate (PFHxA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorononanoate (PFNA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorooctane sulfonamide (PFOSA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											

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				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorooctanesulfonate (PFOS)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluorooctanoate (PFOA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluoropentanoate (PFPeA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
	Perfluoroundecanoate (PFUnA)	AXYS MLA-041	MLA-041			Y		Y	Y	Y																						
		AXYS MLA-042	MLA-042		Y																											
		AXYS MLA-043	MLA-043												Y	Y	Y	Y														
		AXYS MLA-060	MLA-060																		Y	Y	Y	Y		Y	Y	Y				
PPCP	1,7-Dimethylxanthine	EPA 1694	MLA-075			Y								Y							Y											Y
	10-hydroxy-amitriptyline	EPA 1694	MLA-075			Y															Y											
	2-hydroxy-ibuprofen	EPA 1694	MLA-075			Y															Y											
	4-Epianhydrochlortetracycline (EACTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	4-Epianhydrotetracycline (EATC)	EPA 1694	MLA-075			Y								Y							Y											Y
	4-Epichlortetracycline (ECTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	4-Epioxytetracycline (EOTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	4-Epitetracycline (ETC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Acetaminophen	EPA 1694	MLA-075			Y								Y							Y											Y
	Albuterol	EPA 1694	MLA-075			Y								Y							Y											Y
	Alprazolam	EPA 1694	MLA-075			Y															Y											
	Amitriptyline	EPA 1694	MLA-075			Y															Y											
	Amlodipine	EPA 1694	MLA-075			Y															Y											
	Amphetamine	EPA 1694	MLA-075			Y															Y											
	Anhydrochlortetracycline (ACTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Anhydrotetracycline (ATC)	EPA 1694	MLA-075			Y								Y							Y											Y

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Atenolol	EPA 1694	MLA-075			Y															Y											
	Atorvastatin	EPA 1694	MLA-075			Y															Y											
	Azithromycin	EPA 1694	MLA-075			Y								Y							Y											Y
	Benzoylecgonine	EPA 1694	MLA-075			Y															Y											
	Benztropine	EPA 1694	MLA-075			Y															Y											
	Betamethasone	EPA 1694	MLA-075			Y															Y											
	Bisphenol A	EPA 1694	MLA-075			Y								Y							Y											Y
	Caffeine	EPA 1694	MLA-075			Y								Y							Y											Y
	Carbadox	EPA 1694	MLA-075			Y								Y							Y											Y
	Carbamazepine	EPA 1694	MLA-075			Y								Y							Y											Y
	Cefotaxime	EPA 1694	MLA-075			Y								Y							Y											Y
	Chlortetracycline (CTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Cimetidine	EPA 1694	MLA-075			Y								Y							Y											Y
	Ciprofloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Clarithromycin	EPA 1694	MLA-075			Y								Y							Y											Y
	Clinafloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Clonidine	EPA 1694	MLA-075			Y															Y											
	Cloxacillin	EPA 1694	MLA-075			Y								Y							Y											Y
	Cocaine	EPA 1694	MLA-075			Y															Y											
	Codeine	EPA 1694	MLA-075			Y								Y							Y											Y
	Cotinine	EPA 1694	MLA-075			Y								Y							Y											Y
	DEET (N,N-diethyl-m-toluamide)	EPA 1694	MLA-075			Y															Y											
	Dehydronifedipine	EPA 1694	MLA-075			Y								Y							Y											Y
	Demeclocycline	EPA 1694	MLA-075			Y								Y							Y											Y
	Desmethyldiltiazem	EPA 1694	MLA-075			Y															Y											
	Diazepam	EPA 1694	MLA-075			Y															Y											
	Digoxigenin	EPA 1694	MLA-075			Y								Y							Y											Y
	Digoxin	EPA 1694	MLA-075			Y								Y							Y											Y
	Diltiazem	EPA 1694	MLA-075			Y								Y							Y											Y
	Diphenhydramine	EPA 1694	MLA-075			Y								Y							Y											Y
	Doxycycline	EPA 1694	MLA-075			Y								Y							Y											Y
	Enalapril	EPA 1694	MLA-075			Y								Y							Y											Y
	Enrofloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Erythromycin	EPA 1694	MLA-075			Y															Y											

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Flumequine	EPA 1694	MLA-075			Y								Y							Y											Y
	Fluocinonide	EPA 1694	MLA-075			Y															Y											
	Fluoxetine	EPA 1694	MLA-075			Y								Y							Y											Y
	Fluticasone propionate	EPA 1694	MLA-075			Y															Y											
	Furosemide	EPA 1694	MLA-075			Y															Y											
	Gemfibrozil	EPA 1694	MLA-075			Y								Y							Y											Y
	Glipizide	EPA 1694	MLA-075			Y															Y											
	Glyburide	EPA 1694	MLA-075			Y															Y											
	Hydrochlorothiazide	EPA 1694	MLA-075			Y															Y											
	Hydrocodone	EPA 1694	MLA-075			Y															Y											
	Hydrocortisone	EPA 1694	MLA-075			Y															Y											
	Ibuprofen	EPA 1694	MLA-075			Y								Y							Y											Y
	Isochlortetracycline (ICTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Lincomycin	EPA 1694	MLA-075			Y								Y							Y											Y
	Lomefloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Meprobamate	EPA 1694	MLA-075			Y															Y											
	Metformin	EPA 1694	MLA-075			Y								Y							Y											Y
	Methylprednisolone	EPA 1694	MLA-075			Y															Y											
	Metoprolol	EPA 1694	MLA-075			Y															Y											
	Miconazole	EPA 1694	MLA-075			Y								Y							Y											Y
	Minocycline	EPA 1694	MLA-075			Y								Y							Y											Y
	Naproxen	EPA 1694	MLA-075			Y								Y							Y											Y
	Norfloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Norfluoxetine	EPA 1694	MLA-075			Y															Y											
	Norgestimate	EPA 1694	MLA-075			Y								Y							Y											Y
	Norverapamil	EPA 1694	MLA-075			Y															Y											
	Ofloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Ormetoprim	EPA 1694	MLA-075			Y								Y							Y											Y
	Oxacillin	EPA 1694	MLA-075			Y								Y							Y											Y
	Oxolinic acid	EPA 1694	MLA-075			Y								Y							Y											Y
	Oxycodone	EPA 1694	MLA-075			Y								Y							Y											Y
	Oxytetracycline (OTC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Paroxetine	EPA 1694	MLA-075			Y								Y							Y											Y
	Penicillin G	EPA 1694	MLA-075			Y								Y							Y											Y

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				Matrix and Accrediting Body: Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Penicillin V	EPA 1694	MLA-075			Y								Y							Y											Y
	Prednisolone	EPA 1694	MLA-075			Y															Y											
	Prednisone	EPA 1694	MLA-075			Y															Y											
	Promethazine	EPA 1694	MLA-075			Y															Y											
	Propoxyphene	EPA 1694	MLA-075			Y															Y											
	Propranolol	EPA 1694	MLA-075			Y															Y											
	Ranitidine	EPA 1694	MLA-075			Y								Y							Y											Y
	Roxithromycin	EPA 1694	MLA-075			Y								Y							Y											Y
	Sarafloxacin	EPA 1694	MLA-075			Y								Y							Y											Y
	Sertraline	EPA 1694	MLA-075			Y															Y											
	Simvastatin	EPA 1694	MLA-075			Y															Y											
	Sulfachloropyridazine	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfadiazine	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfadimethoxine	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfamerazine	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfamethazine	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfamethizole	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfamethoxazole	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfanilamide	EPA 1694	MLA-075			Y								Y							Y											Y
	Sulfathiazole	EPA 1694	MLA-075			Y								Y							Y											Y
	Tetracycline (TC)	EPA 1694	MLA-075			Y								Y							Y											Y
	Theophylline	EPA 1694	MLA-075			Y															Y											
	Thiabendazole	EPA 1694	MLA-075			Y								Y							Y											Y
	Trenbolone	EPA 1694	MLA-075			Y															Y											
	Trenbolone acetate	EPA 1694	MLA-075			Y															Y											
	Triamterene	EPA 1694	MLA-075			Y															Y											
	Triclocarban	EPA 1694	MLA-075			Y								Y							Y											Y
	Triclosan	EPA 1694	MLA-075			Y								Y							Y											Y
	Trimethoprim	EPA 1694	MLA-075			Y								Y							Y											Y
	Tylosin	EPA 1694	MLA-075			Y								Y							Y											Y
	Valsartan	EPA 1694	MLA-075			Y															Y											
	Verapamil	EPA 1694	MLA-075			Y															Y											
	Virginiamycin	EPA 1694	MLA-075			Y								Y							Y											Y
	Warfarin	EPA 1694	MLA-075			Y								Y							Y											Y

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Matrix and Accrediting Body

Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
				CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Erythromycin anydrate	EPA 1694	MLA-075											Y																		Y
Targeted Metabolites	11, 14, 17-eicosatrienoic acid (eicosatrienoic acid)	AXYS MLM-001	MLM-001												Y																	
	11, 14-eicosadienoic acid	AXYS MLM-001	MLM-001												Y																	
	3-hydroxytyrosine	AXYS MLM-001	MLM-001												Y																	
	Acetylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Acetylornithine	AXYS MLM-001	MLM-001												Y																	
	Alanine	AXYS MLM-001	MLM-001												Y																	
	alpha-Aminoadipic acid	AXYS MLM-001	MLM-001												Y																	
	Arginine	AXYS MLM-001	MLM-001												Y																	
	Asparagine	AXYS MLM-001	MLM-001												Y																	
	Aspartate	AXYS MLM-001	MLM-001												Y																	
	Asymmetric dimethylarginine	AXYS MLM-001	MLM-001												Y																	
	Butenylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Butyrylcarnitine	AXYS MLM-001	MLM-001												Y																	
	C22:5 ISOMER 1 (tentatively all-cis-4, 8, 12, 15, 19-docosapentaenoic acid)	AXYS MLM-001	MLM-001												Y																	
	C22:5 ISOMER 2 (all-cis-7,10,13,16,19-docosapentaenoic acid (DPA)	AXYS MLM-001	MLM-001												Y																	
	C22:5 ISOMER 3 (tentatively all-cis-4, 7, 10, 13, 16-docosapentaenoic acid)	AXYS MLM-001	MLM-001												Y																	
	Carnitine	AXYS MLM-001	MLM-001												Y																	
	Carnosine	AXYS MLM-001	MLM-001												Y																	
	chenodeoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	cholic acid	AXYS MLM-001	MLM-001												Y																	
	Citrulline	AXYS MLM-001	MLM-001												Y																	
	Creatinine	AXYS MLM-001	MLM-001												Y																	
	Decadienylcarnitine	AXYS MLM-001	MLM-001												Y																	
	decanoic acid (capric acid)	AXYS MLM-001	MLM-001												Y																	
	Decanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Decenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	deoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	docosahexaenoic acid (DHA)	AXYS MLM-001	MLM-001												Y																	
	docosatetraenoic acid (adrenic acid)	AXYS MLM-001	MLM-001												Y																	
	Dodecanedioylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Dodecanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Dodecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Dopamine	AXYS MLM-001	MLM-001												Y																	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	eicosapentaenoic acid (EPA)	AXYS MLM-001	MLM-001												Y																	
	Eicosatetraenoic acid (arachidonic acid)	AXYS MLM-001	MLM-001												Y																	
	eicosatrienoic acid (dihomo-γ-linolenic acid)	AXYS MLM-001	MLM-001												Y																	
	Glutaconylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Glutamate	AXYS MLM-001	MLM-001												Y																	
	Glutamine	AXYS MLM-001	MLM-001												Y																	
	Glutarylcarnitine (Hydroxyhexanoylcarnitine)	AXYS MLM-001	MLM-001												Y																	
	Glycine	AXYS MLM-001	MLM-001												Y																	
	glycochenodeoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	glycocholic acid	AXYS MLM-001	MLM-001												Y																	
	glycodeoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	Hexadecadienylcarnitine	AXYS MLM-001	MLM-001												Y																	
	hexadecanoic acid (palmitic acid)	AXYS MLM-001	MLM-001												Y																	
	Hexadecanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	hexadecenoic acid (palmitoleic acid)	AXYS MLM-001	MLM-001												Y																	
	Hexadecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hexanoylcarnitine (Fumarylcarnitine)	AXYS MLM-001	MLM-001												Y																	
	Hexenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hexose (sum isomers)	AXYS MLM-001	MLM-001												Y																	
	Histamine	AXYS MLM-001	MLM-001												Y																	
	Histidine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyhexadecadienylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyhexadecanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyhexadecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxylbutyrylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyoctadecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyproline	AXYS MLM-001	MLM-001												Y																	
	Hydroxypropionylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxysphingomyeline C14:1	AXYS MLM-001	MLM-001												Y																	
	Hydroxysphingomyeline C16:1	AXYS MLM-001	MLM-001												Y																	
	Hydroxysphingomyeline C22:1	AXYS MLM-001	MLM-001												Y																	
	Hydroxysphingomyeline C22:2	AXYS MLM-001	MLM-001												Y																	
	Hydroxysphingomyeline C24:1	AXYS MLM-001	MLM-001												Y																	
	Hydroxytetradecadienylcarnitine	AXYS MLM-001	MLM-001												Y																	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Hydroxytetradecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Hydroxyvalerylcarnitine (Methylmalonylcarnitine)	AXYS MLM-001	MLM-001												Y																	
	Isoleucine	AXYS MLM-001	MLM-001												Y																	
	Kynurenine	AXYS MLM-001	MLM-001												Y																	
	Leucine	AXYS MLM-001	MLM-001												Y																	
	lithocholic acid	AXYS MLM-001	MLM-001												Y																	
	Lysine	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C14:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C16:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C16:1	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C17:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C18:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C18:1	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C18:2	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C20:3	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C20:4	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C24:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C26:1	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C28:0	AXYS MLM-001	MLM-001												Y																	
	lysoPhosphatidylcholine acyl C28:1	AXYS MLM-001	MLM-001												Y																	
	Methionine	AXYS MLM-001	MLM-001												Y																	
	Methioninesulfoxide	AXYS MLM-001	MLM-001												Y																	
	Methylglutarylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Nitrotyrosine	AXYS MLM-001	MLM-001												Y																	
	Nonaylcarnitine	AXYS MLM-001	MLM-001												Y																	
	octadecadienoic acid (linoleic acid)	AXYS MLM-001	MLM-001												Y																	
	Octadecadienylcarnitine	AXYS MLM-001	MLM-001												Y																	
	octadecanoic acid (stearic acid)	AXYS MLM-001	MLM-001												Y																	
	Octadecanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	octadecatrienoic acid (γ-linolenic acid)	AXYS MLM-001	MLM-001												Y																	
	Octadecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Octanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Ornithine	AXYS MLM-001	MLM-001												Y																	
	Phenylalanine	AXYS MLM-001	MLM-001												Y																	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Phenylethylamine	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C30:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C30:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C30:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C32:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C32:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C34:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C34:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C34:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C34:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C36:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C38:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C40:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C42:5	AXYS MLM-001	MLM-001												Y																	

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	Phosphatidylcholine acyl-alkyl C44:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C44:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C44:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine acyl-alkyl C44:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C24:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C26:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C28:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C30:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C30:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C32:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C32:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C32:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C32:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C34:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C34:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C34:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C34:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C36:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C38:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C40:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C40:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C40:3	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C40:4	AXYS MLM-001	MLM-001												Y																	

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Compound Class	Compound	Accredited Reference Method	AXYS Method	Pulp CALA	Serum CALA	Solids CALA	Solids California DPH	Solids Florida DOH	Solids Minnesota DOH	Solids New Jersey DEP	Solids New York DOH	Solids Virginia DGS	Solids Washington DE	Solids Maine DOH	Tissue CALA	Tissue Florida DOH	Tissue Minnesota DOH	Tissue New Jersey DEP	Tissue Virginia DGS	Urine CALA	Water CALA	Water, Drinking Florida DOH	Water, Drinking Minnesota DOH	Water, Drinking New Jersey DEP	Water, Non-Potable California DPH	Water, Non-Potable Florida DOH	Water, Non-Potable Minnesota DOH	Water, Non-Potable New Jersey DEP	Water, Non-Potable New York DOH	Water, Non-Potable Virginia DGS	Water, Non-Potable Washington DE	Water, Non-Potable Maine DOH
	Phosphatidylcholine diacyl C40:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C40:6	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:0	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:1	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:2	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:4	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:5	AXYS MLM-001	MLM-001												Y																	
	Phosphatidylcholine diacyl C42:6	AXYS MLM-001	MLM-001												Y																	
	Pimelylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Proline	AXYS MLM-001	MLM-001												Y																	
	Propenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Propionylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Putrescine	AXYS MLM-001	MLM-001												Y																	
	Sarcosine	AXYS MLM-001	MLM-001												Y																	
	Serine	AXYS MLM-001	MLM-001												Y																	
	Serotonin	AXYS MLM-001	MLM-001												Y																	
	Spermidine	AXYS MLM-001	MLM-001												Y																	
	Spermine	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C16:0	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C16:1	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C18:0	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C18:1	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C20:2	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C22:3	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C24:0	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C24:1	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C26:0	AXYS MLM-001	MLM-001												Y																	
	Sphingomyeline C26:1	AXYS MLM-001	MLM-001												Y																	
	Symmetric dimethylarginine	AXYS MLM-001	MLM-001												Y																	
	Taurine	AXYS MLM-001	MLM-001												Y																	
	taurochenodeoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	taurocholic acid	AXYS MLM-001	MLM-001												Y																	
	taurodeoxycholic acid	AXYS MLM-001	MLM-001												Y																	
	taurolithocholic acid	AXYS MLM-001	MLM-001												Y																	

AXYS Analytical Services Ltd. - Accreditation Summary

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				Matrix and Accrediting Body																												
				Pulp	Serum	Solids									Tissue					Urine	Water	Water, Drinking			Water, Non-Potable							
Compound Class	Compound	Accredited Reference Method	AXYS Method	CALA	CALA	CALA	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	Virginia DGS	CALA	CALA	Florida DOH	Minnesota DOH	New Jersey DEP	California DPH	Florida DOH	Minnesota DOH	New Jersey DEP	New York DOH	Virginia DGS	Washington DE	Maine DOH
	tauroursodexoycholic acid	AXYS MLM-001	MLM-001												Y																	
	Tetradecadienylcarnitine	AXYS MLM-001	MLM-001												Y																	
	tetradecanoic acid (myristic acid)	AXYS MLM-001	MLM-001												Y																	
	Tetradecanoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Tetradecenoylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Threonine	AXYS MLM-001	MLM-001												Y																	
	Tiglylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Total dimethylarginine	AXYS MLM-001	MLM-001												Y																	
	Tryptophan	AXYS MLM-001	MLM-001												Y																	
	Tyrosine	AXYS MLM-001	MLM-001												Y																	
	ursodexoycholic acid	AXYS MLM-001	MLM-001												Y																	
	Valerylcarnitine	AXYS MLM-001	MLM-001												Y																	
	Valine	AXYS MLM-001	MLM-001												Y																	
TBBPA	Tetrabromobisphenol A	AXYS MLA-079	MLA-079		Y																											

Legend

BPA and mPE	Bisphenol A and mono-Phthalate Esters
HBCDD	Hexabromocyclododecane
OC Pesticides	Organochlorine Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PBDPE	Polybrominated diphenylethers
PCB	Polychlorinated Biphenyls
PCDDF	Polychlorinated dibenzodioxins/furans
PFC	Perfluorinated Compounds
PPCP	Pharmaceutical and Personal Care Products
TBBPA	Tetrabromobisphenol A
CALA	Canadian Association for Laboratory Accreditation Inc., Lab ID A2637
California DPH	California Department of Public Health, Lab ID 01138CA
Florida DOH	Florida Department of Health, Lab ID E871007
Minnesota DOH	Minnesota Department of Health, Lab ID 232-999-430
New Jersey DEP	New Jersey Department of Health, Lab ID CANA005
New York DOH	New York Department of Health, Lab ID 11674
Washington DE	Washington Department of Ecology, Lab ID C404
Virginia DGS	Virginia Department of General Services, Division of Consolidated Laboratory Services, Lab ID 460224
Maine DOH	Maine Center for Disease Control and Prevention, Department of Health and Human Services, Lab ID CN00003

APPENDIX B

CEQG for Marine Water Quality

Canadian Water Quality Guidelines for the Protection of Aquatic Life

INTRODUCTION

The aquatic ecosystem is composed of the biological community (producers, consumers, and decomposers), the physical and chemical (abiotic) components, and their interactions. Within the aquatic ecosystem, a complex interaction of physical and biochemical cycles exists, and changes do not occur in isolation. Aquatic systems undergo constant change. However, an ecosystem has usually developed over a long period of time and the organisms have become adapted to their environment. In addition, ecosystems have the inherent capacity to withstand and assimilate stress based on their unique physical, chemical, and biological properties. Nonetheless, systems may become unbalanced by natural factors, which include drastic climatic variations or disease, or by factors due to human activities. Any changes, especially rapid ones, could have detrimental or disastrous effects. Adverse effects due to human activity, such as the presence of toxic chemicals in industrial effluents, may affect many components of the aquatic ecosystem, the magnitude of which will depend on both biotic and abiotic site-specific characteristics.

Canadian water quality guidelines are intended to provide protection of freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical components (e.g., pH, temperature, and debris). Guidelines are numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameter of interest. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term. Ambient water quality guidelines developed for the protection of aquatic life provide the science-based benchmark for a nationally consistent level of protection for aquatic life in Canada.

Canadian water quality guidelines for aquatic life are not restricted to a particular (biotic) species, but species-specific information is provided in the respective fact sheets, and, more detailed, in the supporting documents, so that the water quality manager and other users may determine the appropriateness of the guideline for the protection and enhancement of local species. A consistent approach according to the nationally approved, scientifically defensible protocol for the development of water quality guidelines (freshwater and marine) for the protection of aquatic life was maintained. It is important to note that the national protocol emphasizes best scientific judgment in all cases, so the nature of the parameter and the variation in the quality and quantity of supporting information necessitates modifications to the derivation procedures from time to time.

This chapter contains (a) a summary table of the guidelines, listing the ones that either have been carried over from the original *Canadian Water Quality Guidelines* (CCREM 1987), revised since then, or newly developed; (b) the protocol (originally published in 1991); and (c) fact sheets for the respective substances and parameters of concern. These guidelines, therefore, replace the former recommendations published in CCREM (1987) and its appendixes. The fact sheets, and, more extensively, the supporting documents on which they are based, provide details for the derivation of the guidelines, physical-chemical properties, fate in the aquatic environment, use patterns, environmental concentrations, and toxicological data. Effects diagrams give a graphical summary of the relevant toxicity information, i.e., the most sensitive effects thresholds for the different taxonomic groups. The recommended guideline values are expressed to two significant figures, unless otherwise required or indicated by the original toxicity study. The guideline values apply to the total element or substance in an unfiltered sample, unless otherwise specified. It should be noted, however, that certain information about a parameter changes over time, and that the data presented in the fact sheets may not reflect current use patterns. The guidelines and their supporting documents will be reviewed and updated following national priorities and as further relevant information becomes available.

Information on the implementation of guidelines for the protection of aquatic life can be found in the Appendix IV of CCREM (1987). The CCME Task Group recognizes the importance of providing the most up-to-date scientific and technical guidance on implementing national environmental quality guidelines. For this reason, an update of Appendix IV, entitled "Scientific and Technical Guidance on Canadian Water Quality Guideline Implementation", is currently being written and will be released shortly.

For waters of superior quality or that support valuable biological resources, the CCME nondegradation policy states that the degradation of the existing water quality should always be avoided. The natural background concentrations of parameters and their range should also be taken into account in the design of monitoring programs and the interpretation of the resulting data.

In order to apply this scientific information, for example to recommend site-specific water quality objectives, many factors such as the local water quality, resident biotic species, local water demands, and other elements have to be considered. When developing or using guidelines and site-specific objectives for aquatic life, the aquatic ecosystem should be viewed as a whole unit, not as isolated organisms affected by one or a few pollutants. The aquatic ecosystem is part of a complex system with aquatic and terrestrial components and should not be studied in isolation.

Since the release of *Canadian Water Quality Guidelines* (CCREM 1987), it has been recognized that water quality guidelines for highly persistent, bioaccumulative substances such as polychlorinated biphenyls (PCBs), toxaphene, and DDT have a high level of scientific uncertainty and limited practical management value, and are, therefore, no longer recommended. For these substances, it is more appropriate to use the respective tissue residue guidelines and/or sediment quality guidelines.

It has been recognized that the definition of the terms criteria, guidelines, objectives, and standards varies widely among jurisdictions and users. For the purpose of this chapter, these terms will be defined as follows:

- **Criteria:** scientific data evaluated to derive the recommended limits for water uses.
- **Water quality guideline:** numerical concentration or narrative statement recommended to support and maintain a designated water use.
- **Water quality objective:** a numerical concentration or narrative statement that has been established to support and protect the designated uses of water at a specified site.
- **Water quality standard:** an objective that is recognized in enforceable environmental control laws of a level of government.

References

CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Introduction. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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Canadian Council of Ministers of the Environment

CCME

Le Conseil canadien des ministres de l'environnement

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2,2- Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	110	1993	*No data*	Insufficient data	1993
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	21	1991	*No data*	Insufficient data	1991

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.8	1997	*No data*	Insufficient data	1997
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	8	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	24	1997	*No data*	5.4	1997
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	0.7	1997	*No data*	42	1997
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	100	1991	*No data*	Insufficient data	1991
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	150	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	26	1997	*No data*	Insufficient data	1997
1,4-Dioxane		NRG	NRG	2008	NRG	NRG	2008
3-Iodo-2-propynyl butyl carbamate IPBC **CASRN** 55406-53-6	Organic Pesticides Carbamate pesticides	*No data*	1.9	1999	*No data*	*No data*	*No data*
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	5.8	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	*No data*	1999	*No data*	*No data*	1999
Acridine PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	4.4	1999	*No data*	Insufficient data	1999
Aldicarb **CASRN** 116063	Organic Pesticides Carbamate pesticides	*No data*	1	1993	*No data*	0.15	1993
Aldrin	Organic Pesticides Organochlorine compounds	*No data*	~~0.004~~	1987	*No data*	*No data*	*No data*
Aluminium	Inorganic	*No data*	Variable	1987	*No data*	*No data*	*No data*
Ammonia (total)	Inorganic Inorganic nitrogen compounds	*No data*	Table	2001	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Ammonia (un-ionized) **CASRN** 7664417	Inorganic Inorganic nitrogen compounds	*No data*	19	2001	*No data*	*No data*	*No data*
Aniline **CASRN** 62533	Organic	*No data*	2.2	1993	*No data*	Insufficient data	1993
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.012	1999	*No data*	Insufficient data	1999
Arsenic **CASRN** none	Inorganic	*No data*	5	1997	*No data*	12.5	1997
Atrazine **CASRN** 1912249	Organic Pesticides Triazine compounds	*No data*	1.8	1989	*No data*	*No data*	*No data*
Benz(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.018	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzene **CASRN** 71432	Organic Monocyclic aromatic compounds	*No data*	370	1999	*No data*	110	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.015	1999	*No data*	Insufficient data	1999
Beryllium	Inorganic	No data	No data	2015-02-23	No data	No data	2015-02-23
Boron	Inorganic	29,000µg/L or 29mg/L	1,500µg/L or 1.5mg/L	2009	NRG	NRG	2009

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Bromacil **CASRN** 314409	Organic Pesticides	*No data*	5	1997	*No data*	Insufficient data	1997
Bromoxynil	Organic Pesticides Benzonitrile compounds	*No data*	5	1993	*No data*	Insufficient data	1993
Cadmium **CASRN** 7440439	Inorganic	1.0	0.09	2014	NRG	0.12	2014
Captan **CASRN** 133062	Organic Pesticides	*No data*	1.3	1991	*No data*	*No data*	*No data*
Carbaryl **CASRN** 63252	Organic Pesticides Carbamate pesticides	3.3	0.2	2009	5.7	0.29	2009
Carbofuran **CASRN** 1564662	Organic Pesticides Carbamate pesticides	*No data*	1.8	1989	*No data*	*No data*	*No data*
Chlordane	Organic Pesticides Organochlorine compounds	*No data*	~~0.006~~	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Chloride	Inorganic	640,000 µg/L or 640 mg/L	120,000 µg/L or 120 mg/L	2011	NRG	NRG	2011
Chlorothalonil **CASRN** 1897456	Organic Pesticides	*No data*	0.18	1994	*No data*	0.36	1994
Chlorpyrifos **CASRN** 2921882	Organic Pesticides Organophosphorus compounds	0.02	0.002	2008	NRG	0.002	2008
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	*No data*	1	1997	*No data*	1.5	1997
Chromium, trivalent (Cr(III)) **CASRN** 7440473	Inorganic	*No data*	8.9	1997	*No data*	56	1997
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Colour **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Copper	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Cyanazine **CASRN** 2175462	Organic Pesticides Triazine compounds	*No data*	2	1990	*No data*	*No data*	*No data*
Cyanide	Inorganic	*No data*	5 (as free CN)	1987	*No data*	*No data*	*No data*
Debris **CASRN** N/A	Physical	*No data*	*No data*	*No data*	*No data*	Narrative	1996
Deltamethrin **CASRN** 52918635	Organic Pesticides	*No data*	0.0004	1997	*No data*	Insufficient data	1997
Deposited bedload sediment	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999
Di(2-ethylhexyl) phthalate **CASRN** 117817	Organic Phthalate esters	*No data*	16	1993	*No data*	Insufficient data	1993

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Di-n-butyl phthalate **CASRN** 84742	Organic Phthalate esters	*No data*	19	1993	*No data*	Insufficient data	1993
Di-n-octyl phthalate **CASRN** 117840	Organic Phthalate esters	*No data*	Insufficient data	1993	*No data*	Insufficient data	1993
Dibromochloromethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Dicamba **CASRN** 1918009	Organic Pesticides Aromatic Carboxylic Acid	*No data*	10	1993	*No data*	*No data*	*No data*
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	*No data*	~~0.001~~	1987	*No data*	*No data*	*No data*
Dichlorobromomethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	98.1	1992	*No data*	Insufficient data	1992

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	0.2	1987	*No data*	*No data*	*No data*
Diclofop-methyl **CASRN** 51338273	Organic Pesticides	*No data*	6.1	1993	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Didecyl dimethyl ammonium chloride DDAC **CASRN** 7173515	Organic Pesticides	*No data*	1.5	1999	*No data*	Insufficient data	1999
Diethylene glycol **CASRN** 111466	Organic Glycols	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
Diisopropanolamine DIPA **CASRN** 110974	Organic	*No data*	1600	2005	*No data*	Insufficient data	2005
Dimethoate **CASRN** 60515	Organic Pesticides Organophosphorus compounds	*No data*	6.2	1993	*No data*	Insufficient data	1993
Dinoseb **CASRN** 88857	Organic Pesticides	*No data*	0.05	1992	*No data*	*No data*	*No data*
Dissolved gas supersaturation **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Dissolved oxygen DO **CASRN** N/A	Inorganic	*No data*	Variable	1999	*No data*	>8000 & Narrative	1996

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Endosulfan	Organic Pesticides Organochlorine compounds	0.06	0.003	2010	0.09	0.002	2010
Endrin	Organic Pesticides Organochlorine compounds	*No data*	~~0.0023~~	1987	*No data*	No data	*No data*
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	*No data*	90	1996	*No data*	25	1996
Ethylene glycol **CASRN** 107211	Organic Glycols	*No data*	192 000	1997	*No data*	Insufficient data	1997
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.04	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	3	1999	*No data*	Insufficient data	1999
Fluoride	Inorganic	*No data*	120	2002	*No data*	NRG	2002
Glyphosate **CASRN** 1071836	Organic Pesticides Organophosphorus compounds	27,000	800	2012	NRG	NRG	2012
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	*No data*	~~0.01~~	1987	*No data*	*No data*	*No data*
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
Hexachlorobutadiene HCBD **CASRN** 87683	Organic Halogenated aliphatic compounds	*No data*	1.3	1999	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	*No data*	0.01	1987	*No data*	*No data*	*No data*
Imidacloprid **CASRN** 13826413		*No data*	0.23	2007	*No data*	0.65	2007
Iron	Inorganic	*No data*	300	1987	*No data*	*No data*	*No data*
Lead	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Linuron **CASRN** 41205214	Organic Pesticides	*No data*	7	1995	*No data*	*No data*	1995
Mercury **CASRN** 7439976	Inorganic	*No data*	0.026	2003	*No data*	0.016	2003
Methoprene **CASRN** 40596698		*No data*	0.09 (Target Organism Management value: 0.53)	2007	*No data*	Insufficient data	2007

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methyl tertiary-butyl ether MTBE **CASRN** 1634044	Organic Non-halogenated aliphatic compounds Aliphatic ether	*No data*	10 000	2003	*No data*	5 000	2003

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid) MCPA **CASRN** 94746	Organic Pesticides	*No data*	2.6	1995	*No data*	4.2	1995
Methylmercury	Organic	*No data*	0.004	2003	*No data*	NRG	2003
Metolachlor **CASRN** 51218452	Organic Pesticides Organochlorine compounds	*No data*	7.8	1991	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Metribuzin **CASRN** 21087649	Organic Pesticides Triazine compounds	*No data*	1	1990	*No data*	*No data*	*No data*
Molybdenum	Inorganic	*No data*	73	1999	*No data*	*No data*	*No data*
Monobromomethane Methyl bromide	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.3	1997	*No data*	25	1997
Monochloromethane Methyl chloride	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	7	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	1.1	1999	*No data*	1.4	1999
Nickel	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Nitrate **CASRN** 14797-55-8	Inorganic Inorganic nitrogen compounds	550,000 µg/L or 550 mg/L	13,000 µg/L or 13 mg/L	2012	1,500,000 µg/L or 1500 mg/L	200,000 µg/L or 200 mg/L	2012

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nitrite	Inorganic Inorganic nitrogen compounds	*No data*	60 NO_2-N	1987	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	*No data*	1	2002	*No data*	0.7	2002
Nutrients		*No data*	Guidance Framework	2004	*No data*	Guidance framework	2007
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	6	1997	*No data*	Insufficient data	1997
Pentachlorophenol PCP	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	0.5	1987	*No data*	*No data*	*No data*
Permethrin **CASRN** 52645531	Organic Pesticides Organochlorine compounds	*No data*	0.004	2006	*No data*	0.001	2006
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.4	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	*No data*	4	1999	*No data*	*No data*	*No data*
Phenoxy herbicides 2,4 D; 2,4-Dichlorophenoxyacetic acid	Organic Pesticides	*No data*	4	1987	*No data*	*No data*	*No data*
Phosphorus	Inorganic	*No data*	Guidance Framework	2004	*No data*	Guidance Framework	2007
Picloram **CASRN** 1918021	Organic Pesticides	*No data*	29	1990	*No data*	*No data*	*No data*
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	*No data*	~~0.001~~	1987	*No data*	~~0.01~~	1991
Propylene glycol **CASRN** 57556	Organic Glycols	*No data*	500 000	1997	*No data*	Insufficient data	1997

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	0.025	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
pH	Inorganic Acidity, alkalinity and pH	*No data*	6.5 to 9.0	1987	*No data*	7.0 to 8.7 & Narrative	1996
Quinoline PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	3.4	1999	*No data*	Insufficient data	1999

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Reactive Chlorine Species total residual chlorine, combined residual chlorine, total available chlorine, hypochlorous acid, chloramine, combined available chlorine, free residual chlorine, free available chlorine, chlorine-produced oxidants	Inorganic Reactive chlorine compunds	*No data*	0.5	1999	*No data*	0.5	1999
Salinity	Physical	*No data*	*No data*	*No data*	*No data*	Narrative	1996
Selenium	Inorganic	*No data*	1	1987	*No data*	*No data*	*No data*
Silver	Inorganic	*No data*	0.1	1987	*No data*	*No data*	*No data*
Simazine **CASRN** 122349	Organic Pesticides Triazine compounds	*No data*	10	1991	*No data*	No data	*No data*
		Concentration	Concentration	Date	Concentration	Concentration	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Sodium adsorption ratio SAR		*No data*	*No data*	*No data*	*No data*	*No data*	*No data*
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Streambed substrate	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Styrene **CASRN** 100425	Organic Monocyclic aromatic compounds	*No data*	72	1999	*No data*	*No data*	*No data*
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	*No data*	50 000	2005	*No data*	Insufficient data	2005
Suspended sediments TSS	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Tebuthiuron **CASRN** 34014181	Organic Pesticides	*No data*	1.6	1995	*No data*	Insufficient data	1995

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Temperature	Physical Temperature	*No data*	Narrative	1987	*No data*	Narrative	1996
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	13.3	1992	*No data*	Insufficient data	1992
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	1	1987	*No data*	*No data*	*No data*
Thallium	Inorganic	*No data*	0.8	1999	*No data*	*No data*	*No data*
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	*No data*	2	1996	*No data*	215	1996
Toxaphene	Organic Pesticides Organochlorine compounds	*No data*	~~0.008~~	1987	*No data*	*No data*	*No data*
Triallate **CASRN** 2303175	Organic Pesticides Carbamate pesticides	*No data*	0.24	1992	*No data*	*No data*	*No data*

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Tribromomethane Bromoform	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Tributyltin	Organic Organotin compounds	*No data*	0.008	1992	*No data*	0.001	1992
Trichlorfon **CASRN** 52-68-6		1.1	0.009	2012	NRG	NRG	2012
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	1.8	1992	*No data*	Insufficient data	1992
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	18	1987	*No data*	*No data*	*No data*
Tricyclohexyltin	Organic Organotin compounds	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Trifluralin **CASRN** 1582098	Organic Pesticides Dinitroaniline pesticides	*No data*	0.2	1993	*No data*	*No data*	*No data*
Triphenyltin	Organic Organotin compounds	*No data*	0.022	1992	*No data*	*No data*	1992
Turbidity	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Uranium **CASRN** 7440-61-1	Inorganic	33	15	2011	NRG	NRG	2011
Zinc	Inorganic	*No data*	30	1987	*No data*	*No data*	*No data*

Chemical name	Chemical groups
Chemical name	Chemical groups
Sodium adsorption ratio SAR	

APPENDIX C

Fish Habitat Alteration Video Assessments 2014

		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**
Kelp (brown)	Laminariales												
Polymastia	*Polymastia spp.*	19	14	1	14	2	3	1	2	5			
Encrusting sponge	Porifera	O				R	R						
Sponge*	Porifera	165	26	33	15	52	4	4	38	38	1	17	8
Corymorpha sp.	Corymorpha sp.								5	4	4		
Hydrozoa	Hydrozoa												
Sea anemone	Actinaria	296	55	33	11	13	5	4	4	4	35	26	97
Cerianthus sp*	*Cerianthus sp.*		27	290	283	526	457	748	572	397	13	212	2
Soft Coral*	Alcyonacea							1					
Brachiopod	*Terebratulina sp.*		C		R								
Buccinum sp.	*Buccinum sp.*												
Colus sp.	*Colus sp.*												
Gastropod	Gastropoda												
Neptunea sp.	*Neptunea sp.*												
Scallop	*Placopecten magellanicus*			2	1				1				
Barnacle (lg)	*Balanus sp.*												
Jonah crab	*Cancer borealis*	11	38	116	147	118	129	124	102	71	115	121	162
Cancer sp.	*Cancer sp.*						4					1	
Snow crab	*Chionoecetes opilio*	1	1		3	3	2	1			2	17	74
Unid. Decapod	*Decapoda*											1	
Lobster	Homarus americanus												
Toad crab	*Hyas sp.*												
Portly spider crab	*Libinia emarginata*												1
Northern Stone Crab	*Lithodes maja*	1	1	8	5	4	6	2	4	5	3	20	7
Hermit crab	*Pagurus sp.*										1		
Shrimp	Pandalidae	1					4	1					
Ceramaster	*Ceremaster sp.*								1	14	1		1
Crossaster	*Crossaster sp.*							2					
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	641	1525	588	343	417	3694	5578	4247	2078	2110	390	1595
Hippasteria sp	*Hippasteria sp.*	2	4	15	5	8	5	10	8	36	28	11	13
Pteraster sp.	*Pteraster sp.*			1			1			1			
Solaster	*Solaster sp.*	6	2	13	5	1	7	1	1	20			
Basket star	*Gorgoncephalus sp.*												
Sand dollar	*Echinarachnius parma*				4								
Sea urchin	*Strongylocentrotus sp.*	5				1					1	2	
Sea cucumber	*Cucumaria frondosa*	4	2	10	2	6	11	8	1		15	10	9
Feather star	Crinoidea												
Sea potato	*Boltenia ovifera*												
Tunicate	Tunicata	S	S	A	A	A	A	A	A	A	C	O	O
Skate	Rajidae			1									
Torpedo ray	*Torpedo nobiliana*			1									
Atlantic Wolffish	*Anarhichas lupus*				5	1	2	1		1			
Atlantic Herring	*Clupea harengus*										~20		~100
Gadoid	Gadidae												
Atlantic Cod	*Gadus morhua*	10	3	1	5	12	2		1		3	1	3
Sea Raven	*Hemitripterus americanus*						1						
Monkfish	*Lophius sp.*	1			1						1		
Blenny	*Lumpenus sp.*						2			2	1	1	
Atlantic Hagfish	*Mixine glutinosa*			1		2	6	1					
Sculpin	*Myoxocephalus sp.*					1				2	2	1	
Flatfish	Pleuronectiformes			4	1			1			9	3	
Pollock (?)	*Pollachius sp.*					~50	~50	~10					
Redfish	*Sebastes sp.*	2099	2511	854	786	989	489	641	565	591	3	19	4
Hake	*Urophycis sp.*			2		1	19	10	5	5	4	10	17
Eelpout/Ocean pout?	Zoarcidae			4	6	1		1	2	2		4	4

Unid. Fish		1	2	2	2	1	1	1	2	3	2	5	5
Unid. Fish (dead)								1					
Snow crab (dead/exoskelton)	*Chionoecetes opilio*												1
Jonah crab (dead/exoskelton	*Cancer borealis*	8	11	9	7	5	12		1	1	3		1
Garbage (beer/soda can)		1	1	1	1	1							
Garbage (gloves)		1		2									
Garabge (glass bottle)													
Garbage (other debris)												1	
		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**											
	S= Super abundant Taxa A = Abundant Taxa, C = Common 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**
Kelp (brown)	Laminariales												
Polymastia	*Polymastia sp.*	1	7	41	43	23	11	4	23	13	12	13	43
Encrusting sponge	Porifera		R	S		R			R			R	C
Sponge*	Porifera	123	14	S	A	61	40	69	96	208	180	133	47
Corymorpha sp.	Corymorpha sp.				1	1							
Hydrozoa	Hydrozoa		R	F									
Sea anemone	Actinaria	163	139	65	84	61	38	31	79	161	113	53	174
*Cerianthus sp**	*Cerianthus sp.*												
Soft Coral*	Alcyonacea												
Brachiopod	*Terebratulina sp.*			S						R		R	
Buccinum sp.	*Buccinum sp.*					2	1	1	2		1	1	
Colus sp.	*Colus sp.*		9		2								
Gastropod	Gastropoda												
Neptunea sp.	*Neptunea sp.*												
Scallop	*Placopecten magellanicus*												
Barnacle (lg)	*Balanus sp.*				2								
Jonah crab	*Cancer borealis*	10	10	55	46	21	29	22	6	15	14	2	
Cancer sp.	*Cancer sp.*								1				
Snow crab	*Chionoecetes opilio*	42	62	27	25	19	26	37	129	72	11	1	1
Unid. Decapod	*Decapoda*	2						1	3	1			
Lobster	Homarus americanus						1						
Toad crab	*Hyas sp.*												
Portly spider crab	*Libinia emarginata*												
Northern Stone Crab	*Lithodes maja*												
Hermit crab	*Pagurus sp.*	2											
Shrimp	Pandalidae	59	3				2						
Ceramaster	*Ceremaster sp.*												
Crossaster	*Crossaster sp.*	27	16		1		1			1			
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	31	3395	862	1318	617	563	557	644	393	762	533	660
Hippasteria sp	*Hippasteria sp.*	16	5	3	1	1	16	16	3	12	12	4	4
Pteraster sp.	*Pteraster sp.*										2	1	1
Solaster	*Solaster sp.*	21	4	2	8	8	2	4	8	5	2	2	7
Basket star	*Gorgoncephalus sp.*	1											
Sand dollar	*Echinarachnius parma*	236			81	7		1	1	20	9	2	2
Sea urchin	*Strongylocentrotus sp.*	1022	1183	62	1935	487	3	4	38	26			3
Sea cucumber	*Cucumaria frondosa*	5	3	7	45	17	8	1	5	6	9	16	11
Feather star	Crinoidea		3	5	1				1	1		1	
Sea potato	*Boltenia ovifera*	2		2	2			1					1
Tunicate	Tunicata	R	C	O	C	C	A	S	S	S	S	S	S
Skate	Rajidae						1						
Torpedo ray	*Torpedo nobiliana*												
Wolffish	*Anarhichas lupus*		2	1				2	1		5		1
Atlantic Herring	*Clupea harengus*												
Gadoid	Gadidae												
Atlantic Cod	*Gadus morhua*	11	11	6	8	16	7	8	14	18	26	17	13
Sea Raven	*Hemitripterus americanus*												
Monkfish	*Lophius sp.*												
Blenny	*Lumpenus sp.*						7	3	6	3	1		
Atlantic Hagfish	*Mixine glutinosa*				1	1	4	2					1
Sculpin	*Myoxocephalus sp.*	1			1		1		1	1			
Flatfish	Pleuronectiformes												
Pollock (?)	*Pollachius sp.*												
Redfish	*Sebastes sp.*	59	276	697	94	209	559	1050	854	838	1434	1566	1263
Hake	*Urophycis sp.*												
Eelpout/Ocean pout?	Zoarcidae									1			

Unid. Fish		4			2		1	1	2	1	2		1
Unid. Fish (dead)													
Snow crab (dead)	*Chionoecetes opilio*												
Jonah crab (dead)	*Cancer borealis*	2			1	2		4		3	6		5
Garbage (beer/soda can)		4					3	2		2	1	1	1
Garbage (gloves)													
Garabge (glass bottle)													
Garbage (other debris)													
		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 O= Occasional Taxa												

		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**
Kelp (brown)	Laminariales	1								1			
Polymastia	*Polymastia sp.*												3
Encrusting sponge	Porifera							O	R	O	R		
Sponge*	Porifera				5	20	8	46	16	21	5	5	8
Corymorpha sp.	Corymorpha sp.												
Hydrozoa	Hydrozoa	F	R	R	R								
Sea anemone	Actinaria	1	43	3	28	221	407	800	679	485	46	20	32
*Cerianthus sp**	*Cerianthus sp.*					10			1	3			
Soft Coral*	Alcyonacea				1	6	6	7	8	1			
Brachiopod	*Terebratulina sp.*				R	F	F	F	O	O			
Buccinum sp.	*Buccinum sp.*				8		1		1		1		
Colus sp.	*Colus sp.*												
Gastropod	Gastropoda												
Neptunea sp.	*Neptunea sp.*	1											1
Scallop	*Placopecten magellanicus*												
Barnacle (lg)	*Balanus sp.*												
Jonah crab	*Cancer borealis*		3	3	5	15	2	10	2	7	30	19	13
Cancer sp.	*Cancer sp.*												
Snow crab	*Chionoecetes opilio*	24	51	34	28	106	33	102	25	41	156	96	100
Unid. Decapod	Decapoda							2					1
Lobster	Homarus americanus												
Toad crab	*Hyas sp.*											4	
Portly spider crab	*Libinia emarginata*												
Northern Stone Crab	*Lithodes maja*												
Hermit crab	*Pagurus sp.*				2	2			1				
Shrimp	Pandalidae		79			892	53	126	157	154	366	123	29
Ceramaster	*Ceremaster sp.*												
Crossaster	*Crossaster sp.*	8	15	2	2							6	19
Henricia sp./Asterias sp.	*Henricia sp./Asterias sp.*	3	4	99	197	195	187	102	71	181	375	75	64
Hippasteria sp	*Hippasteria sp.*							5	10	2	23	4	16
Pteraster sp.	*Pteraster sp.*				1	1	1						
Solaster	*Solaster sp.*	1	1	2	12	4	1	3	1	3	8	4	13
Basket star	*Gorgoncephalus sp.*	17	9		4	6		1					2
Sand dollar	*Echinarachnius parma*												
Sea urchin	*Strongylocentrotus sp.*	51	253	842	151	11	5	2					
Sea cucumber	*Cucumaria frondosa*	6	5										3
Feather star	Crinoidea						1						
Sea potato	*Boltenia ovifera*												
Tunicate	Tunicata				13								
Skate	Rajidae												
Torpedo ray	*Torpedo nobiliana*												
Atlantic Wolffish	*Anarhichas lupus*												
Atlantic Herring	*Clupea harengus*									10			
Gadoid	Gadidae	9	1	3	2	8	5	2	2				2
Atlantic Cod	*Gadus morhua*				1			1				1	
Sea Raven	*Hemitripterus americanus*												
Monkfish	*Lophius sp.*												
Blenny	*Lumpenus sp.*					2		3					
Atlantic Hagfish	*Mixine glutinosa*		1										
Sculpin	*Myoxocephalus sp.*		1			5	1	1					
Flatfish	Pleuronectiformes				1				1	1		9	1

Pollock (?)	*Pollachius sp.*												
Redfish	*Sebastes sp.*	1		32	35	45	157	8	5	2	11	17	
Hake	*Urophycis sp.*							4	5	7	1	1	
Eelpout/Ocean pout?	Zoarcidae												
Unid. Fish		1	1		1	3	3	2	2	2	2		1
Unid. Fish (dead)													
Snow crab (dead)	*Chionoecetes opilio*										2		
Jonah crab (dead)	*Cancer borealis*												
Garbage (beer/soda can)													
Garbage (gloves)													
Garabge (glass bottle)													
Garbage (other debris)													
		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												

APPENDIX D

Assessment of bird interactions with offshore infrastructure associated with the oil and gas industry of Nova Scotia, Canada. Acadia University – Final Report- January 2015

Assessment of bird interactions with offshore infrastructure associated with the oil and gas industry of Nova Scotia, Canada.

Final Report – January 2015

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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:
EMC – ExxonMobil Canada
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 limited 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 combined 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. Here we summarize field and lab work conducted during the period June 2011 to June 2014.

Receiver Development **–** To improve our ability to detect radio-tagged birds in offshore and noisy working environments, and to address problems of data storage capacity on commercially available VHF receivers, we developed a low-cost, automated VHF receiver using commercial off-the-shelf components. These receivers monitor multiple antennas simultaneously and improve our ability to detect VHF radio-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. They are now being extensively used at a variety of field projects from the southern US to Nunavut.

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 596 birds including Herring Gulls, Great Black-backed Gulls, Common Terns, Arctic Terns, Leach's Storm-petrels, Ipswich Sparrows, and Blackpoll Warblers;
2) satellite-GPS and GPS-logger tag deployments on 9 Herring Gulls and 11 Great Black-backed Gulls;
3) light-level geolocator tag deployments on 67 Leach's Storm-petrels;
4) colour wing- and leg-banding of 60 Herring Gulls (adults) and 164 Great Black-backed Gulls (mixed chicks, immatures, and adults); and
5) ~1200 receiver tracking-days in 2012 (including 400 days from supply vessels), and >5000 receiver tracking-days in 2013/2014 (including > 1300 days from supply vessels)

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 poor due to excessive VHF noise when using commercially available receivers. Improvements in detections were not realized in 2012 because of the late deployment receivers, equipment failures, and software problems. Receiver deployments in 2013 were highly effective with minimal failures.

In 2012, supply vessels equipped with custom-built VHF receivers recorded 14 interaction events with gulls, but no detections of tagged petrels, terns, sparrows, or warblers. In 2013 vessel-based VHF receivers were active during the entire tagging period and numerous individual birds were detected. 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 vessels; interaction events were usually longer for Herring Gulls than for Great Black-backed Gulls. No Blackpoll Warblers were detected from vessels in 2013, but we did detect Ipswich Sparrows, Leach's Storm-petrels and terns. Interactions are summarized below.

Gulls. VHF tags and colour wing-bands showed that most gulls depart from colonies on Sable Island between mid-July and mid-August. This departure period corresponds with our observations of gull-platform interactions offshore. The radio-tracking 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. 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. Individuals interacting with platforms in 2012 also interacted with platforms in 2013, suggesting individual specialization. Most of the satellite-tag derived 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, and were primarily with 3 of the 9 tagged individuals. Satellite tags deployed on 6 Great Black-backed Gulls in 2013 showed no evidence of sustained interaction with platforms.

Terns. During breeding, terns on Sable Island made regular foraging trips of 3 to 6 h duration. 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 shows that terns regularly travel long distances 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 thus 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; nearly all had departed by mid-August.

Storm Petrels. Foraging trips by Leach's Storm-petrels from Bon Portage Island and Country Island lasted from 3 to 5 days during incubation phases and from 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. From Country Island storm-petrels, only 1% of offshore locations were estimated to occur near the offshore platforms, though approximately 10% of foraging trips were estimated to transit across the platform area to more distant foraging areas. Colony-based VHF-tracking data showed 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. In 2013, when offshore VHF receivers were fully operational during the petrel tracking season, one VHF tagged petrel out of 20 from Country Island was also detected by a vessel-based receiver near offshore platforms. The distinct foraging locations of these colonies to the northeast and south of the main oil and gas infrastructure area (Pollet et al. 2014) suggests that Leach's Storm-petrel colonies that exist along the shore between Bon Portage Island and Country Island likely have a higher probability of interacting with the offshore infrastructure.

Ipswich Sparrow. During 2012 and 2013, Ipswich Sparrows tagged in August commenced migration 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 suggested that adults and juveniles differed in their route choice, with adults displaying a more westerly or southerly route than juveniles. If juvenile Ipswich take a direct route between Sable and northern portions of Nova Scotia's eastern shore, they would limit their over-water travel distance and the overlap with the Deep Panuke platform. The more westerly 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. One tagged individual was detected from platform supply vessels during autumn migration in 2013; none were detected in 2012. During the 2013 spring migration, Ipswich Sparrows tagged on the Nova Scotia mainland initiated over water migration immediately following sunset, with most departures from the central portions of Nova Scotia between Conrad's Beach and Clam Harbour. Ten of 21 individuals successfully migrated to Sable Island. Two individuals were detected by offshore supply-vessels, one passing by the vessel near the Deep Panuke platform (and later detected 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 (and not later detected on Sable, indicating an unsuccessful migration).

Blackpoll Warbler. In 2012, 4 Blackpoll Warblers were tagged in Cape Breton; 3 moved south-west along the coast of Nova Scotia. 34 of 53 warblers tagged on Bon Portage (BP) Island 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 suggesting considerable landscape-scale movements within Nova Scotia prior to migration. This result may also indicate that some individuals undertake their trans-oceanic flights from points further east. In 2013 50 Blackpoll Warblers were tagged at Canso Peninsula in NE mainland Nova Scotia. 86% (43/50) of these were subsequently detected at other locations along the Nova Scotia coast and into the Gulf of Maine. The last point of detection (a possible surrogate for departure location) ranged across the extremes of the study area, from Canso to Cape Cod; none of these were detected flying over Sable Island or supply vessels. The last times of detection ranged from 19 September through 26 October, with more of the later detections occurring at the more westerly sites (e.g. in the Gulf of Maine). There is no evidence from these data of any concentration of departure location and most of the individuals tagged likely departed from locations that would not have put them in proximity to offshore platforms.

Platform Observations **–** From 30 April to 07 May 2014, one observer was deployed on the Deep Panuke platform to conduct visual observations of birds during the spring migration period. "Sea Watch" observations documented the relative abundance of seabirds in flight and on the water around the platform: 89% Herring Gull, 8% Northern Fulmar, and less than 1% for each of 5 other species. A "Platform census", conducted three times daily to search for live and dead stranded birds on the platform, found 21 live birds (three of which were subsequently found dead). Fourteen dead birds were found on the platform: 10 were highly decomposed (probably mortalities from the previous year or over winter), 1 was desiccated but not severely decomposed (likely from migration this year), and 3 were fresh mortalities (noted above). Leach's storm-petrels were the most commonly found bird (6 of 14), most of which were oiled and trapped under grated walkway on one of the lower decks. The discovery and documentation of live and dead stranded birds highlight the value of systematic bird surveys aboard platforms to accurately document the timing, species composition, and abundance of strandings.

Risk Assessment **–** Results of the telemetry studies, platform observations, and other available information were used to assess the risk of impacts to study species from offshore oil and gas platforms in Nova Scotia (see summary table below). Terns and Blackpoll Warblers have a low risk of impact due to the limited frequency and low impact of interactions. Leach's Storm-petrels have a low to high risk of impacts (depending on the population) since we demonstrate that Eastern Shore colonies transit through the platform area, this was the most commonly stranded species found dead on the platform, the population appears to be declining in this region and there is uncertainty over total annual mortality estimates associated with oil and gas activities. Gulls have a frequent rate of interaction from a high proportion of the Sable Island breeding colony indicating a "medium" risk for these species. However, no lethal interactions were documented, and the interactions with offshore platforms may be beneficial in providing food and shelter to individuals. Ipswich Sparrows have a low risk of impact from offshore platforms during fall migration but a high risk of impact during spring migration. Additional research on the dynamics and risks of spring migration for this species is recommended.

Species (group or population)	Impact	Probability	Risk
Gulls	Minor	Frequent	Medium
Terns	Minor	Unlikely	Low
Leach's Storm-petrels (Bon Portage)	Minor	Unlikely	Low
Leach's Storm-petrels (Country Island)	Moderate	Frequent	High
Ipswich Sparrow (spring)	Moderate	Frequent	High
Ipswich Sparrow (fall)	Minor	Unlikely	Low
Blackpoll Warbler	Moderate	Unlikely	Low

Platform Sensors Deployment **–** Deployment of independent bird-radar system was deemed not feasible due to interference associated with PFC RACON system. 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. The use of existing platform radars to detect birds was deemed not feasible at this time for a variety of reasons, the most important being inability to test various digitizing options on an equivalent system on-shore. Due to delays in the hook up and commissioning of the platform, bird monitoring equipment was not installed on the platform in 2013 for the VHF telemetry study. Although these delays precluded our obtaining data from the platform itself, our use of the platform supply vessels and the receiving stations on nearby Sable Island still allowed us to address the main goals of the study. Deep Panuke achieved "first gas" in December 2013 and the VHF receiver was installed in April 2014. On board testing in May 2014 demonstrated that the installed VHF receiver is capable of detected VHF tags virtually anywhere aboard the Deep Panuke platform. We recommend continued use of VHF receivers on platforms and support vessels whenever possible to facilitate future studies and contribute to a regional migration monitoring network over the next 5 to 10 years.

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; Ronconi et al. 2015). 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 (except for some examples with offshore wind energy development; see Ronconi et al. 2015). 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 further 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 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 was to *develop knowledge that could help reduce bird-human conflict at offshore installations*. The research objectives were:

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, Conrad's Beach (spring 2013) and north-eastern Nova Scotia (Point Michaud, autumn 2012 and 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 was 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).

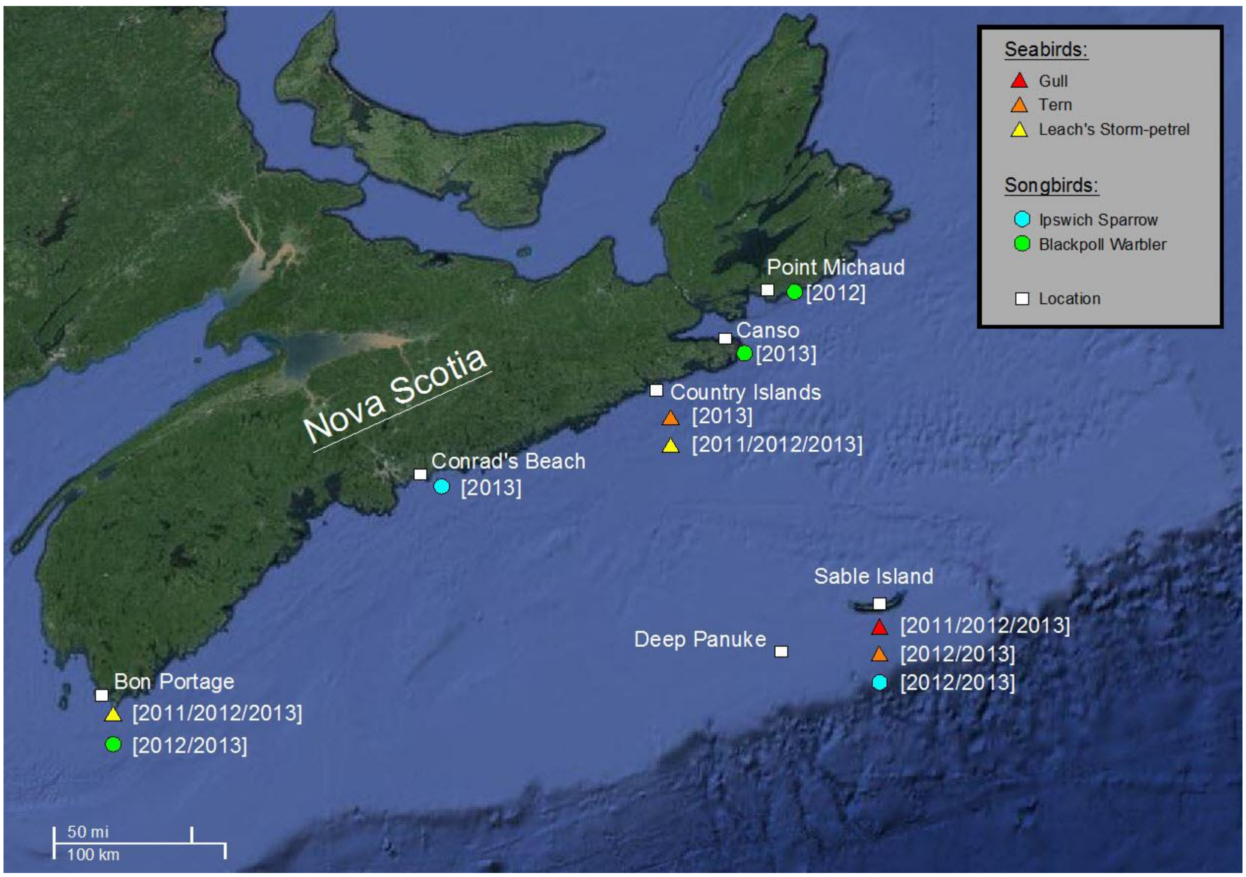


Figure 4.1-1 – Location of study sites relative to the Deep Panuke platform. See Section 4.4 for additional details on tag deployments by species and site.

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). 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). SOEP platforms developed by EMC began production in 1999 (3 platforms), 2003 (1), and 2004 (1); Encana's Deep Panuke platform was installed on location in July 2011 and started production in August 2013 with full production ('First Gas') achieved in December 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 receiver 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 the date of production commencement (EMC platforms) and the date each 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	EMC	43.89188	-60.19989	1999	yes	9	48
Venture	EMC	44.03328	-59.58175	1999	no	7	44
North Triumph	EMC	43.69958	-59.85454	1999	no	25	18
Alma	EMC	43.59483	-60.682	2003	no	60	27
South Venture	EMC	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 songbirds are regularly observed (McLaren 1981). Two songbird species are most vulnerable to potential interactions with platforms: Ipswich Sparrow (*Passerculus sandwichensis princeps*) breeds only on Sable Island, and Blackpoll Warbler (*Dendroica striata*) undertakes trans-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 et al. in review) 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, EMC, 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 little is known about their foraging ranges or habitat use.

Terns – Large colonies of Common and Arctic Terns nest on Sable Island, and the island 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, because all three species nest together, the recovery strategy for the species includes protecting large, healthy colonies of Common and Arctic Terns (Environment Canada 2010). 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); such information aids in assessing 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;Z. Lucas pers. comm.) 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 4.1-1) which are the largest known 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 **–** The Ipswich Sparrow is a sub-species of Savannah Sparrow. It 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). Ipswich Sparrows migrate annually between Sable Island and coastal areas of Nova Scotia and New England. 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 VHF 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

Our receiver is named "SensorGnome". Details on the construction and list of components can be found at www.sensorgnome.org. The unit is built around a tunable 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 attached to the Beaglebone's single USB host port. 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 internal micro SD cards. The USB hub and Beaglebone computer are 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 Sensorgnome receivers allow us to continually and simultaneously listen to VHF signals from up to 3 antennas, and store a complete record of pulses detected that match those generated by tags. These are run through a pattern-matching algorithm to extract tag IDs. During 2012, Sensorgnomes 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 problems with receiver deployments related to both hardware and software issues. These problems were addressed, enabling us to vastly increase the temporal and spatial extent of coverage in 2013.

4.2.3 Data processing

Data collected from Sensorgnomes and Lotek receivers are uploaded to a central server, and incorporated into a database of putative tag pulses. These pulses are run through a tag-detection algorithm (described below) and a file of putative tag hits is produced. For the Sensorgnome, the basic conceptual framework is to be liberal in allowing putative tag pulses (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

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', sequential bursts with a specific spacing) to a library of pre-recorded tags. The algortithm then searches for bursts at the appropriate intervals (the burst rates). In 2013, this algorithm proved effective at finding tag detections even in "noisy" environments. We continue to explore alternate tag algorithms which may improve data extraction efficiency for past or future deployments.

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 Sensorgnome 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 2013 and 2014. In 2013, Sensorgnome and wiki users included project partners from New Brunswick, Maine, and Massachussetts who ran receiver stations capable of detecting birds tagged in our study. In 2014, the nascent network developed under this NSERC CRD was operationalized as the 'Motus Wildlife Tracking System' (www.motus-wts.org).

4.2.6 Tag detection in "noisy" environments

In 2012 we conducted the first deployments of Sensorgnome receivers on vessels. Although there was a significant improvement over commercial receiver deployments in 2011, a bug in the software exacerbated "noise" from receivers on vessels (section 5.1). As a result, extra data processing procedures had to be used to eliminate potential false positive detections for these data. These are described in this section. The bug was fixed for deployments from 2013 onwards (sections 4.2.4 and 5.1).

The Sensorgnomes 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 consecutive pulses in sets of four) and inter-burst intervals (time in seconds between sets of four pulses, typically 5-10 sec 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 of "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 eliminated periods of excessive hits which were likely generated from periods of extensive VHF "noise" recorded sporadically from vessel-based receiver.

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.

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) and other stations from partner projects. In 2013 on Sable Island we established additional stations 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 two tern colonies. A total of 5425 receiver-tracking-days were obtained between 19 March 2013 and 13 March 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).

Antenna towers were equipped with either SRX-600, SRX-DL telemetry receivers (Lotek Wireless Inc.), or a Sensorgnome (see 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 12V DC deep-cycle batteries, 100 to 115 amh each; or two or more 33 amh sealed lead acid batteries).

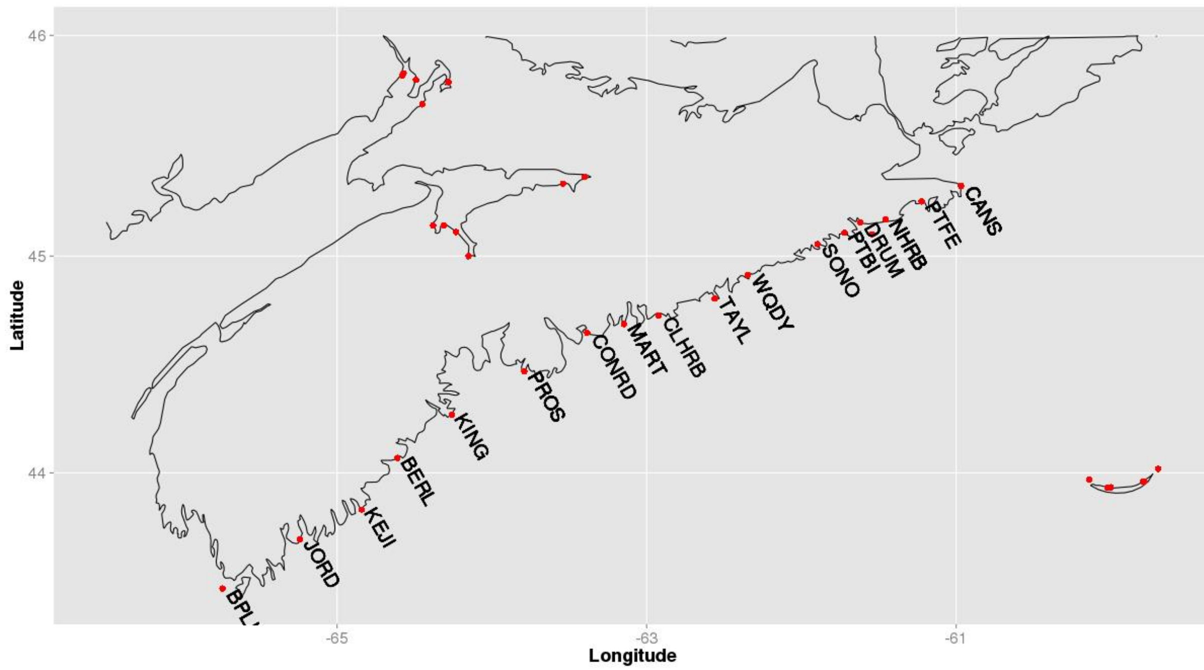


Figure 4.3-1 – Distribution of automated VHF receiver stations in Nova Scotia and New Brunswick during 2013. Site codes can be found in Table 3 of Appendix I. Stations without labels in the upper Bay of Fundy were from partner projects (Aug to Sept, 2013, only) but had no detections of birds from this study. 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 Islands). 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 - 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. When recovered, these light levels are used to estimate sunrise and sunset times which can be used to estimate latitude and longitude. These tags must be recovered for data to be retrieved for analysis, which limits their use to species that can easily be recaptured within the same or a subsequent season. The precision of location estimates is low (~ ±180 km), but these are still useful for species that travel long-distances to foraging areas and species 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 sites in proximity of a base station.

Satellite tags are 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	12	**59**
	Sable Island	Sat/GPS		6	3	**9**
Great Black-backed Gull	Sable Island	VHF		26	32	**58**
	Sable Island	Sat/GPS			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**	**307**	**596**
		Sat/GPS	**0**	**6**	**14**	**20**
		GLS	**0**	**37**	**30**	**67**
		Overall	**65**	**267**	**351**	**683**

*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.

				Sample size		
Year	**Species**	**Age**	**Season (month)**	**Colour Band**	**Wing-tag + Colour Band**	**Wing-tag colour**
2011	HERG	adult	breeding (May/June)		21	Pink
	GBBG	HY	breeding (May/June)	29		na
2012	HERG	adult	breeding (May/June)	14	13	Pink
	GBBG	AHY	winter (Jan)		12	Turquoise
	GBBG	AHY	breeding (May/June)	1	25	Lime green
	GBBG	HY	breeding (May/June)	19		na
	GBBG	HY	post-breeding (Aug)	9		na
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 (i.e. breeding adults) but Great Black-backed Gulls were captured with traps at seal carcasses and so 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 – Satellite tags provide locations from anywhere on the planet. 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 genetic methods. 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 tags were programmed with two seasonal duty cycles to optimize use of solar power:

1. *spring/summer/fall*: 21-Feb to 21 Oct, 15 GPS positions daily at hours 0, 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 0, 3, 6, 9, 12, 15, 18, 21, and transmit cycle = 5 d.

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 2012 and 2013, we deployed VHF tags on terns at two colonies on Sable Island and in 2013, on one mainland colony at Country Island. 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 – In 2012 and 2013 63 Common Terns and 53 Arctic Terns were tagged between 9 and 17 June. 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, 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, 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 were about ~20 km apart and both were <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. In 2012 a receiver was mounted to the roof of a building within 100 m of the Main Station and in 2013, additional receivers were placed within East Colony, and the East and West Spits of Sable Island (see section 4.3 for details).

Country Island is situated ~5 km off the coast of eastern Nova Scotia (45° 5" 58' N, -61° 32" 34' W) and hosts a mixed colony of approximately 1300 pairs of Common and Arctic Terns. The island is nearly round and ~500 m in diameter; nesting terns on the island are usually <100 m from the ocean. A monitoring program (run by EC-CWS) was ongoing during our study 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 (see section 4.3). Additional visual monitoring of the tagged terns was conducted at the Country Island colony which ultimately will be used to validate the presence/absence of VHF signals recorded from automated receiver stations. Observations were conducted from within wooden blinds situated 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. Individuals 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 Sensorgnome 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 5 mm 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 as was done for Terns, using sub-dermal sutures (see section 4.42 – Capture and Radio tagging).

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 (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

In 2012, work on Ipswich Sparrows 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 a higher probability of successfully migrating off the island. 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, 0.1 mL 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 15 km 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, 0.1 mL 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 h 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 × 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. 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: Glasgow Head (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 Glasgow head site was at the tip of the Canso peninsula, about 175 km north-northwest of Sable Island. At Glasgow head, 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.*

	Hatch-year		After-hatch-year	
Site	**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 situated 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 Glasgow Head 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 Platform observations

From 30 April to 07 May 2014, one observer was deployed on the Deep Panuke platform to conduct visual observations of birds during the spring migration period. Based on recommendations for observers on platforms in Atlantic Canada (Wiese et al. 2001) and protocols used on platforms in the Gulf of Mexico (Russel 2005) two types of observations were conducted: sea watch and platform census.

Sea Watch – Sea watch observations are intended to count the numbers of marine birds on the water or in the air visible from the platform. During 60 or 30 min observation periods, we followed Environment Canada protocols for stationary platforms (Gjerdrum et al. 2012) conducting instantaneous scan counts with distance sampling at five minute intervals. Instantaneous counts can be used to provide accurate estimates of bird densities, however, in locations and periods of low bird abundance, zero counts are frequently recorded and therefore provide few data on species composition unless conducted over long periods of time. Between instantaneous counts we also recorded all birds flying through the area (timed scan sampling; Wiese et al. 2001, Burke et al. 2005). This continuous sampling can be used to provide indices of relative abundance (e.g. birds per interval of time) and assessment of species composition. During the platform visit, "sea watch" observations were conducted twice daily, weather permitting, from the galley landing on the north east corner of the PFC.

Platform Census – A timed "platform census" route was designed to walk around all levels and laydown areas of the PFC to search for live and dead stranded birds. Each census took 1 to 1.5 h to complete, and was conducted three times daily at dawn, mid-day, and dusk. For safety, the observer was escorted by a platform employee who also helped search for birds. For each live and dead stranded bird, the observer recorded the location, species, number of individuals, and bird condition.

5. Results

5.1 Receiver development

Initial deployments of commercially available receivers on vessels in 2011 identified problems associated with extraneous VHF noise that impaired our ability to detect individually tagged birds, and data storage capacity limited our ability to run VHF receivers autonomously for long periods of time. This severely limited our capacity to assess bird-platform interactions in that year, and instigated the development of new receivers (Sensorgnomes) in subsequent years (see section 4.2 for details).

Early in the season of 2012, Lotek Wireless receivers (SRX-600 and -DL) were deployed on Sable Island before Sensorgnome receivers were ready for field deployment. Sensorgnome 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 Island. 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 has an impact on our ability to monitor gull-platform interactions for VHF tagged birds in 2012, which occur most frequently during this period, and also limits our investigations of tern-platform interactions in 2012 since most terns had departed the Sable Island area by mid-August (see results below).

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.

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

In 2013, the vessel-based receivers worked continuously from April through to December except Panuke Sea was not activated until 08-Jul, Ryan Leet had one failure from 27-Sep to 13-Nov (46.7 d), and the Venture Sea was away from the study area from 03-Sep to 08-Oct (35.3 d). Receivers were operated in 2014 and data collated up to 01-Jun except for the following gaps: Panuke sea failed after 19-Apr (accidentally unplugged), Venture Sea failed between 04-28 Mar (24 d, accidentally unplugged), and Ryan Leet was disconnected 03-Mar (contract with Deep Panuke terminated). There were 1,318 vessel-days of VHF receiver deployment between 16-Apr 2013 and 01-Jun 2014. After 01-Jan 2014, there were only 3 detection events of gulls from vessels, all < 2 min in duration, and this period also suffered from the equipment failures and the termination of tracking from one vessel mentioned above. As a result, all 2013-2014 analysis presented in this report focuses on the period from 16-Apr 2013 to 01-Jan 2014. There were a total of 13,537 vessel-hours of active VHF receiver deployments: 68% on standby, 8% loading at platforms, and 24% in transit. Receiver effort varied considerably among platforms and study months (Table 5.1-2) as a result of deployment schedules and receiver malfunctions (affecting months; see methods) and vessel duties (standby vessels move between platforms depending on scheduled maintenance requirements). Receiver effort was low in April, May and June, but roughly even between July and December. Among platforms, effort was roughly equal between the two manned platforms (Deep Panuke and Thebaud) but two to ten times lower at the other platforms.

Table 5.1-2 Summary of VHF receiver effort from supply vessels from April through December 2013. Effort is quantified in vessel-hours of active receiver deployments. For individual platforms (names in top row) vessel-hours represent times when vessels were within 6 km of the platform. "in transit" refers to all vessel-hours > 5 km from a platform, but excludes locations in Halifax Harbour.

	Deep Panuke	**Thebaud**	**Alma**	**North Triumph**	**Venture**	**South Venture**	**in transit**	**Total**	**% Total**
April	15	98	0	0	10	11	80	**214**	**1.6**
May	173	337	1	13	51	49	226	**850**	**6.3**
June	180	207	0	8	44	166	258	**863**	**6.4**
July	532	224	24	34	179	297	552	**1842**	**13.6**
August	798	399	153	21	298	256	585	**2510**	**18.5**
September	756	419	0	160	0	0	543	**1878**	**13.9**
October	344	744	0	30	252	59	258	**1687**	**12.5**
November	467	705	57	27	158	122	444	**1980**	**14.6**
December	246	407	57	67	430	155	351	**1713**	**12.7**
Total	**3511**	**3540**	**292**	**360**	**1422**	**1115**	**3297**	**13537**	**100.0**
% Total	**25.9**	**26.2**	**2.2**	**2.7**	**10.5**	**8.2**	**24.4**	**100.0**	

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 Sensorgnome 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.

5.2 Bird movements

The primary objective of this study was 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 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, 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 for casual observers 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 the limitations associated with non-systematic resighting effort, resightings of wing-tags and colour bands provide evidence of general patterns of 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. Moreover, there were technical issues that limited the utility of the vessel-based receivers in that year (see sections 4.2 and 5.1). Nonetheless, there were six confirmed tag detections from receivers deployed on vessels (Table 5.2-4) illustrating the patterns of detections and interactions that can be recorded from vessel-based receivers. Four detections were recorded from the sailing vessel Balaena while it was anchored near Sable Island on each of three separate occasions (13 Jul, 30 Jul, 16 Aug). These detections ranged in duration from approximately 3 minutes to 3 hours and were most likely from gulls roosting or foraging on Sable Island. One individual (tag 36) was detected on two nights in September attending the offshore supply vessel, Panuke Sea. During these detections, which lasted all night (Figure 5.2-1), the supply vessel was on stand-by adjacent to the Thebaud platform, situated approximately 9 km from Sable Island. This pattern of night-time attendance was likely associated with gulls foraging behind supply vessels which illuminate the water surface with deck lights (R. Ronconi pers. obs.). In this year, there were no gull detections from vessels attending Deep Panuke, though this was likely limited by technical issues associated with extraneous VHF noise (see above) and limited deployment period for one of the Deep Panuke supply vessels (Appendix I). No gulls were detected from receivers deployed on Coast Guard vessels, though Coast Guard vessel deployments operated outside of the study area for most of the fall (Appendix I) – due to lack of available equipment and lack of spatial overlap with our study area, Coast Guard vessel deployments were not continued in subsequent years.

Table 5.2-4 – Confirmed detections of gull tags from receivers deployed on vessels. Signal strength is determined from the receiver on a scale of 1-255 which indicates the relative proximity of tags from the vessels. See also Figure 5.2-1.

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

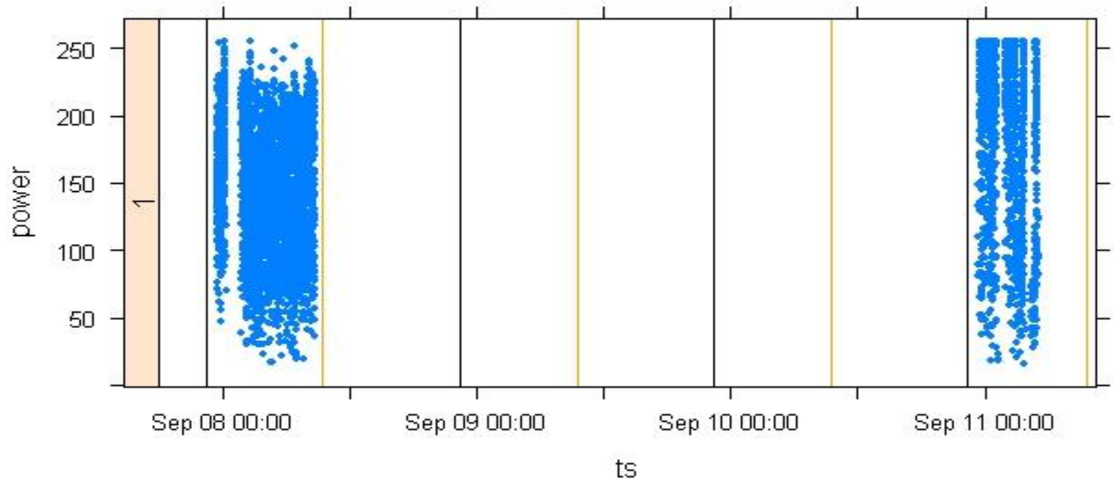


Figure 5.2-1 – Detections of Herring Gull tag #36 recorded from a receiver deployed on the Panuke Sea in August and September, 2011. Each dot represents a single detection from an individual tag which was programmed to transmit every 5 seconds. ts = time stamp (i.e. date/time), power = relative signal strength of the VHF tag on a scale of 1-255. The strong and continuous detections on two days in September represent sustained interaction with bird 36 starting after sunset (black bars) and ending before sunrise (yellow bars). Time is in UTC (3 hrs ahead of local time – Atlantic Daylight Savings Time ADT).

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 that 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. 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.

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 a 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 analyzed 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). 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) because equipment failures and excessive VHF noise from vessels limited the detection of VHF tags in 2012 (see Section 5.1 above).

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		
Date (2012)	**Species**	**Bird ID**	**Vessel**	**Name**	**Distance (km)**	**Start time (UTC)**	**VHF detections (n)**	**Duration (min)**
26-Jul	HERG	27	RL	DP	14	19:13	4	9
28-Jul	HERG	27	RL	DP	30	15:24	4	10
24-Aug	HERG	196	VS	T	2.3	23:08	4	8
25-Aug	HERG	205	VS	T	1 to 1.4	5:09	13	98
25-Aug	HERG	195	VS	T	1 to 1.8	3:13	58	224
29-Aug	HERG	185	VS	T	1.5 to 3	2:10	21	79
31-Aug	HERG	195	VS	T	1.5 to 2	0:53	4	10
31-Aug	HERG	185	VS	T	2.2	2:02	6	14
1-Sep	HERG	185	VS	T	4.5 to 6	5:53	5	26
4-Sep	HERG	205	VS	T	2.1 to 2.7	2:54	6	14
8-Sep	HERG	205	VS	T	1.7	23:49	5	14
9-Sep	HERG	205	VS	T	2.8	4:03	13	19
29-Sep	GBBG	188	RL	DP	3.4	18:39	15	3
29-Sep	GBBG	188	RL	DP	2.1	21:05	22	5

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. Most interactions with vessels occurred during post-breeding periods, but there were strong differences in patterns of detections between species with shorter interaction events for Great Black-backed Gulls, and prolonged interactions for some individual Herring Gulls (Figure 5.2-2). Spatially, interactions occurred primarily at Thebaud and Deep Panuke platforms with very few interactions near other platforms (Figure. 5.2-3), though this is largely a function of spatial coverage since stand-by vessels spend more time at these two platforms (Table 5.1-2, Figure. 5.2-3). Great Black-backed Gulls also show greater rates of movement on Sable Island, between receiver stations, than did Herring Gulls (Figure. 5.2-3), also reinforcing the greater use of terrestrial habitats and less reliance on offshore foraging near supply vessels.

Table5.2-6 – 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%

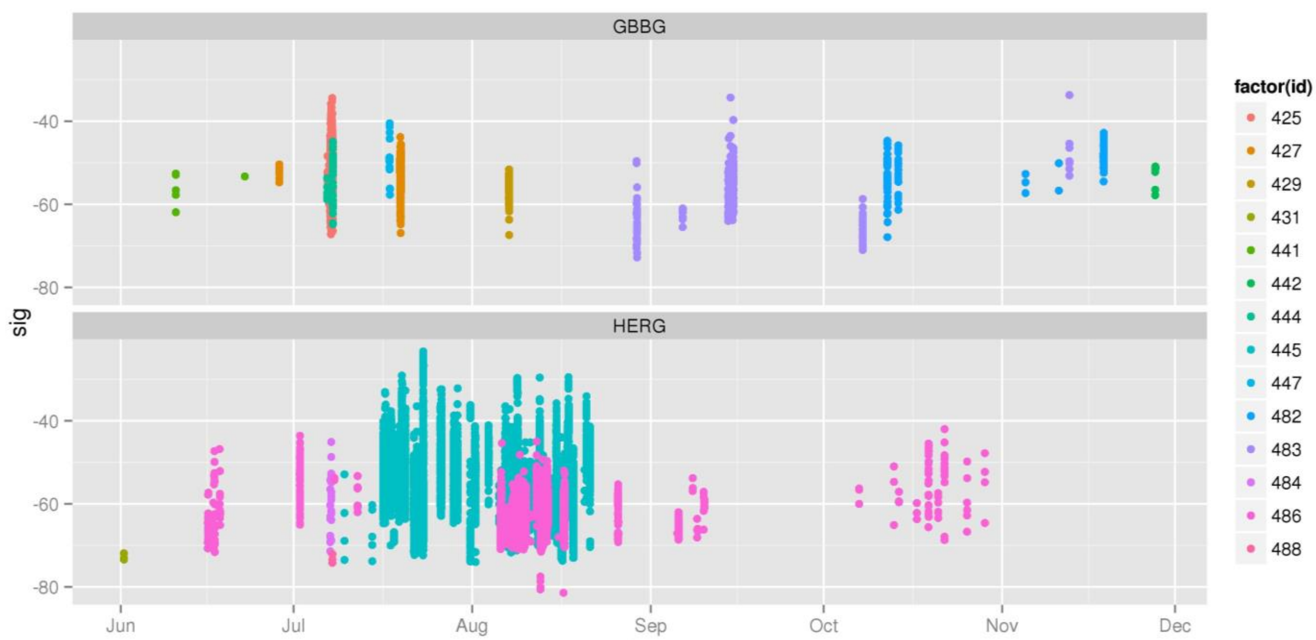


Figure 5.2-2 – Seasonal patterns of VHF-tagged Great Black-backed Gull (GBBG; upper panel) and Herring Gull (HERG; lower panel) detected from offshore supply vessels attending platforms around Sable Island. Signal strength (sig) is plotted against months in 2013. Colour depicts unique tag IDs.

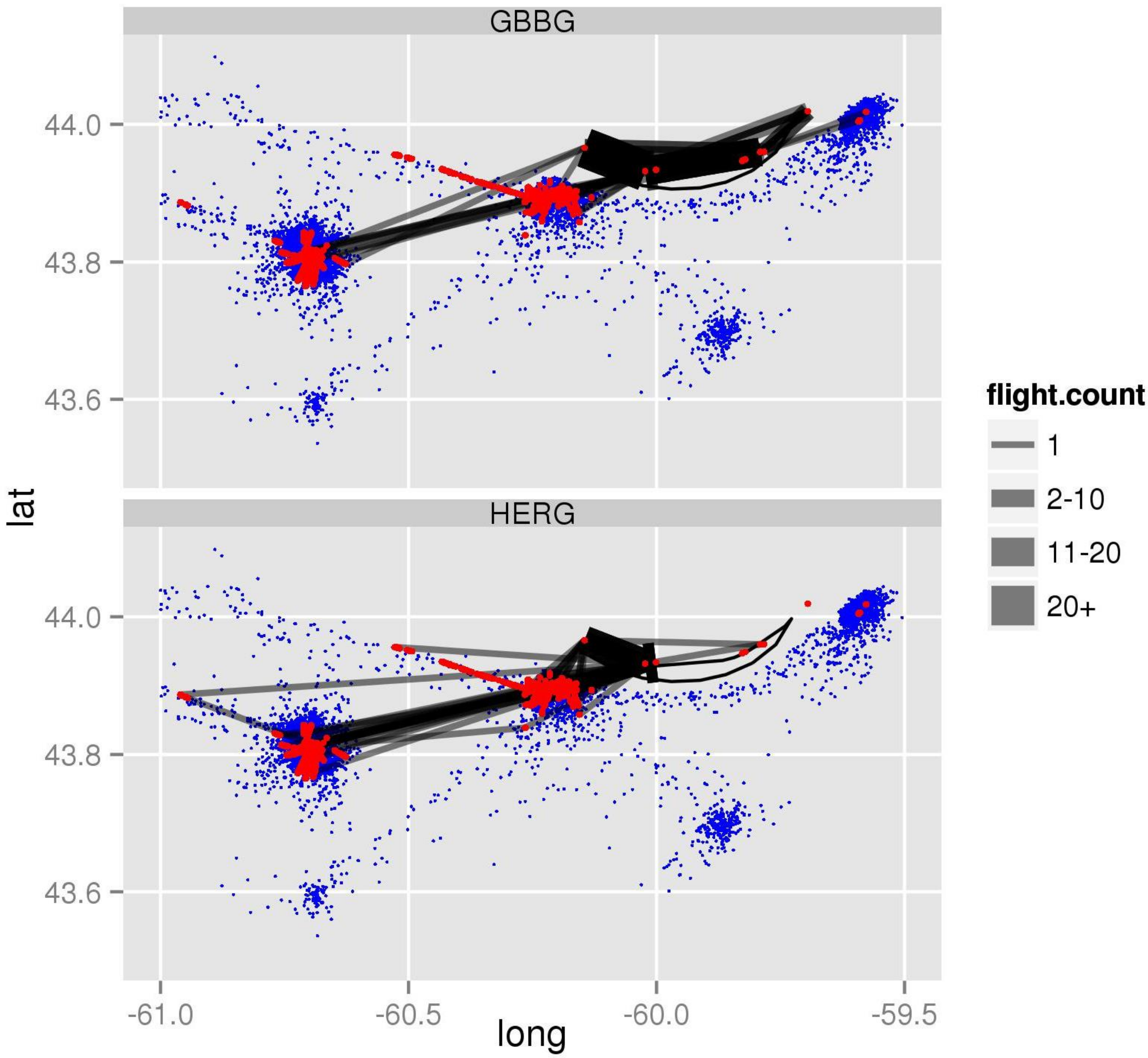


Figure 5.2-3 – Spatial patterns of VHF-tagged Great Black-backed Gull (GBBG; upper panel) and Herring Gull (HERG; lower panel) detected from offshore supply vessels attending platforms around Sable Island in 2013. Dark lines connect sequence of bird detections between receivers (red dots) with line thickness corresponding to the number of flights between these pathways. Blue dots indicate the hourly position of mobile vessel-based receivers which were clustered near offshore platforms.

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. 5.2-4). 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 (Figure 5.2-4). 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.

*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 5.2-5). Most interactions occurred during chick-rearing and post-breeding phases (Figure 5.2-5), between July and November (Figure 5.2-6), 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.

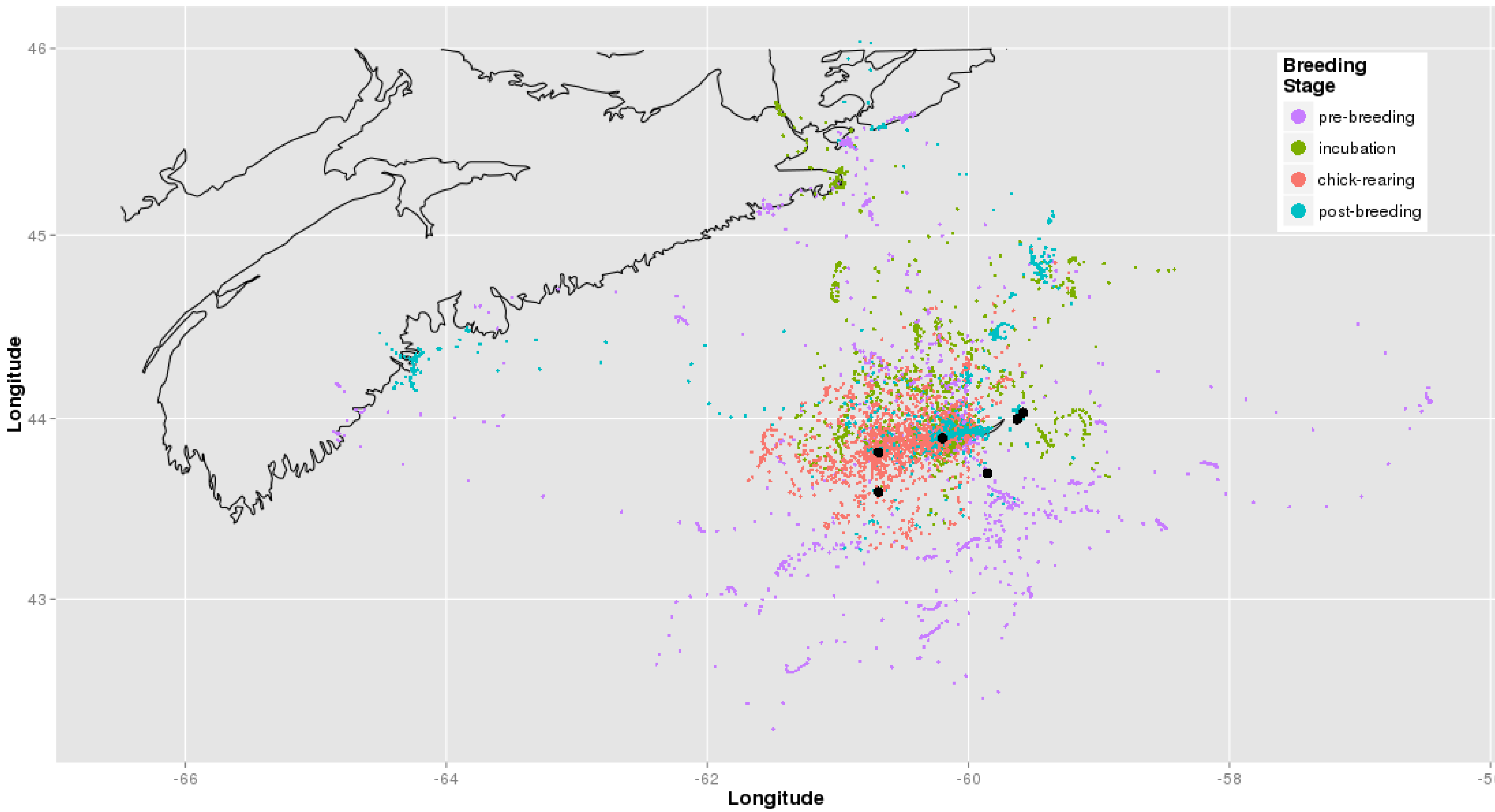


Figure 5.2-4 – Locations, classified by breeding stage, of 9 Herring Gulls tracked by satellite tags from Sable Island between May 2012 and December 2013. All locations in each year occur between dates of first and last detection on Sable Island, thus, omitting migrations and over-winter periods. Black dots are locations of 6 offshore natural gas platforms.

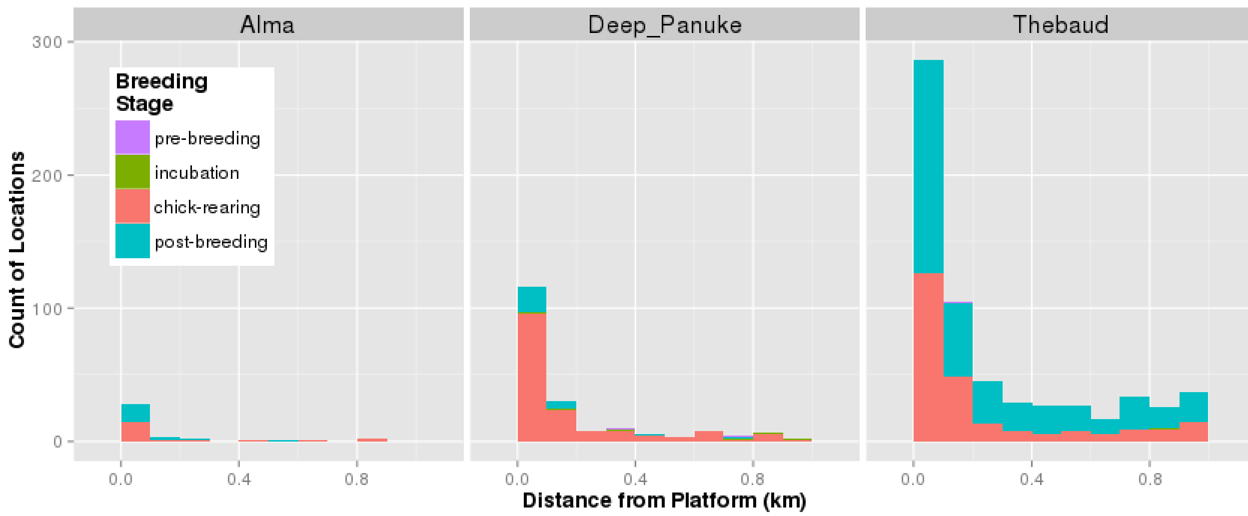


Figure 5.2-5 – Count of all Herring Gull locations tracked by satellite tags, classified by breeding stage, within 1 km of platforms between May 2012 and December 2013. Counts are binned in 200 m increments. Data not shown for three platforms with fewer than 10 locations within 1 km.

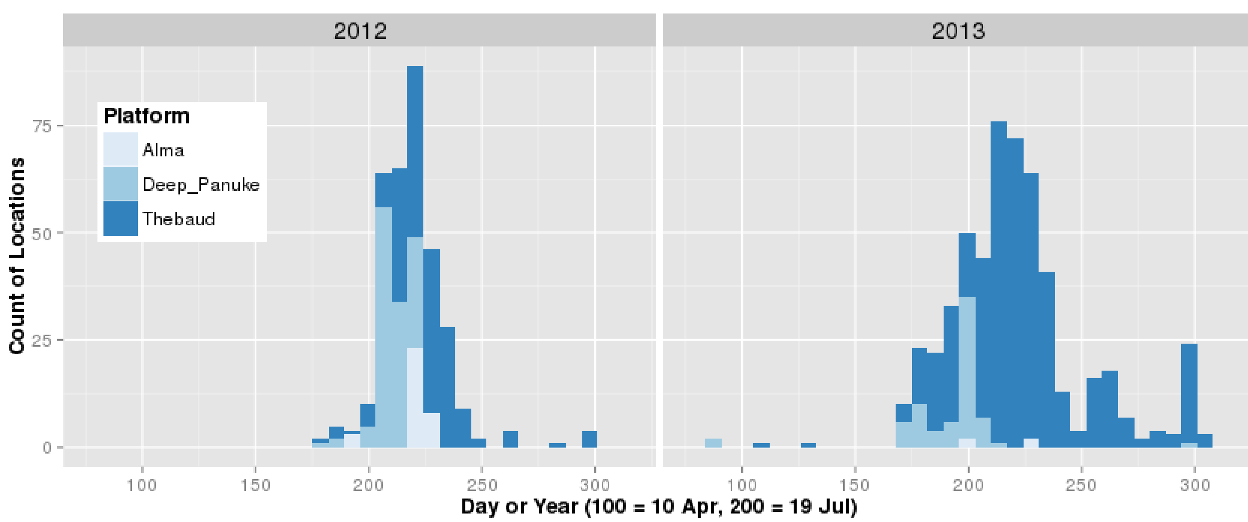


Figure 5.2-6 – Seasonal patterns of Herring Gull tracked by satellite tags occurring within 200 m of platforms around Sable Island. Counts are binned in 7 day increments. Data not shown for three platforms with fewer than 2 locations within 200 m.

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 Herring Gulls (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 5.2-7).

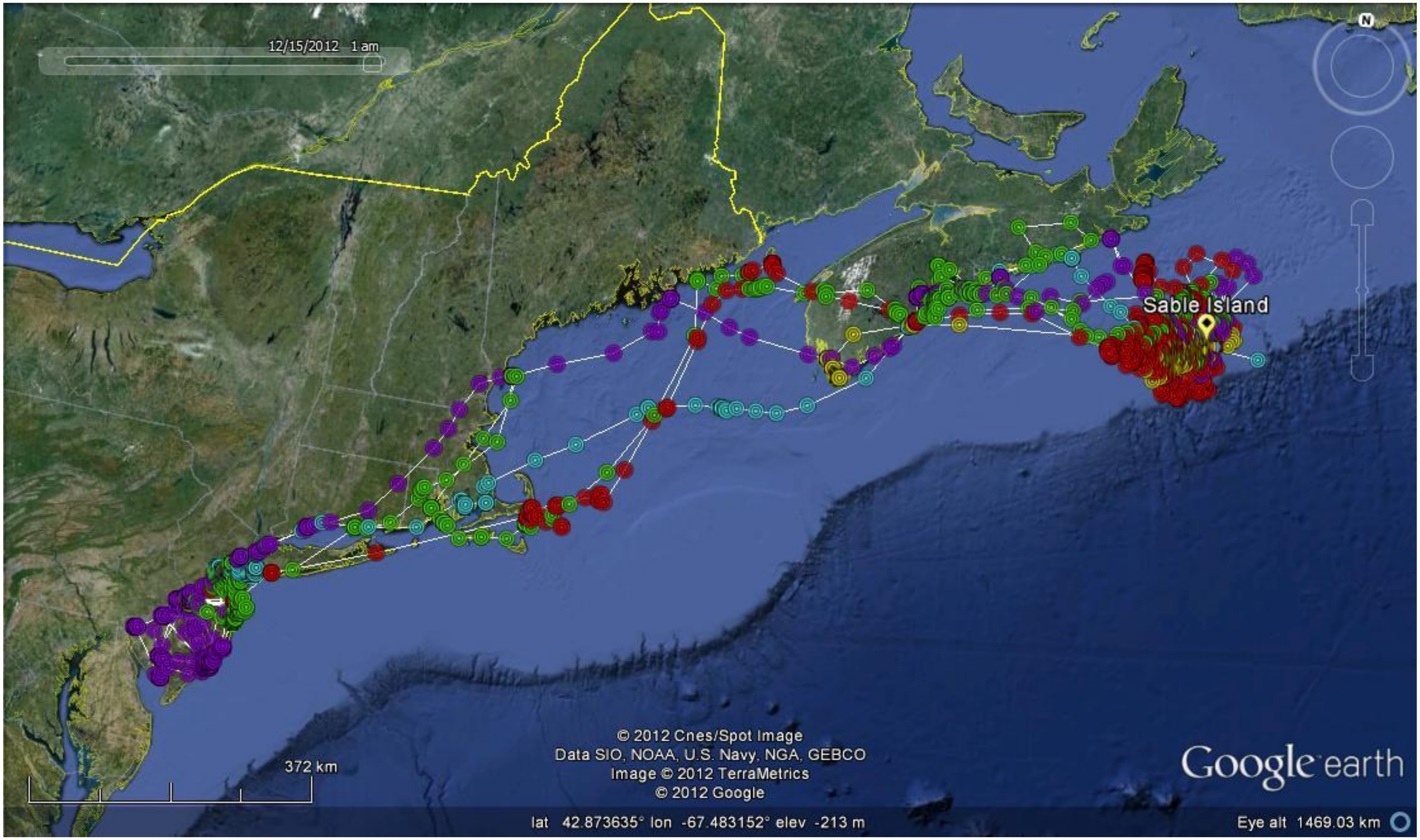


Figure 5.2-7 – Satellite tracking data from five Herring Gulls tagged on Sable Island (26-28 May 2012) until 20 December 2012. Migration routes are shown between Sable Island and New Jersey (4 birds) and southern Nova Scotia (1 bird in yellow).

In contrast to patterns of offshore foraging observed by Herring Gulls, six Great Black-backed Gulls tracked by satellite tags from June 2013 to June 2014 showed very little offshore foraging, and no association with offshore platforms (Figure 5.2-8). Moreover, 3 individuals continued to forage on or near Sable Island throughout the year, and only one individual moved to the US coast and returned to Sable by mid-January (tags on the remaining two individuals failed in August and November of the deployment year).

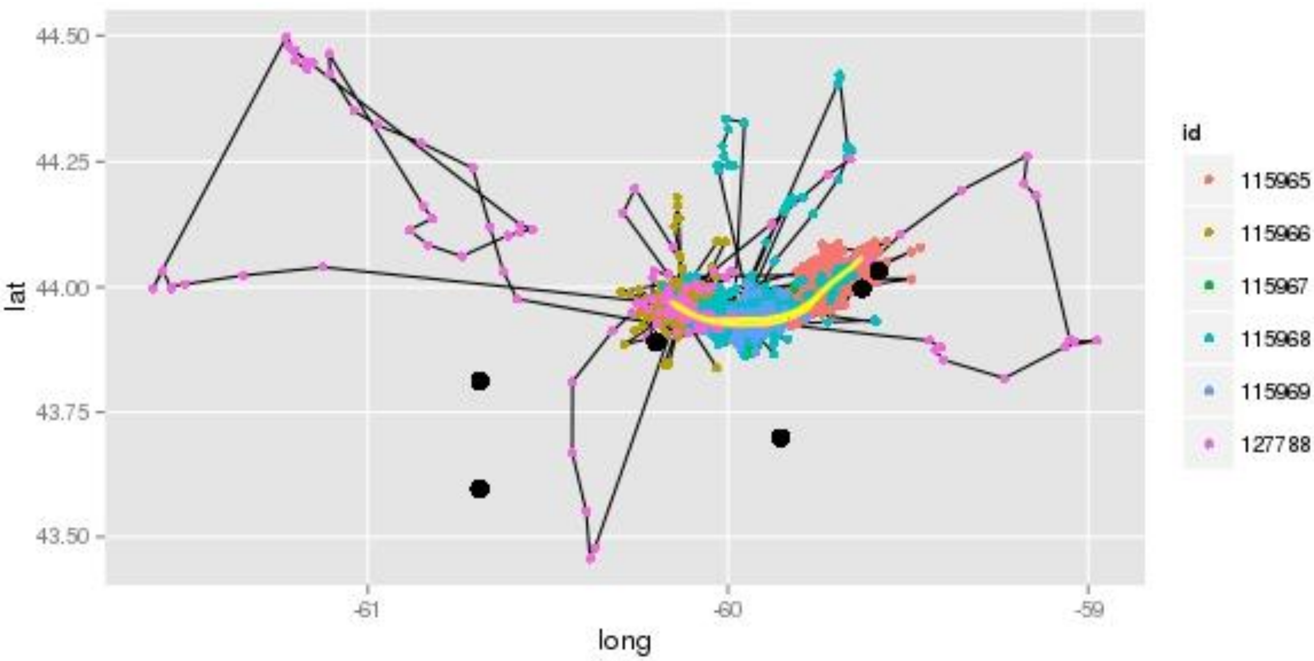


Figure 5.2-8 – Satellite tracking data from six Great Black-backed Gulls around Sable Island (yellow outline) and offshore platforms (black dots) from June 2013 to June 2014. Migratory periods away from the Sable Island area are omitted. Colours show unique bird IDs.

5.2.2 Common and Arctic Terns

Of the 35 transmitters deployed on Common and Arctic Terns on Sable Island in June 2012, 33 were recorded on multiple occasions by one or more of the 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 trips. Examples of colony attendance patterns measured by VHF detections are presented in Figure 5.2-9. Analysis of these attendance patterns classified data into “events” of 1) colony attendance, and 2) foraging trips, each of which has a start and end time which provide duration and time of day for events. 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.

2013 data of monitored Common and Arctic Terns nesting at Main Station and East Light Colonies on Sable Island suggests a high level of variability of foraging trip durations among tagged individuals throughout the breeding season. Foraging trips were determined from 8 individuals nesting at East Light (3 COTE, 2 ARTE) and Main Station (2 COTE, 1 ARTE). Foraging trips ranged from 20-600+ min. Despite this high variability in foraging trip duration, both species from each colony averaged roughly the same foraging trip durations, though Arctic Terns slightly longer: Main Station Common Terns 119 ± 101 (SD) min; Main Station Arctic Terns 146 ± 121 min, East Light Common Terns 115 ± 110 min; and East Light Arctic Terns 138 ± 141 min. Duration of foraging trips also showed high variance but similar averages among breeding season periods (Fig. 5.2-10). Overall, the average foraging trip duration in 2013 was 126 ± 118 minutes.

If we assume a flight speed of approximately 10 m/s (Gudmundsson et al. 1992, Egevang et al. 2010; speed of Arctic Terns during migration), during an average trip length of 126 minutes, a tern could travel up to approximately 75 km round trip, or 37.5 km one way. However, it is unlikely that a bird would travel this distance during a foraging trip since this does not account for variation in flight speeds, likely slower speeds during foraging than migration, search time, and time spent foraging at prey patches. Therefore, it is much more likely that the typical foraging range of Sable Island terns is at least under 25 km, unlikely to overlap with the Deep Panuke platform (55 km from Main Station colony), but possibly overlapping with nearby platforms such as Thebaud (16 km from Main Station colony), Venture and South Venture (17 and 13 km from East Light colony).

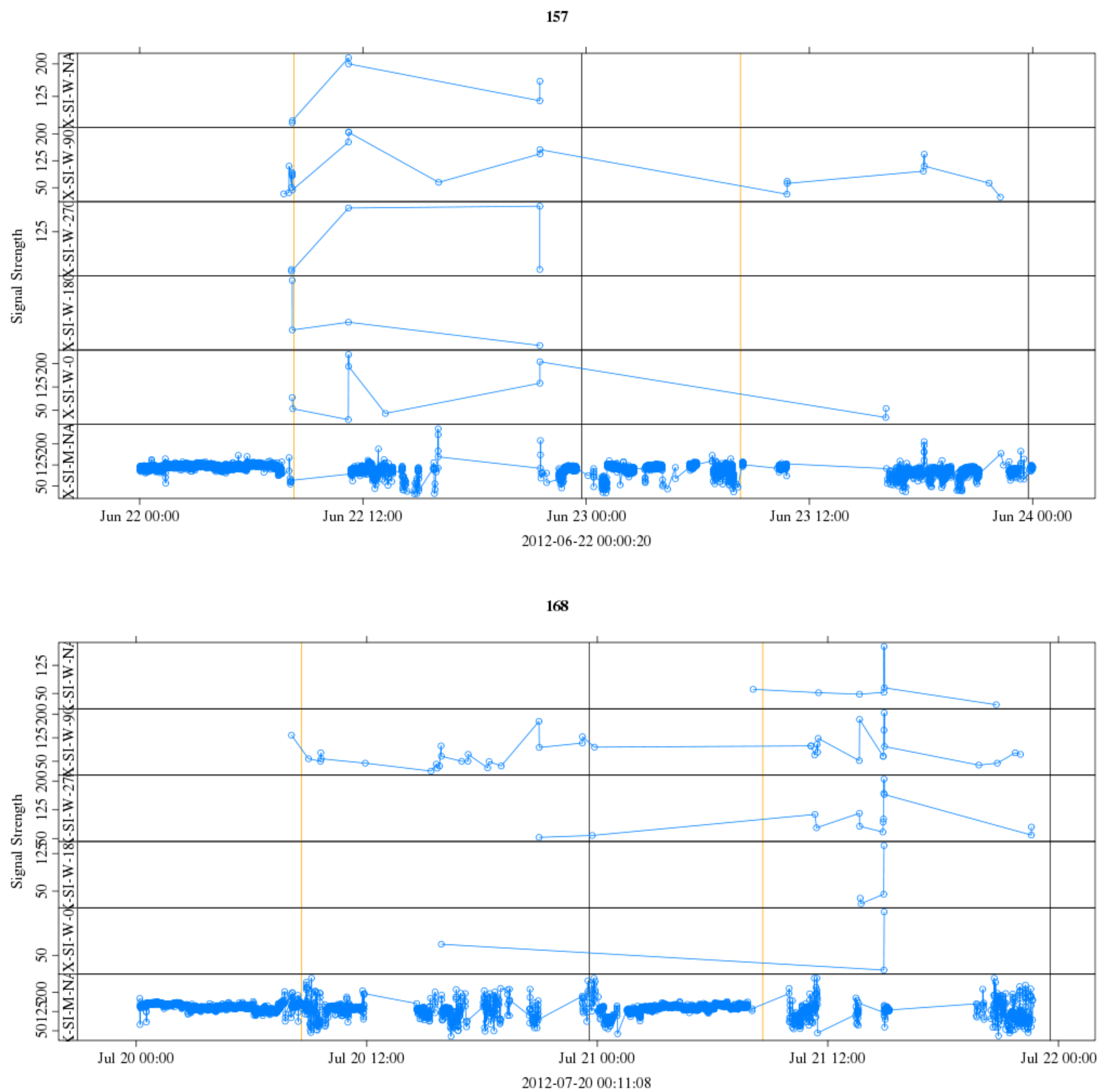


Figure 5.2-9 Example plots showing 2 days of colony attendance patterns in 2012 by one Common Tern (Tag ID 157, upper plot) and one Arctic Tern (tag ID 168, lower plot). Both birds were tagged at the Main Station colony where a receiver was deployed within the colony to monitor colony attendance patterns (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.

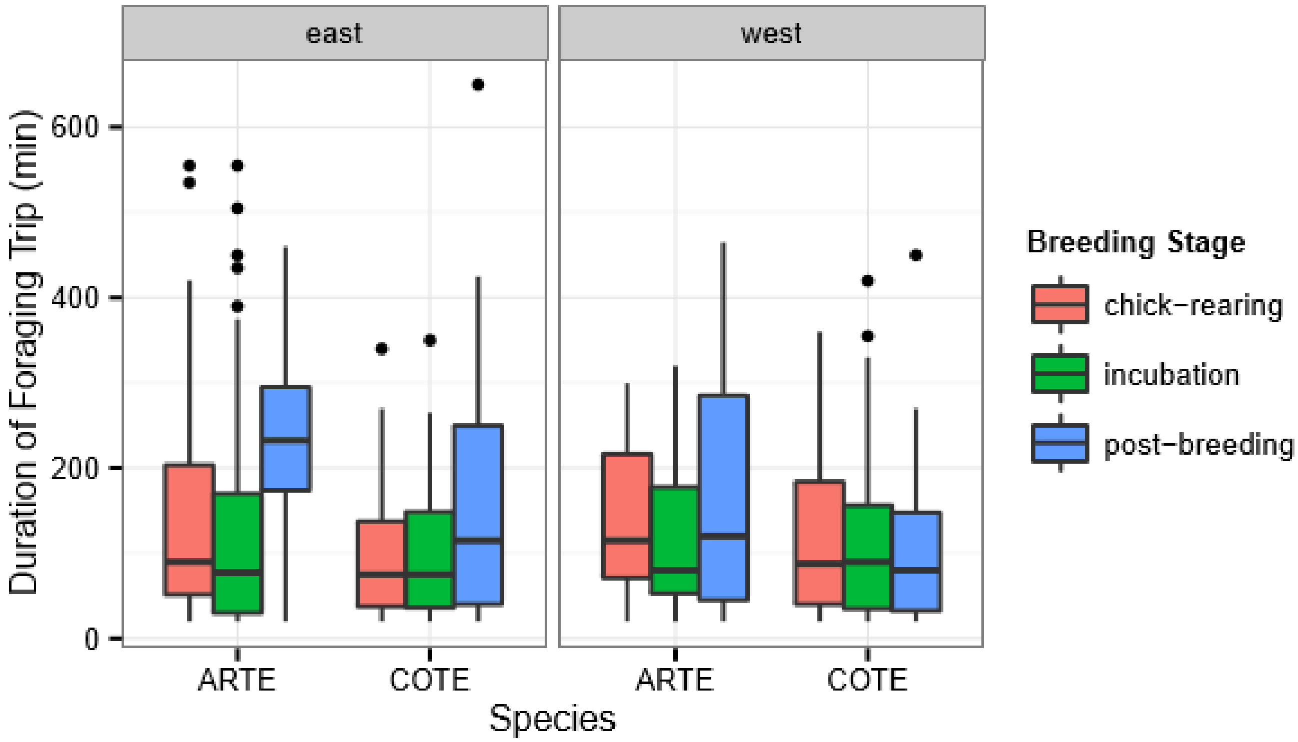


Figure 5.2-10 – Plot of foraging trip duration (in minutes) for individuals nesting at East Light (left) and Main Station (right) colonies on Sable Island in 2013 classified by stage of breeding season. Boxplots show means (horizontal bars), boxes extend to the first and third quartiles (the 25th and 75th percentiles), whiskers represent 1.5 x the inter-quartile range, and dots are outliers.

Movement patterns – Analysis of movement events between receiver stations show widespread movements across Sable Island. 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, areas separated by approximately 20 km. 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. Common and Arctic Terns were found to move along to the island throughout the breeding and post-breeding season (Fig. 5.2-11). All receivers detected individuals from both East Light and Main Station colonies suggesting that terns move along the island for some of their foraging trips.

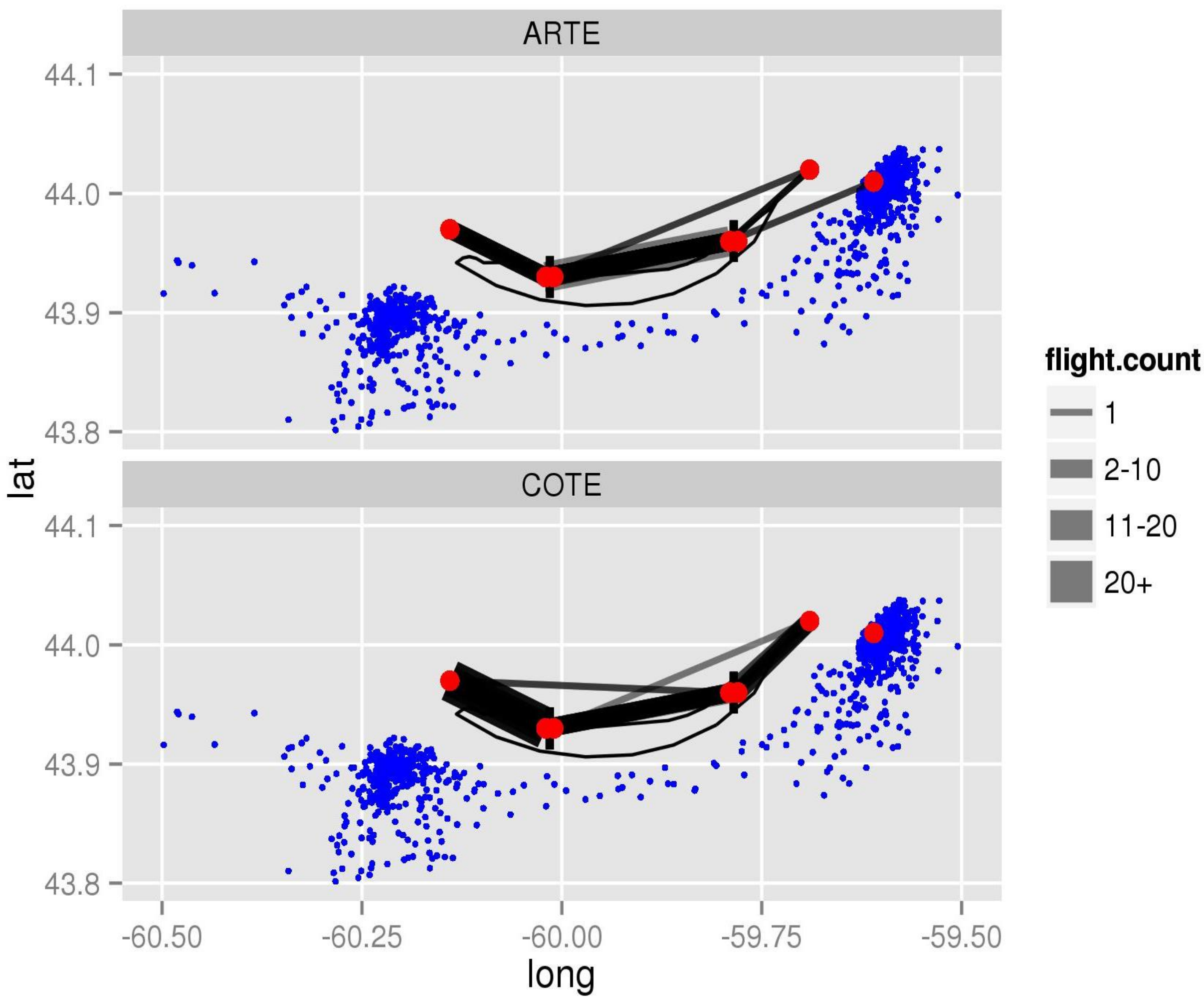


Figure 5.2-11 – Arctic (top panel) and Common (lower panel) Tern movements between Sable Island receivers and offshore areas during the 2013 field season. Dark lines connect sequence of bird detections between receivers (red dots). Blue dots indicate hourly position of mobile vessel-based receivers near offshore platforms.

Receivers were deployed at the tips of Sable Island (commonly known as the East and West Spit) for the 2013 season to monitor tern activity at these locations throughout the breeding and post-breeding season (Figure 5.2-11). 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. In total, 11 out of 50 (22%) tagged terns were detected at the west spit receiver at least once throughout and following the breeding and post breeding season (Fig. 5.2-12, Fig. 5.2-13; 4 Arctic Terns and 6 Common Terns). Fewer tagged individuals were detected at the east spit receiver with 5 out of 50 (10%) terns (Fig. 5.2-12; 2 Arctic Terns and 3 Common Terns).

Individual foraging trips to the spits were identified by a detection at the spit followed by a detection at the breeding colony. The 11 individuals completed 92 foraging trips to the West Spit throughout the breeding and post-breeding season in 2013. Of these 92 trips, 59 (64%) occurred during the early stage (incubation) of the breeding season. 10 out of the 11 idividuals detected at West Spit were detected there at least once during the incubation period. In comparison, there were fewer individuals and fewer trips detected at West Spit during the chick-rearing or post-breeding stages (Fig. 5.2-12, Fig. 5.2-13), though assessment of activity during the chick rearing period was compromised by the receiver malefunction between ~15 July and 05 August. During the post-breeding period, there was only one case of staging behavior detected at the West Spit by a Common Tern: following the last detection at the Main Station colony, this bird was detected at the spit almost daily from August 17th to September 10th, 2013 (Figure 5.2-14). East Spit had fewer foraging trip detections than West Spit, all occurring during the breeding season between June 15 and July 15 2013 (no post-breeding detections; Fig. 5.2-9).

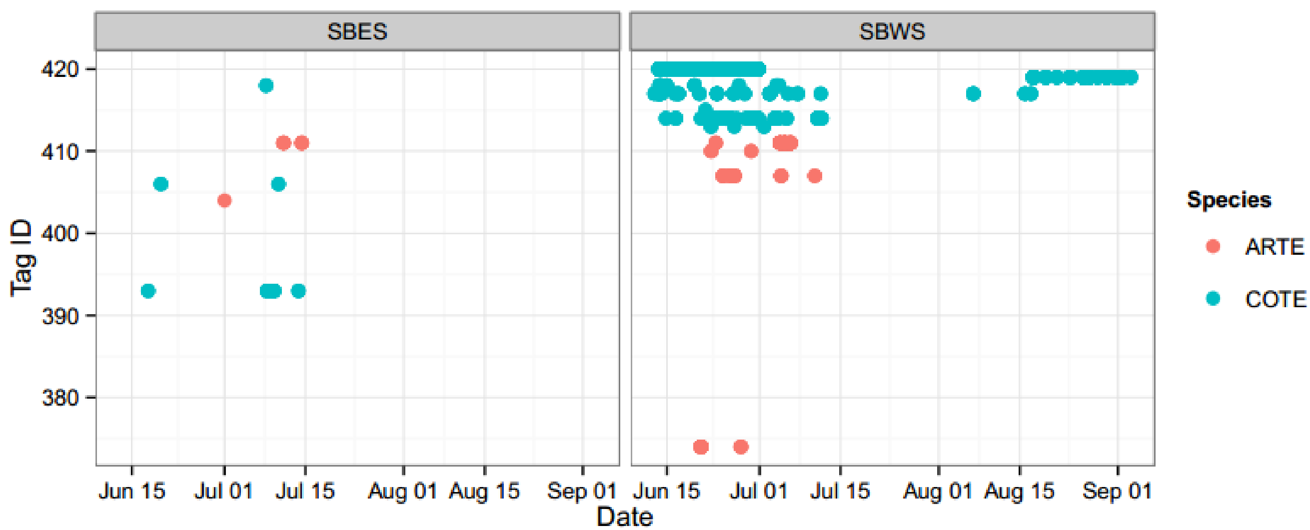


Figure 5.2-12 – Detections of individuals at East (right) and West (left) spits of Sable Island throughout the breeding and post-breeding season of 2013; individual tag ids represented on y-axis with a single dot representing at least one detection on a given day.

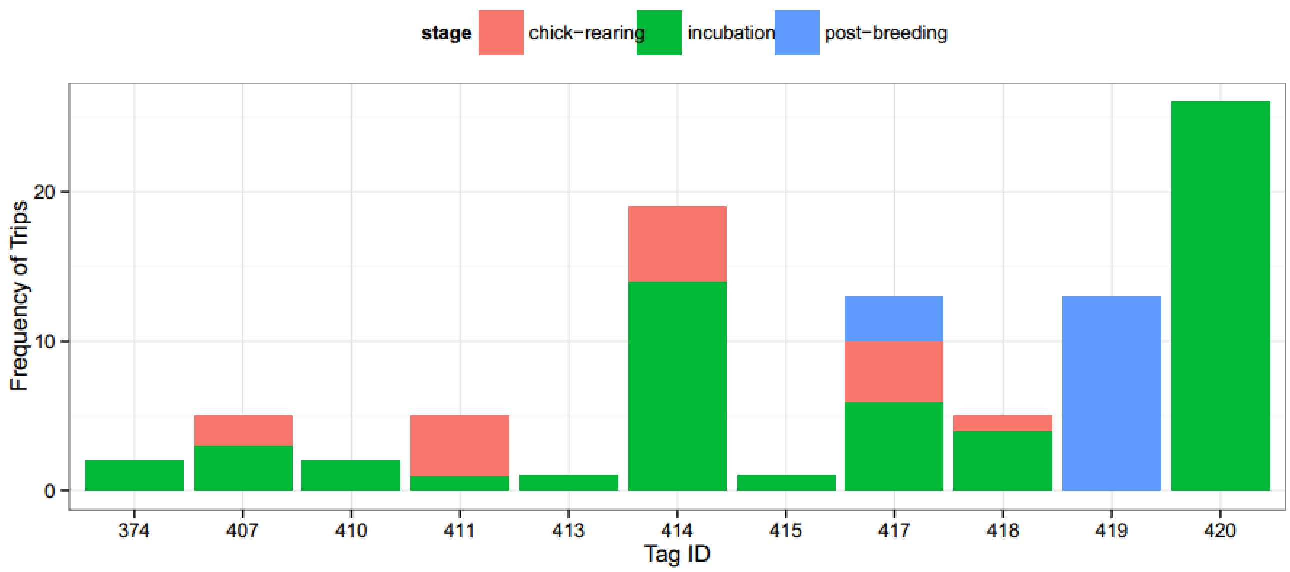


Figure 5.2-13 – Count of all Common and Arctic Tern foraging trips to West Spit, Sable Island, for each individual id, classified by breeding stage between June 10 and September 1st, 2013.

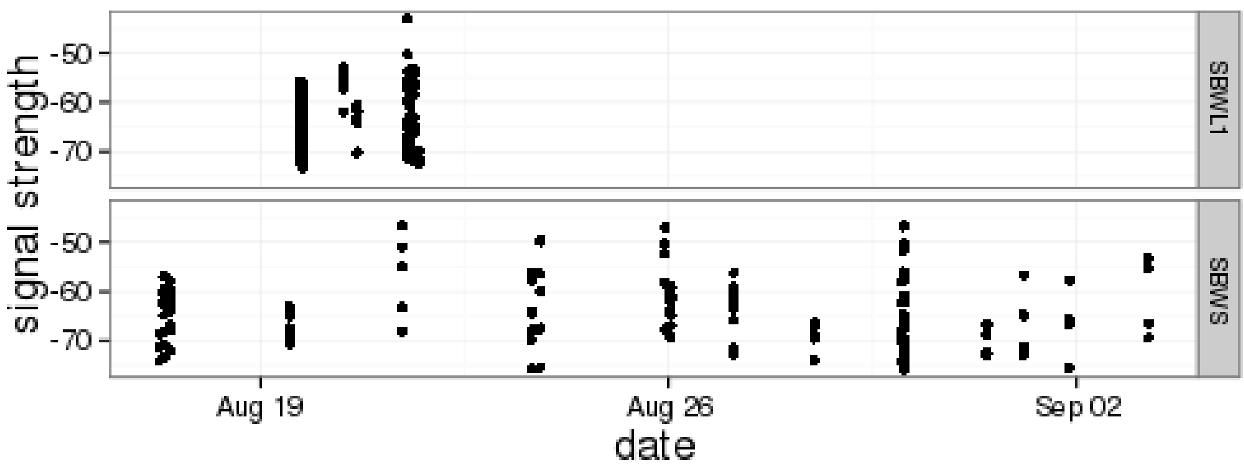
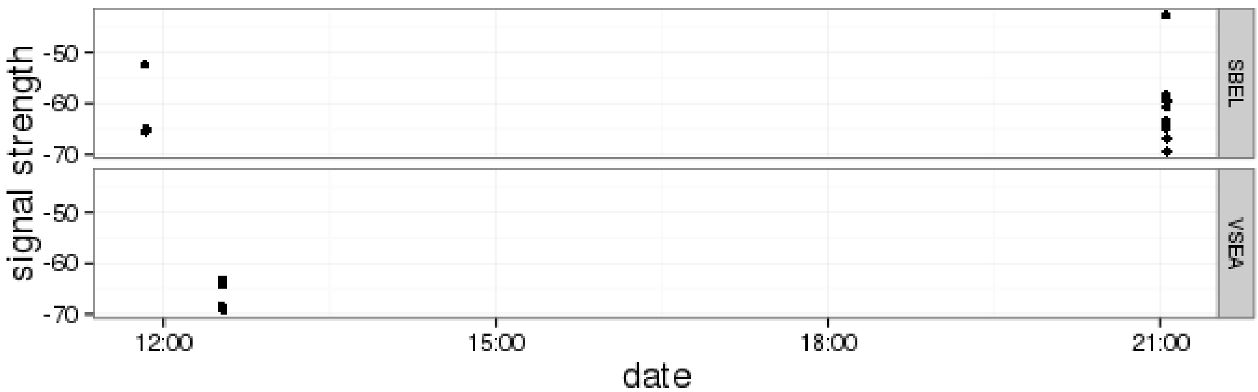


Figure 5.2-14 – Detections from automated receiver stations on Sable Island, 2013, near the breeding colony (SBWL1) and West Spit (SBWS) indicating post-breeding staging behavior of a tagged Common Tern (tag 419) at West Spit.

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 below), there was little chance of any receiver detecting terns around the offshore platform. Nevertheless, a lack of detections in August 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. Most (over 95%) tagged terns were not detected by vessel-based receivers. Two terns were detected by two vessels, the Ryan Leet and the Venture Sea (Figure 5.2-15), suggesting limited offshore foraging during the breeding and post-breeding season. The Venture Sea receiver detected one Arctic Tern (tag 404) on 3 July; prior and following this detection the tern was detected by the East Lighthouse receiver. At the time of detection the vessel was situated roughly 15 km NE 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 (Fig. 5.2-11). The Ryan Leet receiver detected a Common Tern (tag 417) twice on 14 August. These detections were separated by roughly 3.5 h and likely represent a single foraging trip in which the tagged tern flew past the vessel twice (Figure 5.2-15). During these detections the Ryan Leet was on standby approximately 4 to 5 km from the Deep Panuke platform and 48 km from the nearest point of Sable Island. 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 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 foraging near or around them.



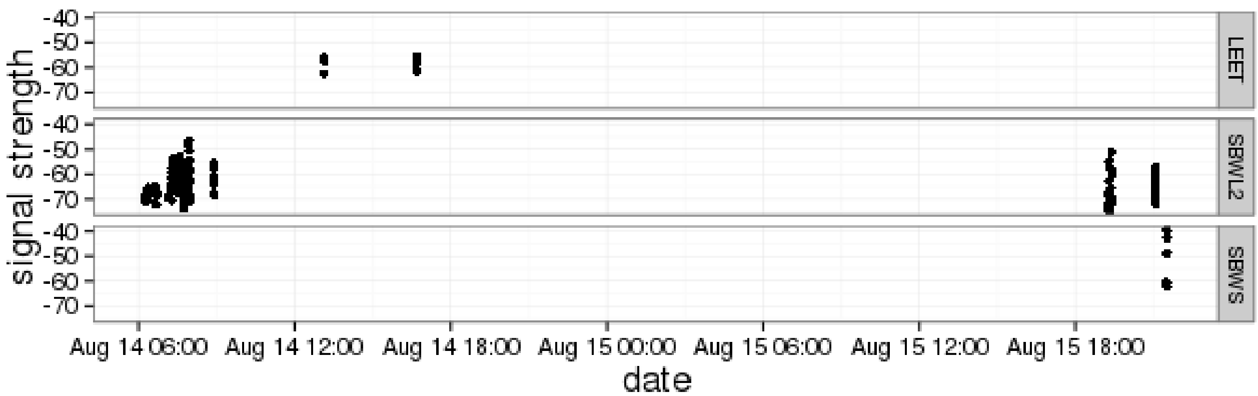


Figure 5.2-15 – Vessel-based receiver detections of foraging terns during breeding and post-breeding season in 2013. Upper plot: Arctic Tern (tag 404) detected at East Light (SBEL) receiver followed by detection on Venture Sea (VSEA) vessel receiver on July 3, 2013; tagged tern detected once again at East Light during breeding season. Lower plot: Common Tern (tag 417) detected at West Light (WBWL) receiver followed two offshore detections from the Ryan Leet (LEET) vessel on Aug 14, 2013; the following day the tagged tern was detected at West Light and West Spit (SBWS).

Dietary analysis - Stable isotope analysis of tern blood samples from Sable Island suggested dietary differences between the two species (Figure 5.2-16). 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 ± 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 slight differences in activity budgets and strong differences in habitat use observed at the spits of Sable Island (above).

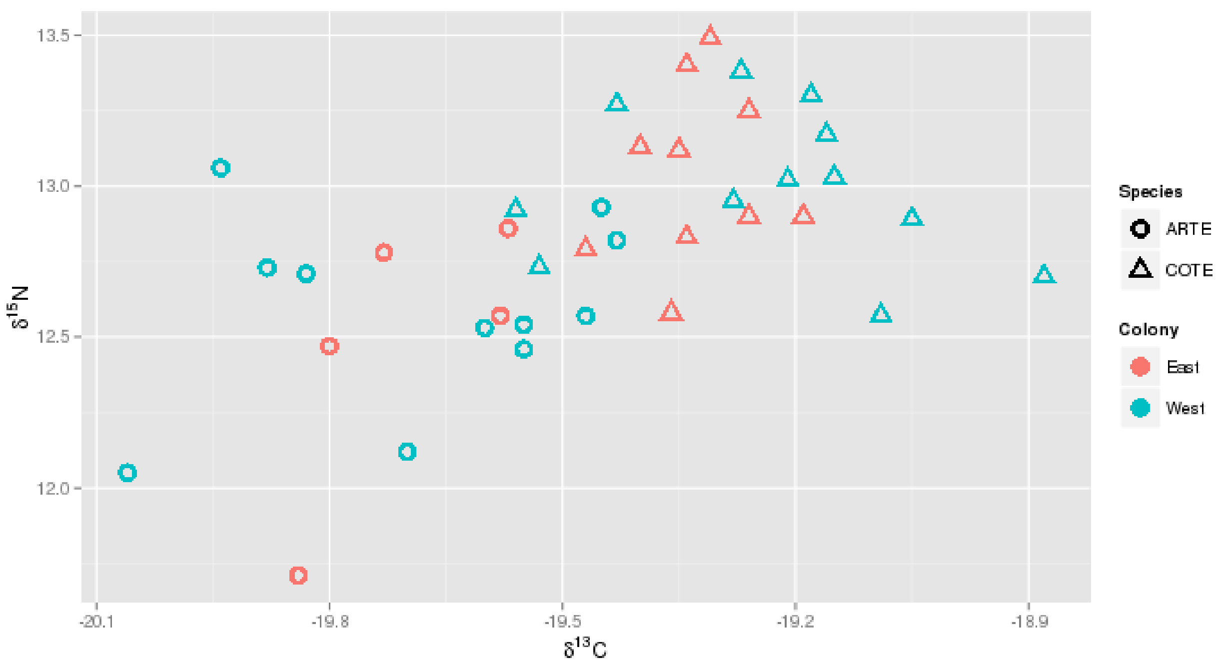


Figure 5.2-16 – Stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope values from blood samples of Common Terns (COTE) and Arctic Terns (ARTE) collected from two colonies on Sable Island: East Light (East) and Main Station (West) colonies. δ^{15}N values represent relative trophic level and δ^{13}C are related to dietary source.

Post-breeding dispersal – 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, we compared timing of departure between Sable Island and other colonies in Nova Scotia and Maine (Figure 5.2-17; partner projects using VHF telemetry systems). For two Nova Scotia colonies, timing of departure (last detection at colony) was similar for Arctic Terns (25-July ± 15.0 d on Sable Island and 24-July ± 15.7 d on Country Island), different for Common Terns (18-July ± 19.1 d on Sable Island and 09-July ± 13.4 d on Country Island). At Petit Manan Island, Maine, departure dates were similar between species (16-July ± 12.5 d for Common Terns and 20-July ± 12.5 d for Arctic terns), but differed from Nova Scotia colonies (Fig. 5.2-17). Colony specific departure dates may reflect local food availability and post-breeding staging behaviour (e.g. Common Terns on Sable Island, see above). The timing of departure from Sable Island marks a period after which we would no longer expect bird-platform interactions to occur.

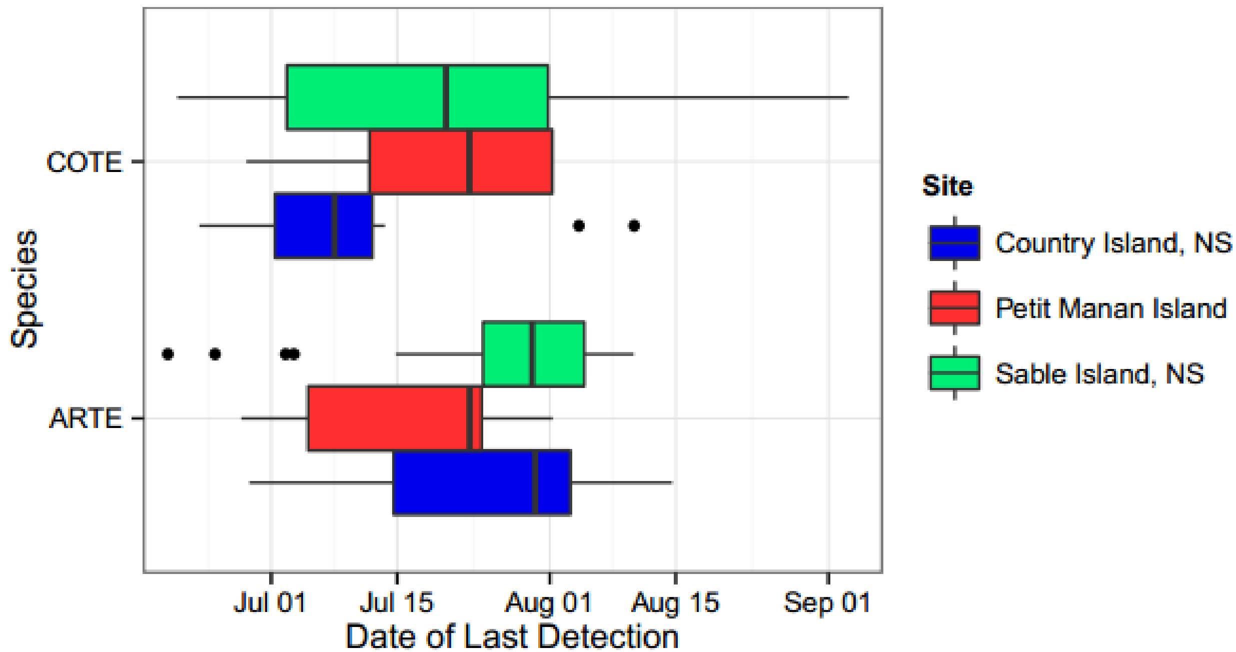


Figure 5.2-17 – Date of last detection at the breeding colony of tagged Common and Arctic Terns during the 2013 field season nesting on Country Island , two colonies on Sable Island, and Petit Manan Island. Boxplots show means (vertical bars), boxes extend to the first and third quartiles (the 25th and 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. Common Terns from Sable Island, Country Island, and Petit Manan Island were detected during the post-breeding season by coastal towers upwards of 850 km away from their original nesting sites (Figure 5.2-18). Ten of thirty-five (29%) 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 5.2-19). Data from an additional tagging site on Petit Manan Island presented a 47% (7/15) detection rate of tagged individuals at Cape Cod during the post-breeding season for up to 3 weeks (Figure 5.2-19). 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 5.2-17) and detections of Sable Island terns staging in the Cape Cod in early August (Figure 5.2-19) indicates a period after which tern interactions with offshore vessels and platforms are less likely to occur.

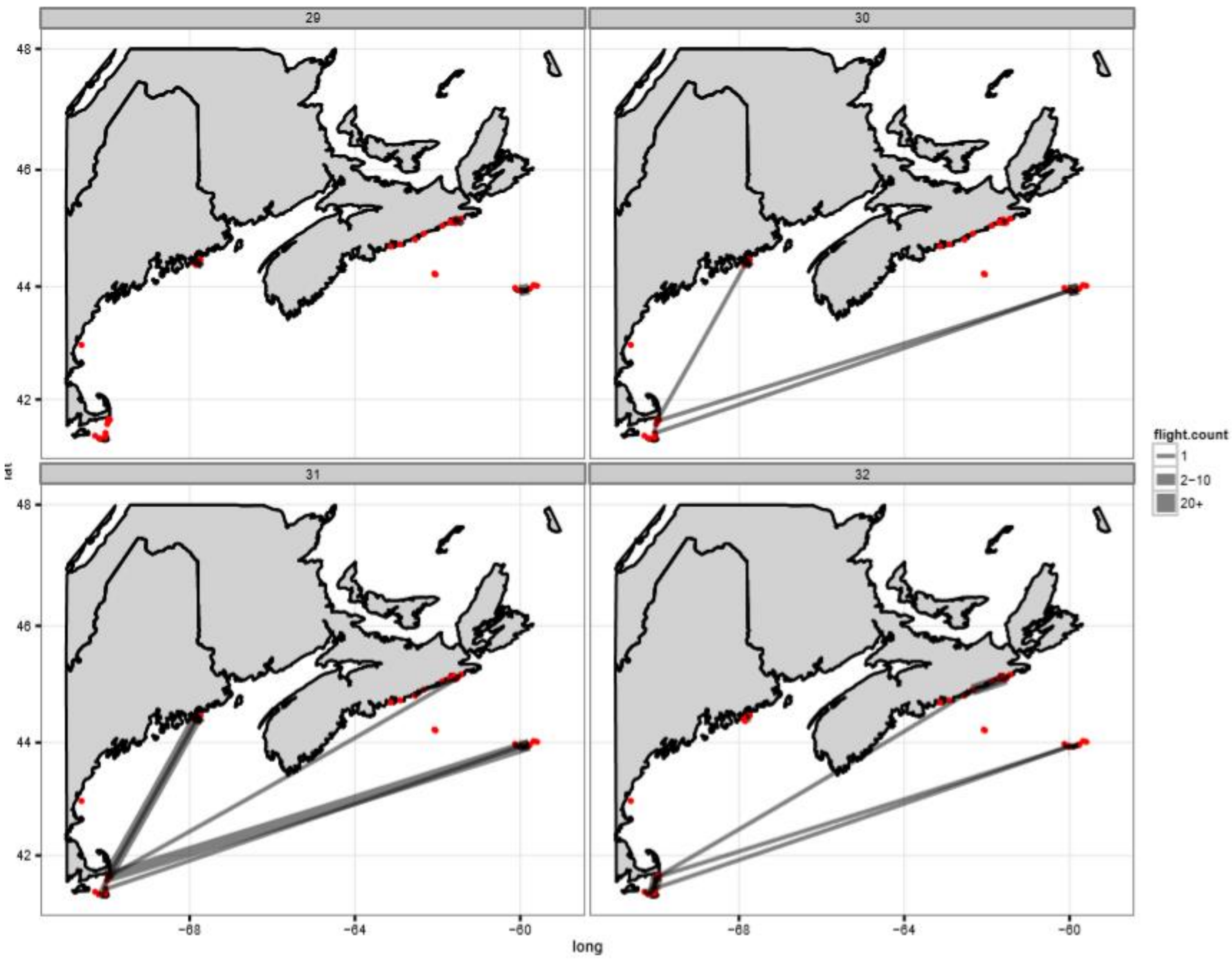


Figure 5.2-18 – Long range detections of Common Terns tagged on Sable Island, NS, Country Island, NS and Petit Manan Island, Maine from late July to mid August, 2013 divided into weekly intervals: 14-20 July (29th calendar week), 21-27 July (30th), 28 July- 3 August (31st) and 4-10 August (32nd); depicting migration movements during the post breeding season.

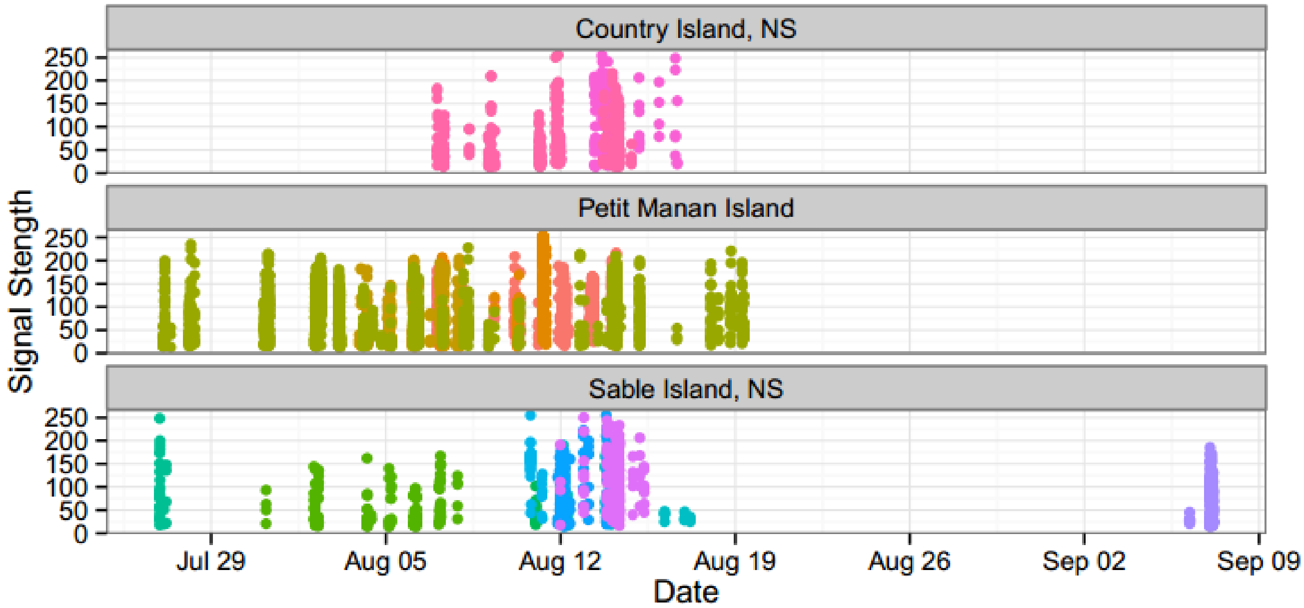


Figure 5.2-19 – Detection of Common Terns at Cape Cod, MA, between 29 July and 9 September 2013; tagged on Country Island, NS, Sable Island, NS and Petit Manan Island, ME; colour depicts unique tag IDs.

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. Below we also describe non-significant effects of GLS tags on petrel fledging success, which suggest that there are limited effects of the smaller VHF tags that were attached using similar methods.

Data on foraging trip and colony visit duration were assessed for Bon Portage Island in each year, and Country Island in 2011 and 2013 and comparisons were made using analysis of variance tests (ANOVA). Changes of receivers and antenna configuration on Country Island in 2012 resulted in poor colony attendance data and we were unable to calculate trip parameters in that year. 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 days) than during chick rearing (~1.5 days 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 days but some were as long as 7 days, 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 available due to technical problems with the receiver). 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 5.2-20). 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. For Country Island our inference of directional data and platform overlap was limited by the use of only two directional antennas in 2011. Data from 2012 and 2013 were not analyzed for directionality.

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, no petrels from Bon Portage and 1 of 20 tagged storm-petrels (5%) from Country Island was detected from a supply vessel (the Atlantic Condor) during the second week in July. This single encounter included only four consecutive tag bursts suggesting a very short interaction or, more likely, a bird passing by the area. This encounter occurred during 1 of 4 foraging trips recorded by that individual from Country Island.

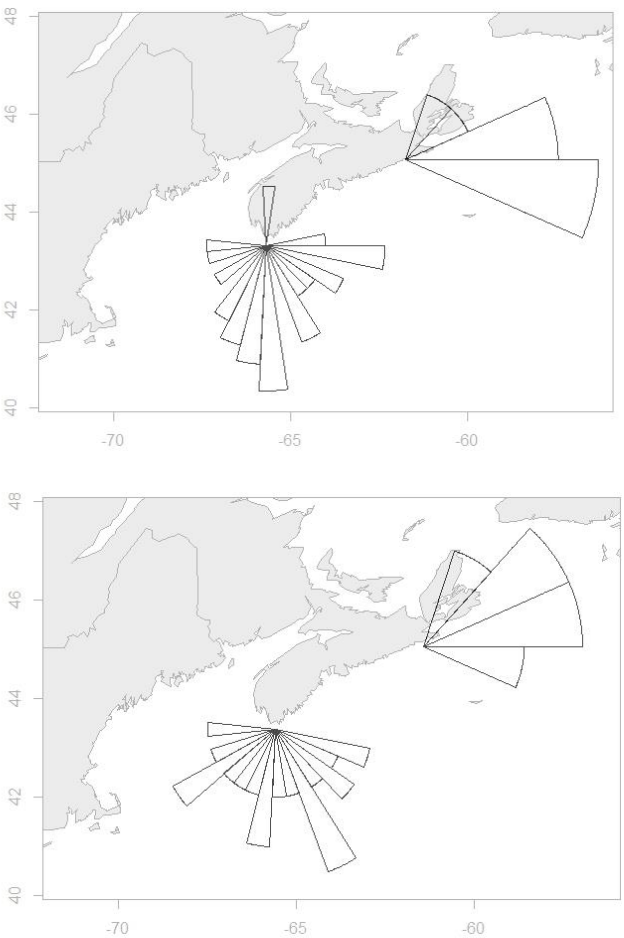


Figure 5.2-20 – Departure (left panel) and arrival (right panel) directions of Leach's Storm-petrels from colonies at Bon Portage Island (2011/2012) and Country Island (2011). Directional data were not determined for other years. Movements were inferred from VHF telemetry and an array of directional 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) during the breeding season. 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 twice-daily location estimates and eliminate spurious locations typical of GLS tracking data. Additional details can be found in Pollet et al. (2014).

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 5.2-21).

Combining all data from both sites over two years, and additional data from a third colony from another study on the eastern shore in 2013 (Bird Island, NS; 44.864ºN, 62.290ºW), there was a total of 1347 offshore locations and 114 foraging trips recorded with GLS tags. These data showed strong differences between colonies in the proportion of overlap (locations within 10 km) with offshore platforms around Sable Island (Table. 5.2-10). Birds tracked from Bon Portage showed no overlap but birds from Country and Bird Islands showed approximately 1% of locations occurred within 10 km of offshore platforms, and 9 to 11% of trips passed within this distance of a platform. Therefore, birds from the north eastern coast of Nova Scotia are more likely to transit across the platform area during the foraging trips to deep offshore waters beyond (Figure 5.2-14). The proportion of trips overlapping with the platform area may be underestimated since these calculations are based on tracks with only 2 locations daily (noon and midnight) and not interpolated between locations.

Country Island supports an estimated 8700 breeding pairs of Leach's Storm-petrels (Pollet et al. 2014) which incubate eggs for ~45 d and rear chicks over a period of ~65 d each year (Huntington et al. 1996). Given an average rotation period of about 4-5 days during incubation (Tables 5.2-8 and 5.2-9) and average foraging trip length of about 3 days during chick rearing (Table 5.2-8) we might expect each individual bird to make about 5 trips during incubation and about 21 trips during chick rearing. Thus, for the colony, this may total approximately 450,000 foraging trips each year, approximately 40,000 of which (9% Table 5.2-10) may pass by the platforms around Sable Island. Alternatively, if we use the VHF detection rates of petrels from offshore supply vessels (5% of individuals, and 25% of trips for that individual; see above), 450,000 foraging trips from the Country Island would equate to at least 5,625 trips transiting through the platform area. Extrapolating for the VHF detection data likely underestimates the total number of birds transiting through the platform area because of a) incomplete spatial and temporal coverage of VHF monitoring near platforms (due to the movement of vessels between platforms), and b) detection range of VHF is only ~200 m, compared to the 10 km radius used to estimate GLS overlap.

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

Table 5.2-10 – Proportion of offshore locations and trips for Leach's Storm-petrels which occurred (locations) or transited (trips) within 10 km of offshore platforms surrounding Sable Island. Data are from 1347 locations and 114 foraging trips obtained by GLS tags during 2012 (Bon Portage and Country Islands) and 2013 (all sites).

	sample size (n)		Overlap within 10 km of platforms	
Colony	**locations**	**trips**	**% of locations**	**% of trips**
Bon Portage Island	586	54	0	0
Bird Islands	364	27	1.1%	11.1%
Country Island	397	33	1.0%	9.1%

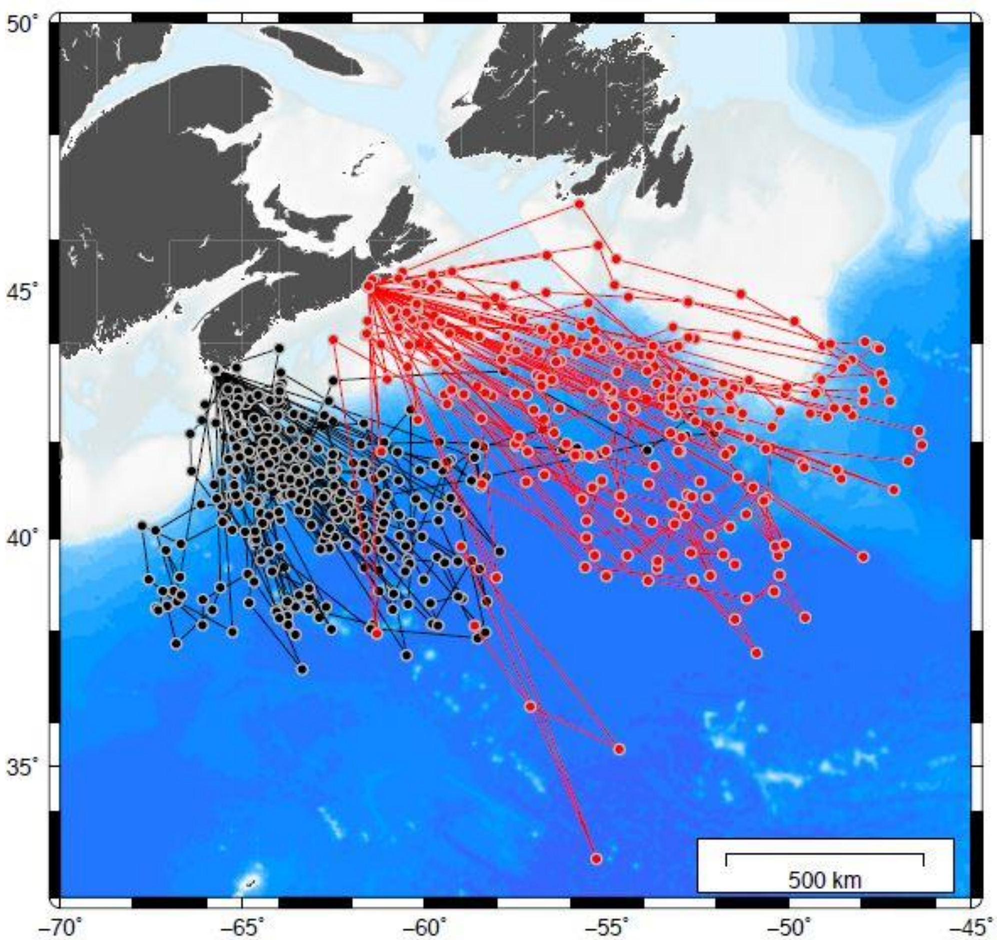


Figure 5.2-21 – Foraging ranges of Leach's Storm-petrels obtained from geolocation tags deployed during incubation period 2012 and 2013 at Bon Portage Island (n = 19 birds, black dots) and Country Island (n = 16, red dots). A State Space Model (SSM) was used to provide estimates of twice daily locations. Figure from Pollet et al. (2014)

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.

***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. Excluding departure flights, juveniles were detected making frequent nocturnal flights past both East Light (20/33 individuals) and West Spit (20/33 individuals) (Figure 5.2-22), no adults were detected outside of West Light, and no birds were detected at East Spit. Timing of flights between locations differed, juveniles were detected at West Spit before East Light, and detections at East Light almost completely stopped in the 6 days prior to migration departure. Conversely, detections at West Spit increased in the 10 days prior to migration. This suggests that juveniles make increasingly farther exploratory flights as their flight muscles develop and focus their movements in a westward direction as departure date approaches. Nocturnal timing of exploratory flights suggests birds are learning celestial cues and developing a homing target for return to Sable Island the following year. Low movement of adults suggests they continue feeding the young of their final clutches and moult within the same area before sudden departures for the mainland.

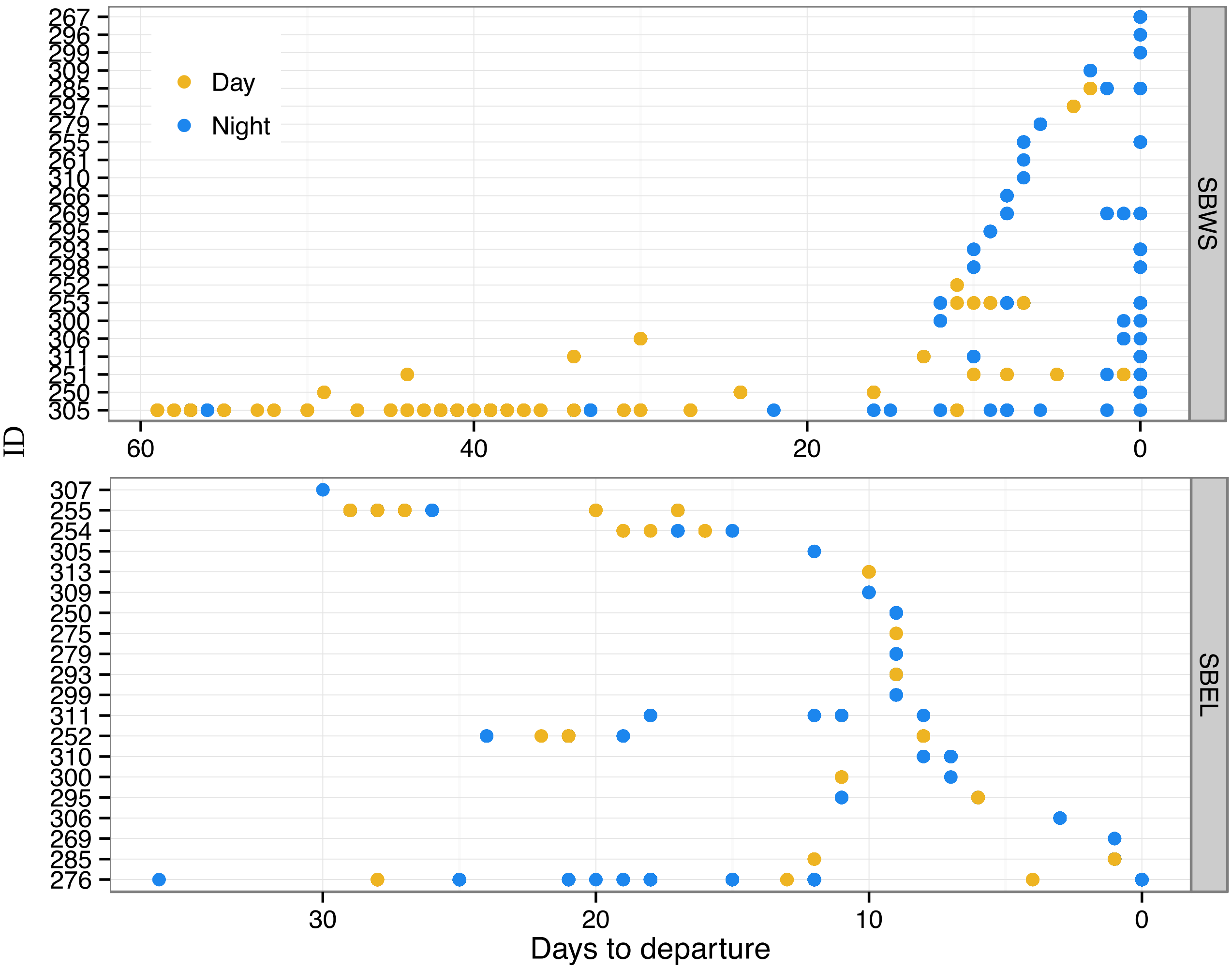


Figure 5.2-22 – Detections of individual juvenile Ipswich Sparrows at West Spit (SBWS) and East Light (SBEL) in the top and bottom panels respectively. Each point represents a detection of an individual relative to the number of days prior to its departure (yellow = daylight detections, blue = nocturnal detections), detections on day 0 being departure dates. Birds were detected at West Spit earlier than East Light, but detections were focused at East Light up until approximately 10 days prior to migration, at which point detections were focused at West Spit.

***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 juvenile birds arrived on the mainland earlier than adult birds. Apart from 1 juvenile sparrow that was first detected on the mainland on November 23rd, juveniles (14) first appeared on the mainland between 20 September and 30 October 2012, whereas adult birds (4 female, 3 male) appeared between 17 October and 13 November (apart from one which was detected 15 September). 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 Ipswich Sparrows 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 5.2-23). There is also a marked difference in migration timing between adult and juvenile Ipswich Sparrows (Figure 5.2-24). 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. While most birds arrived by mid-October, it is important to note that they were all juveniles, thus this peak in migration is due to age differences in migration timing, and activities impacting migration should take the whole migratory period into account.

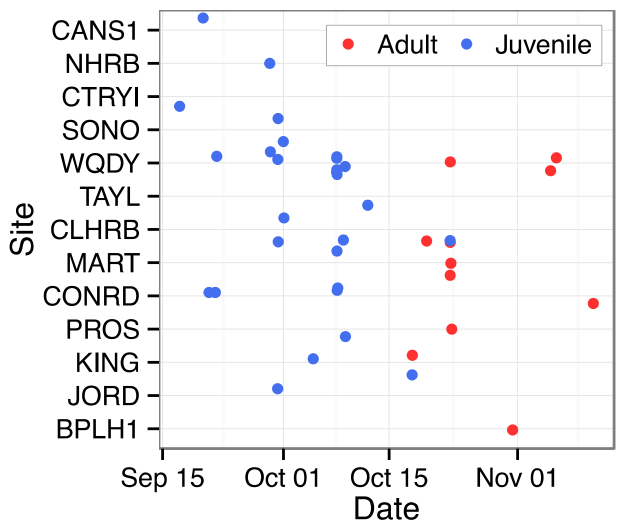


Figure 5.2-23 – Date and location (site) of first detection on the mainland for individual Ipswich Sparrows during fall migration in 2013. The 13 sites along the east and south shores of Nova Scotia are ordered longitudinally from north-east to south-west (top to bottom). Adults (red) initiate migration a month later than the first juveniles (blue) appear. See Appendix Table 3 for full list of site names.

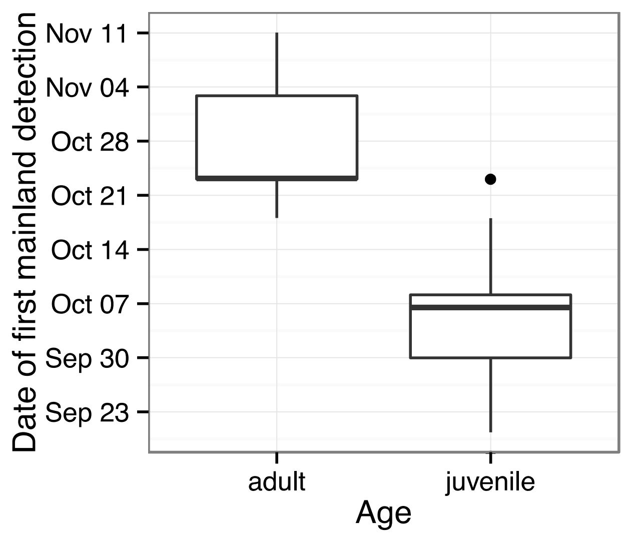


Figure 5.2-24 – Date of first detection on the mainland for adult (n = 11) and juvenile (n = 28) Ipswich Sparrows during the fall 2013 migration. Horizontal line represents the mean date, boxes show 25th and 75th percentiles, whiskers show 1.5 times the inter-quartile range, and dot shows outlier.

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 which also arrived on Sable occurred between 16 April and 7 May (Figure 5.2-25). However since Ipswich 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.

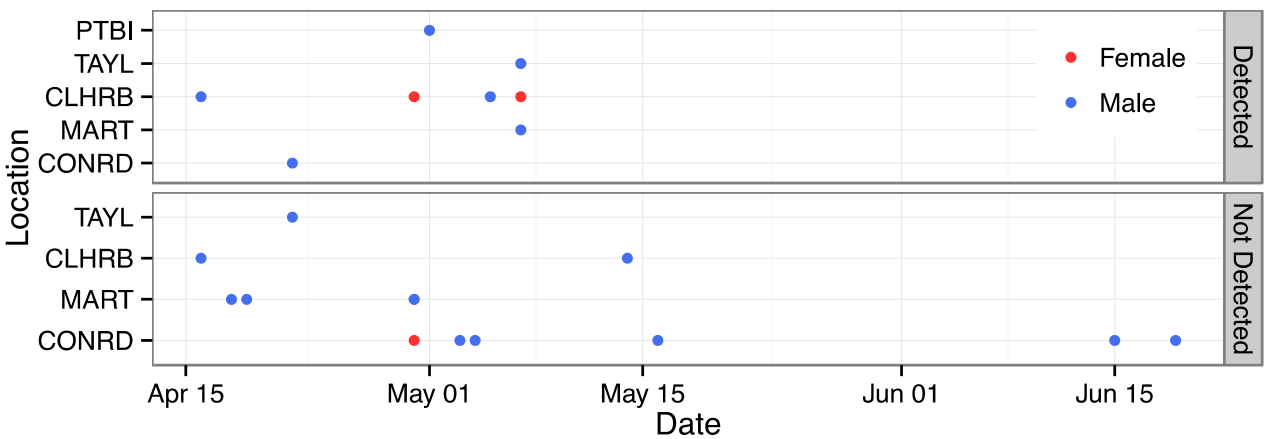


Figure 5.2-25 – Date and location of last mainland detection of male (blue), and female (red) Ipswich Sparrows in spring 2013. Sites ordered top to bottom from northeast to southwest along the Eastern Shore of Nova Scotia: Port Bickerton (PRBI), Taylor's Head (TAYL), Clam Harbour (CLHRB), Martinique beach (MART), and Conrad's Beach (CONRD). The top panel are individuals that were detected on Sable Island, the bottom panel are birds that were not.

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. Possible 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, d) birds passed between receiver stations during migrations across Nova Scotia, or e) tag loss or failure. We have some evidence of possible tag loss (below), but the coastal movements and high rates of detection at multiple Nova Scotia sites suggests that birds do not pass through Nova Scotia undetected (below). However, we did detect a small number of birds remaining on Sable through to December, and some adults appear to take more direct routes to the US coast (below), which may account for some undetected migrants. Thus, mainland detections present a minimum percentage of successful migrations.

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 5.2-11). In both years the majority of these detections were of juveniles, 15/23 in 2012 and 28/39 in 2013. In 2013, fate of five non-migratory birds (7.8% of tags from that year) was determined by continued receiver monitoring on Sable Island until January 2014: 2 adults were alive in January, 2 adults either died or lost their tags on Sable Island prior to migration, and 1 juvenile was briefly detected in January who either died, suffered tag loss, or was alive and overwintering on the island. Thus, the fate of the remaining 20 tags (31% in 2013) is unknown but may include adults migrating directly to the US east coast (below), mortality during over-water migration, or tag loss/failure.

Table 5.2-11 – Total number of tagged birds and tagged birds that were detected on 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 detected on Mainland	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 5.2-12). 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 5.2-12 - 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 – unk. sex							1	**1**
Total	**4**	**10**	**3**	**0**	**0**	**2**	**4**	**23**

In the less patchy 2013 data, time of day of migration initiation could be examined for birds for whom we had "direct flights". That is, birds that were detected on the mainland within 10 hours of final Sable Island detections. The majority of both adults and juveniles with direct over water flights initiated overwater migration within 2 hours after sunset (Figure 5.2-26). Birds that successfully reached the mainland but did not have "direct flights" can be explained; they likely reached the mainland out of range of a receiver site and did not continue southward migration until the following night.

Adults and juveniles appear to differ in their route choice, with adults displaying a more direct southerly route than juveniles (Figure 5.2-27). 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 5.2-12) 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 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.

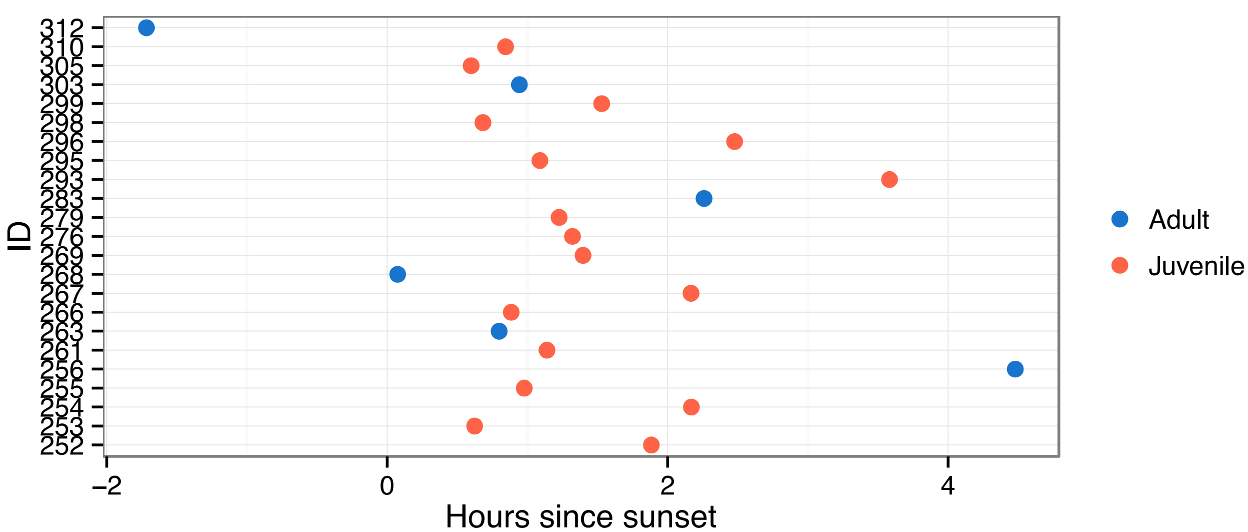
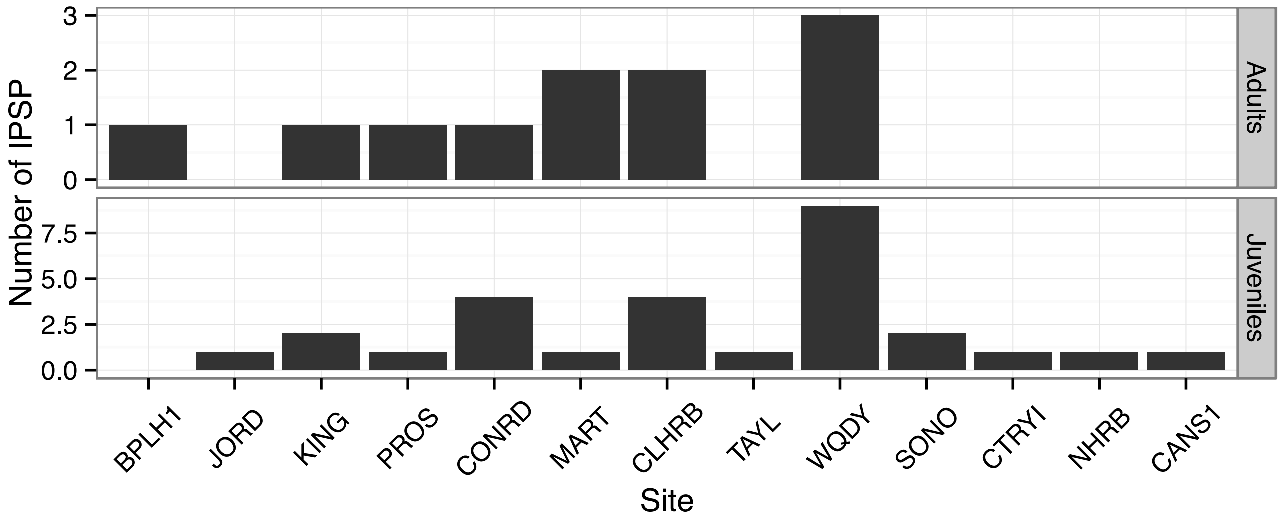


Figure 5.2-26 – Time of last detection on Sable Island for individuals (n=23) that were detected on the mainland within 10 hours of departure from Sable Island, indicating true and direct migratory flights off island. Time of detection is measured as hours since sunset of adult (blue) and juvenile (red) Ipswich Sparrows.



F*igure 5.2-27 – 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).*

During the spring migration period, tag fate and success of migration can be determined with more confidence since all birds were tagged within range of a mainland receiver (at Conrad's Beach) and the destination (Sable Island) was monitored continuously by automated towers and searched in its entirety by manual VHF tracking during May and June. Therefore, possible reasons for not detecting arrival dates on Sable Island include the following: a) some birds remained on the mainland to nest (though very few cases have been documented and we saw no evidence of residency at any of our mainland sites), b) birds died on the mainland prior to migration, c) mortality during the overwater portion of their migration, or d) tag loss or failure.

In spring 2013, 10 of 21 VHF tagged sparrows successfully migrated to Sable Island (Table 5.2-13). 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). The fate of 3 of the 11 remaining individuals was known: 2 were likely depredated at Conrad's beach as indicated by signal patterns and detections through to mid-June (Fig. 5.2-25), and 1 was detected from an offshore supply vessels (details below in section *Detections from vessels*) indicating a likely mortality. The remaining 8 birds (38%) showed last date and locations of detection similar to successful migrants; their fate is unknown but possibility a result of additional mortality along the Nova Scotia coast or during their over-water flight, or tag loss/failure.

Overwater migration of successful migrants with "direct flights" (see above) was initiated within 2 hours after sunset (Figure 5.2-28), 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 5.2-29), or the surrounding sites resulting in a south-east (110°)

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 5.2-13 – 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%

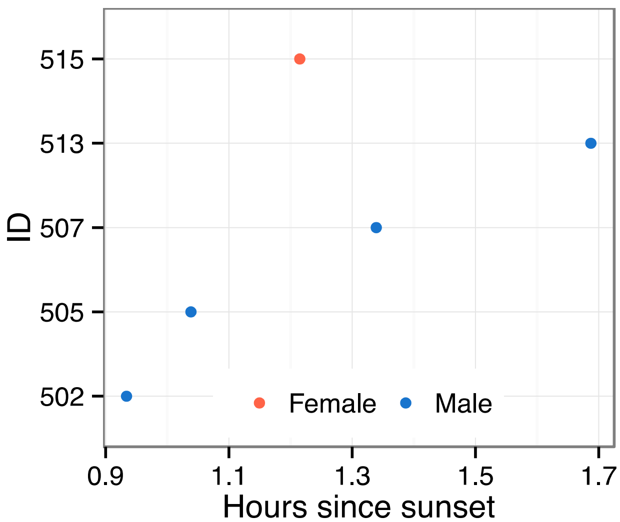


Figure 5.2-28 – Time of last detection on mainland NS for individuals (n=5) that were detected on Sable Island within 10 hours, indicating true and direct migratory flights. Time of detection is measured as hours since sunset of male (blue) and female (red) Ipswich Sparrows.

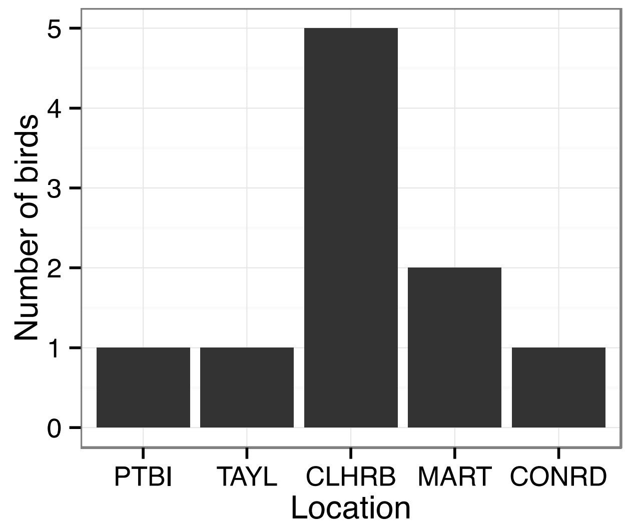


Figure 5.2-29 – Location of last mainland detection during spring 2013 migration. Sites: Conrad's Beach (CONRD), Martinique Beach (MART), Clam Harbour (CLHRB), Taylor's Head (TAYL), Port Bickerton (PTBI).

Detections and movements 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. 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. 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 were flybys and all of these occurred at night. The 5 instances of non-flybys detections during the day were sustained over periods longer than a bird flying past the receiver and had relatively even signal strength, indicating the bird was likely resting or refueling in the area. A clear distinction between flybys (Figure 5.2-30) and sustained detections (Figure 5.2-31) is apparent based on patterns of tag detections. Consecutive detections over a short period (<10 minutes) with increasing and then decreasing signal strength indicate a bird quickly approaching the receiver and continuing past it. Alternately, sustained detections occur over a longer period (> 10 minutes), with no clear peak in detections, likely as a bird is resting, or foraging along the ground in a small area. All locations along the Atlantic coast of Nova Scotia detected at least one Ipswich Sparrow, the majority of which were detected at multiple sites often within the same night (Figure 5.2-32).

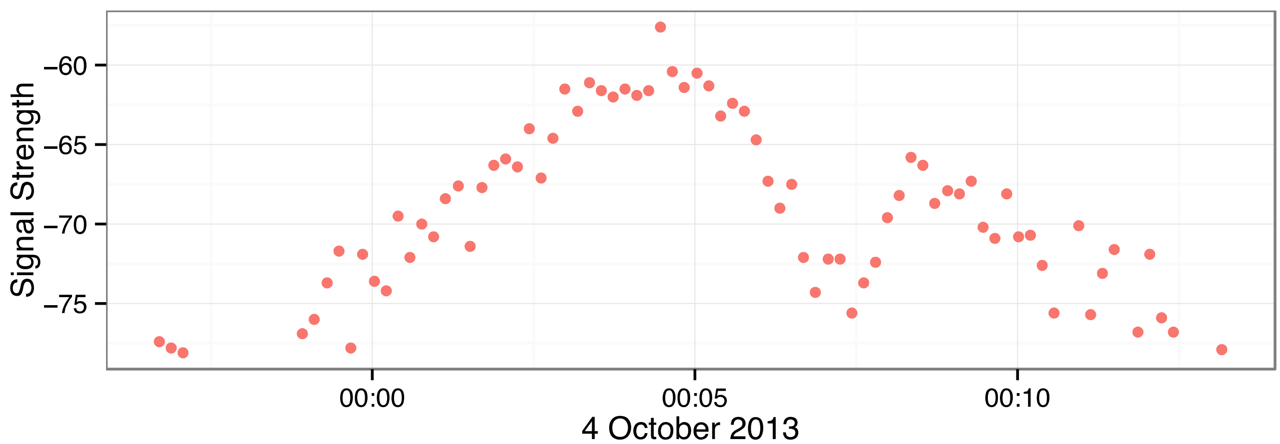


Figure 5.2-30 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#295) passing by a receiver station located at Conrad's Beach (CONRD) (antenna orientation of 53°). Signal strength is a measure of the relative strength of the VHF signal detected and higher strength indicates closer proximity to the receiver station/antenna. Each point represents one detection.

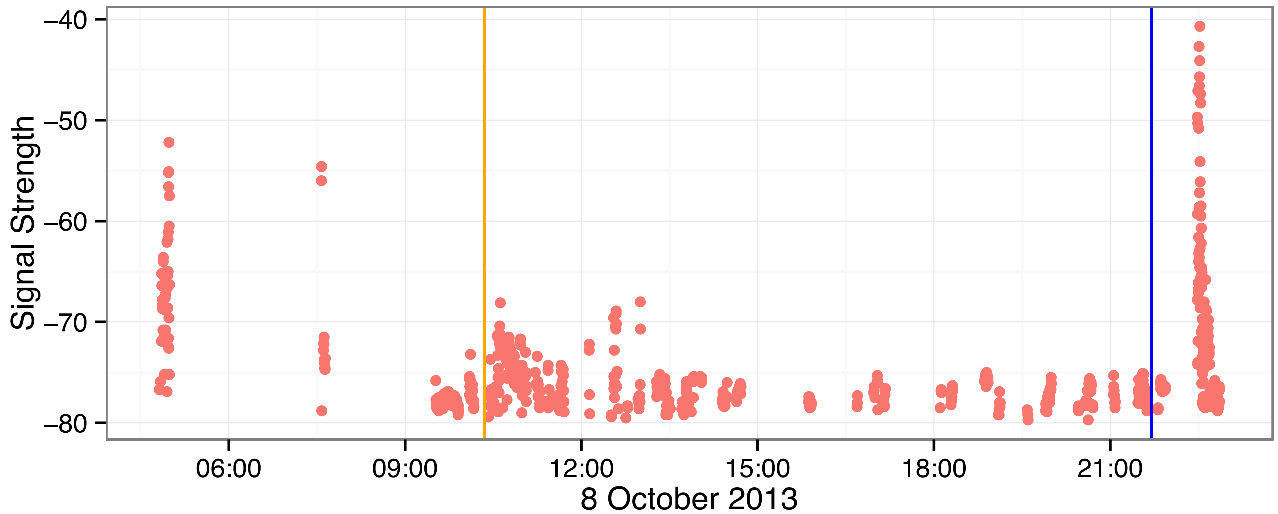


Figure 5.2-31 – Example of sustained detections from an Ipswich Sparrow (tag ID#255) detected at Conrad's Beach. The bird arrived at Conrad's Beach prior to sunrise (yellow line) and was detected at low levels throughout the day before departing after sunset (blue line), departure flight is evident by spike in signal strength as the bird flew up and was more easily detected, and then flew past the tower to continue southward nocturnal migration.

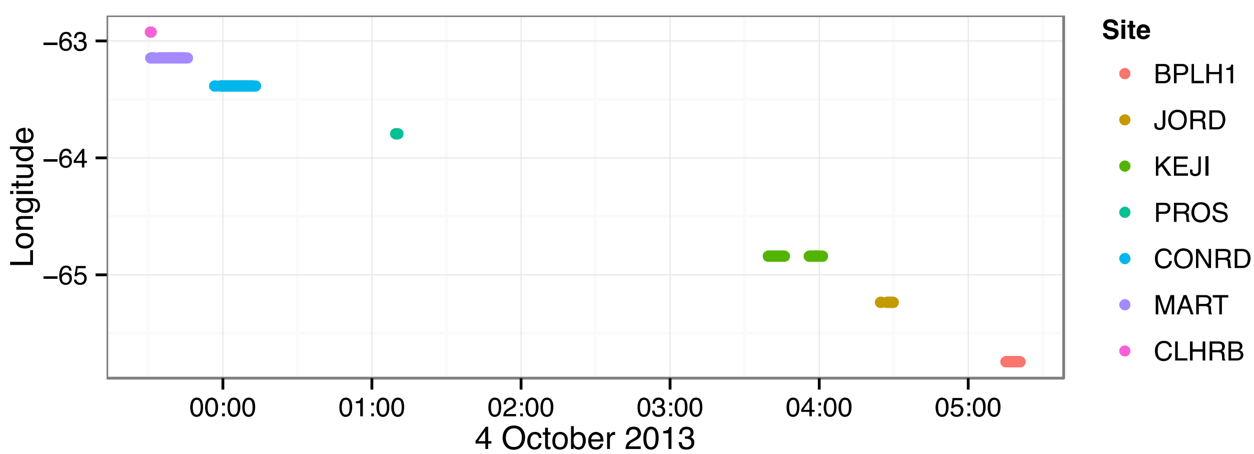


Figure 5.2-32 – Example of VHF tag detections from an Ipswich Sparrow (tag ID#295) detected at multiple receiver stations in a single night, detections are displayed by longitude over time. The sparrow was first detected at Clam Harbour (CLHRB) at 23:09 and was detected at 5 other sites in the next ~5.5 h until reaching Bon Portage Island (BPLH1) which was its final detection for the night. The bird was subsequently detected in Maine 4 days later.

From detections along the Atlantic coast of Nova Scotia and into Maine and Massachusetts, there is indication that adult and juvenile Ipswich Sparrows may be taking different routes Figure 5.2-33). Adults are initially detected farther south in Nova Scotia and continue to move along the coast towards Bon Portage Island (the most southerly receiver station in Nova Scotia) at which point they cross the Gulf of Maine towards Cape Cod, Massachusetts. Juvenile Ipswich Sparrows on the other hand are initially detected farther North than adults, and while some continue along the Atlantic coast towards Bon Portage, others are not detected past Conrad's Beach (mid-province). The former group appears to make a shorter overwater crossing of the Gulf of Maine, arriving in mid-Northern Maine, while the latter group is detected in Northern Maine and could have arrived via land or by crossing the Bay of Fundy. This is further evidence of adults and juveniles displaying different migration strategies.

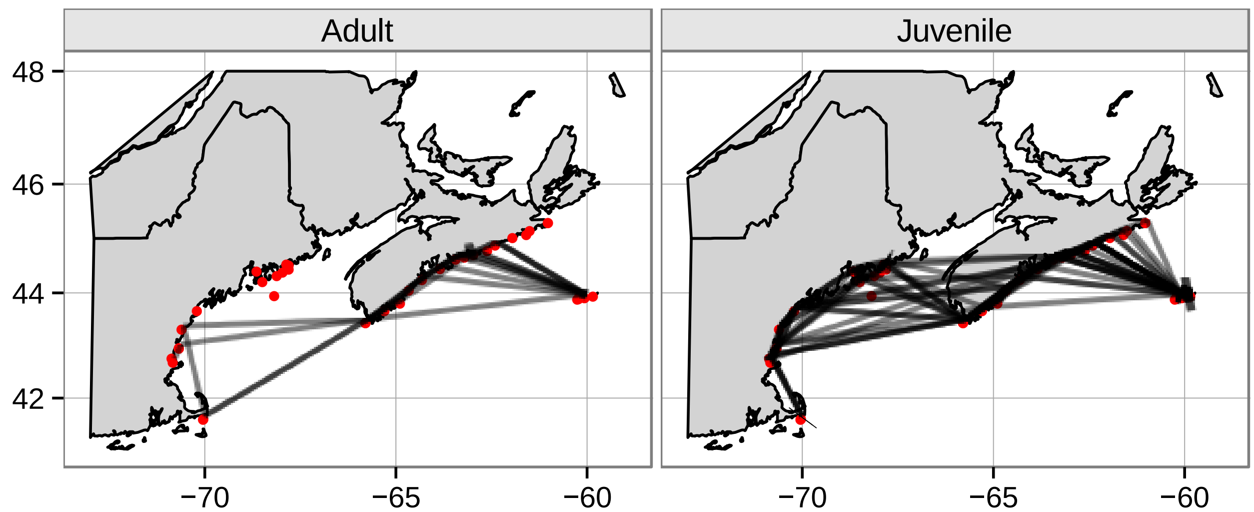


Figure5.2-33 – Map of individual Ipswich Sparrow detections. Lines connect consecutive detections at different sites for each individual, darker lines represent multiple birds taking the same route.

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 Ipswich Sparrow.

Detections from vessels – Receivers on the supply vessels were operational during most of the period during which Ipswich migration was expected and observed to occur, with the exception of three periods. 1) High amounts of VHF noise on the Panuke Sea which would have limited detections in October and November of 2012 in the vicinity of SOEP platforms. 2) The late deployment of the receiver on the Panuke Sea on 08 July 2013 missed the spring migration period for this vessel at the SOEP platforms. 3) In autumn of 2013, Venture Sea was away from the study area between 03-Sep to 08-Oct (35 d) and the Ryan Leet receiver failed from 27-Sep to 13-Nov (47 d). Nonetheless, at least one vessel with an operation receiver was near to each of the Deep Panuke and SOEP platforms during the spring and fall Ipswich migration periods. See also Table 5.1-2 with a summary of seasonal effort which was very low in April when some Ipswich migrations occurred.

During fall 2012 there were no confirmed detections of Ipswich Sparrows from supply vessels.

During the fall of 2013, a single juvenile Ipswich Sparrow was detected by supply vessels (Figure 5.2-34). 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 detections, therefore, all detection events were short in duration of less than 2 minutes. This individual was detected 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 (above). This individual departed Sable on 7 October.

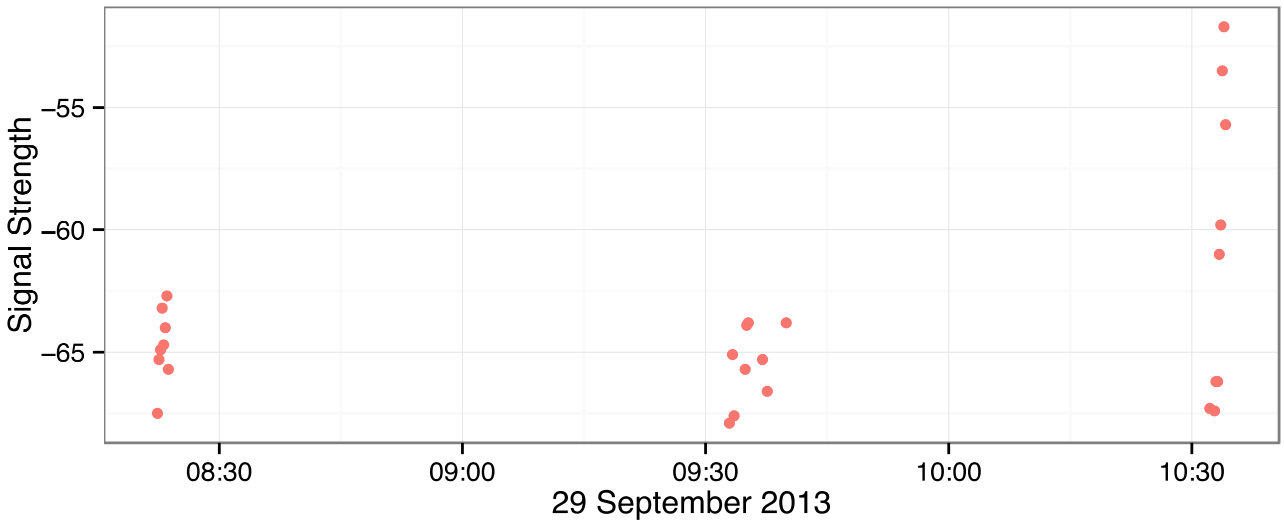


Figure 5.2-34 – Ipswich Sparrow 269 detected on 3 occasions on 29 September on the PSEA vessel. Signals strength indicates the bird did not reach the vessel but likely flew over the water within proximity.

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 5.2-35), 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 5.2-36). 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.

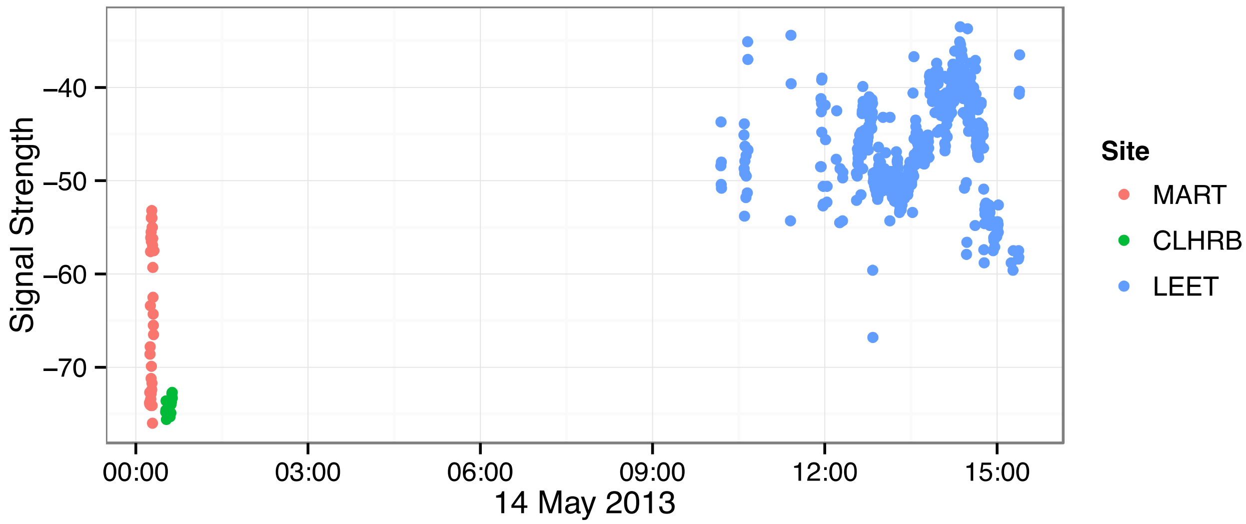


Figure 5.2-35– Ipswich Sparrow 501 detections on 14 May 2013, signal strength indicates the bird departed from Martinique Beach (MART), flew past Clam Harbour (CLHRB), and was detected almost continuously for 5.5 hours on the Ryan Leet vessel (LEET) and was not detected again.

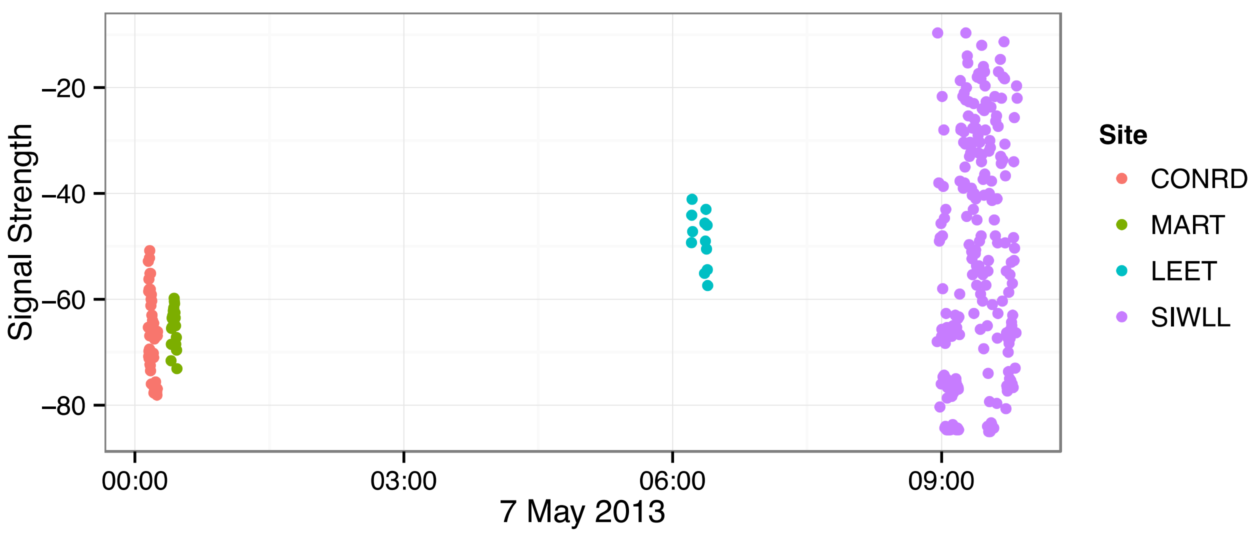


Figure 5.2-36 – Ipswich Sparrow 505 detections on 7 May 2013, signal strength indicates the bird departed from Conrad's Beach (CONRD), flew past Martinique Beach (MART) and Clam Harbour (CLHRB) and was detected for 14 minutes at approximately 6:00 UTC flying past the Ryan Leet vessel (LEET). Approximately 3 hours later it arrived on the West end of Sable Island and was detected at Sable Island West Light (SIWLL).

5.2.5 Blackpoll Warbler

In 2012 we recorded departure flights from 61% (35/57) of Blackpoll Warblers tagged at 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 5.2-37), 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.

In 2013 we detected 86% (43/50) of Blackpoll Warblers tagged at Canso Peninsula at other locations along the coast and into the Gulf of Maine (Figure 5.2-38). The last point of detection (a possible surrogate for departure time) ranged across the extremes of the study area, from Canso to Cape Cod (Figure 5.2-38). Last times of detection ranged from 19 September through 26 October, with more of the later detections occurring at the more westerly sites (e.g. in the Gulf of Maine). There is no evidence from these data of any concentration of departure location.

Several individuals were detected at towers in the Canso area, then subsequently in the upper Gulf of Maine and then again in Nova Scotia, prior to (presumably) departing on their trans-oceanic voyage. Others were detected at multiple towers up and down the coast of Nova Scotia. There were no detections of Blackpoll Warblers on Sable Island receivers or offshore vessels, suggesting that these individuals were not interacting with the platform area.

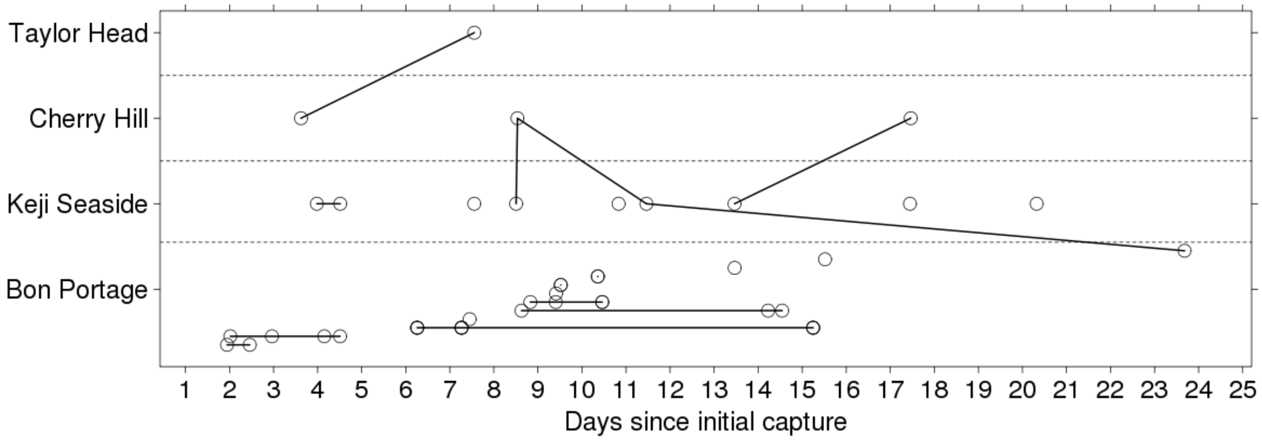


*Figure 5.2-37 - Summary of coastal detections for Blackpoll Warblers tagged on Bon Portage Island in 2012 (*n *= 19). Individuals detected flying by Bon Portage Island one or more days after their initial departure from the island are included. Each point represents a detection event and solid lines 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. There were no detections of Blackpoll Warbler from vessels in 2013.

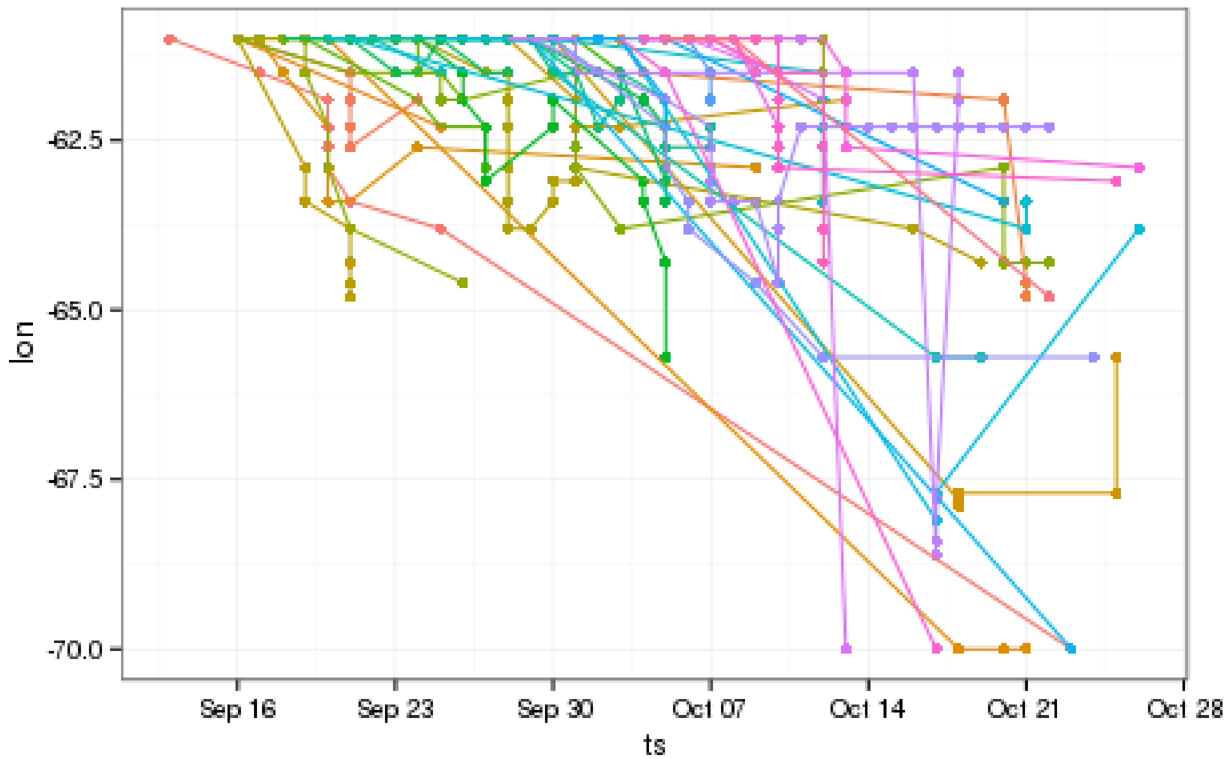


*Figure 5.2-38 - Summary of detections for Blackpoll Warblers tagged at Canso Peninsula in 2013 (*n *= 50). Detections from all other sites along the coast of Nova Scotia and around the Gulf of Maine are indicated by their longitude. Canso is at the top (furthest east) and Main sites are at the bottom (furthest west). Each point represents a detection event and solid lines connect detections of the same individual. Colours depict separate individuals.*

5.3 Platform observations

5.3.1 Sea Watch

Ten sea watch observation periods were conducted from the Deep Panuke PFC between May 1-6, 2014, totaling 8 h of observations. During this time 352 seabirds were observed in waters around the platform (birds in flight and on the water; Table 5.3-1). These were primarily Herring Gulls (89% of individuals), Northern Gannets (8%) and less than 1% for each of Double Crested Cormorant, Dovekie, Great Black-backed Gull, Northern Fulmar and Iceland Gull. Numbers of birds were highly variable among days and watch periods within days (Table 5.3-1) illustrating the stochastic nature of at-sea surveys.

Table 5.3-1 Summary of birds counted during "sea watch" observation periods using continuous scan-sampling. DCCO=Double-crested Cormorant, DOVE=Dovekie, GBBG=Great Black-backed Gull, HERG=Herring Gull, ICGU=Iceland Gull, NOFU=Northern Fulmar, NOGA=Northern Gannet.

				Count of Birds (by species)									
Watch ID	**Date**	**Time (UTC)**	**Duration (min)**	**DCCO**	**DOVE**	**GBBG**	**HERG**	**ICGU**	**NOFU**	**NOGA**	**Total**	**% of total**	**birds / hr**
3	1-May	18:16	60				3				**3**	0.9	3
6	2-May	13:00	60				1				**1**	0.3	1
8	2-May	18:55	60				1			2	**3**	0.9	3
12	3-May	17:30	60				19		2	12	**33**	9.4	33
15	4-May	14:06	60				241	1		2	**244**	69.3	244
17	4-May	18:25	60				9	1		1	**11**	3.1	11
20	5-May	14:00	30				34			1	**35**	9.9	70
22	5-May	19:45	30	1	1				1	4	**7**	2.0	14
25	6-May	14:30	30				6			4	**10**	2.8	20
27	6-May	19:55	30			1	1			3	**5**	1.4	10
			Total	**1**	**1**	**1**	**315**	**2**	**3**	**29**	**352**	100.0	44
			% of total	0.3	0.3	0.3	89.5	0.6	0.9	8.2	**100.0**		
			birds / hr	0.1	0.1	0.1	39.4	0.3	0.4	3.6	**44.0**		

5.3.2 Platform Census

From 19 censuses conducted on the Deep Panuke PFC between May 1-7, 2014, 21 live birds were observed aboard the platform, 3 of which were subsequently found dead (Table 5.3-2). Some of these observations were likely the same individual seen during multiple censuses (e.g. Dark-eyed Junco during three census periods). Most birds (57%) were seen during morning census periods, many of which were also observed during subsequent census periods mid-day or at dusk, indicating that early morning census may be the best time to search for live stranded birds.

Fourteen dead birds were found on the platform (Table 5.3-3): 10 were highly decomposed (probably mortalities from the previous year or over winter), 1 was desiccated but not severely decomposed (likely from migration this year), and 3 were fresh mortalities. Leach's storm-petrels were the most commonly found bird (6 of 14), most of which were oiled and trapped under grated walkway on one of the lower decks. The storm-petrels were decomposed and/or desiccated suggesting that they were mortalities from the previous fall or summer. A Savannah Sparrow found live on the morning of 3 May was later found dead in the evening of the same day; it weighed 14 g suggesting it was underweight and died of starvation or dehydration (normal weight of this species in Nova Scotia is mean 19.8 g [range 18.1-22.7] for males and 18.8 g [16.0-23.4] for females; Stobo & McLaren 1975). Two Gray Catbirds were found dead the same or subsequent day after being found alive; each weighed 22 to 23 g also suggesting they were underweight and died of starvation or dehydration (mean mass during migration: males 32.3 g [range 28.8–36.8], females 32.0 g [26.9–35.6]; mean mass during breeding: females 39.6 g [32.0–49.5], males 35.7 g [32.0–45.0]; Smith et al. 2011). One of the dead Gray Catbirds also had a small amount of oily residue on the tip of its tail.

Table 5.3-2 – Live birds found during 19 platform census searches on the Deep Panuke platform, 01 to 07 May, 2014. Three census were conducted each day at dawn (da), mid-day (md), and dusk (du). Shaded cells indicate census period when a bird of that species was later found dead (see also Table 5.3-3).

	1-May			**2-May**			**3-May**			**4-May**			**5-May**			**6-May**			**7-May**	
Species	**da**	**md**	**du**	**da**	**md**	**du**	**da**	**md**	**du**	**da**	**md**	**du**	**da**	**md**	**du**	**da**	**md**	**du**	**da**	**Total**
Dark-eyed Junco	1	1		1																3
Gray Catbird							1	1									1			3
Ipswich Sparrow	1																			1
Ruby-crowned Kinglet																1				1
Savannah Sparrow							2			1										3
White-throated Sparrow							1	1				1		1		1		2		7
Unknown sparrow sp.	1									1								1		3
Total	**3**	**1**	**0**	**1**	**0**	**0**	**4**	**2**	**0**	**2**	**0**	**1**	**0**	**1**	**0**	**2**	**1**	**3**	0	**21**

Table 5.3-3 – Dead birds found during 19 platform census searches on the Deep Panuke platform, 01 to 07 May, 2014.

Date	**Count**	**Species**	**Oiled**	**Status**	**Location**	**Comments**
1-May-14	1	Magnolia Warbler	N	desiccated	roof of acid gas house	adult male, breeding plumage, likely from this year
1-May-14	1	European Starling	N	desiccated & decomposed	roof of acid gas house	juvenile, likely from last year
3-May-14	1	Red-winged Blackbird	N	trapped, decomposed	essential generator deck	under walkway
3-May-14	1	Leach's Storm-petrel	N	wedged, desiccated	essential generator deck	wedged in bracket, likely from last fall
3-May-14	5	Leach's Storm-petrel	Y	trapped, decomposed	essential generator deck	under walkway, oily water, likely from last fall
3-May-14	1	Savannah sparrow	N	recent, intact	riser deck	weight 14g, bird seen alive during morning census
4-May-14	1	Gray Catbird	N	recent, intact	module 1, level 2	weight 22g, bird seen alive previous day
5-May-14	1	American Redstart	N	decomposed	module 5, level 3	very decomposed, likely from last year
5-May-14	1	unkn	unkn	inaccessible under walkway	main deck, under walkway	no access to confirm species, old carcass
6-May-14	1	Gray Catbird	Y	found live, later died	module 2, level 3	weight 23g, light oil on 2cm tips of tail

6. Discussion

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 directly addressed 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. 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 and observations

In this study, direct evidence of bird-platform interactions is derived from limited platform-based observations and extensive 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 interactions near offshore platforms for all study species. 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 gulls in 2012 (11% of tagged individuals), 14 gulls in 2013 (32%), 2 Ipswich Sparrows during 2013 spring migration (9.5%), 2 terns from Sable Island in 2013 (4%) and 1 Leach's Storm petrel from Country Island in 2013 (5%). No interaction events with other study species, seasons or years were observed. 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). In 2012, most receivers were not operational until mid to late August so there was no opportunity to monitor interactions with terns (most of which depart the area by mid-August) and limited opportunities to monitor storm-petrel and gull interactions. Receivers were fully functional to record potential bird-platform interaction events for Ipswich Sparrow and Blackpoll Warbler migration periods. Vessel-based receivers were fully functional in 2013 allowing a full record of interactions with vessels for all species during all seasons.

Gulls **–** Prior to this study, it was known that gulls showed seasonal interactions with offshore platforms and supply vessels around Sable Island. Gulls have been observed foraging and roosting around vessels and platforms, sometimes causing hazards for helicopter operations at remote un-manned platforms. This study provides better documentation of the species-specific seasonal, spatial, and daily patterns of interactions. Here we discuss these patterns of interaction which provide new insights into gull management options, should this be required to improve operational safety and efficiency.

Interactions do not appear to be characteristic of all Sable Island gulls and a higher proportion of Herring Gulls showed interactions with vessel and platforms than did Great Black-backed Gulls, a pattern which was consistent across all tagging techniques. Together the results suggest that from the breeding population on Sable Island, approximately 30-50% of Herring Gulls and 5-30% of Great Black-backed Gulls interact with platforms and/or supply vessels (also, see below species-specific differences in seasonal and diel patterns of interaction). These results also agree with dietary studies of Sable Island gulls (Ronconi et al. in press) showing that Great Black-backed Gulls scavenge more on seal carcasses and clams found on Sable's shorelines, while Herring Gulls have higher proportions of sand lance in their diet, a prey which can be captured at night under lights behind offshore supply vessels (Ronconi pers. obs.). VHF and satellite tracking data also show that within the subset of the population that attend platforms, certain individuals show much higher frequency and duration of interactions, suggesting specialization on platforms. Therefore, management of gulls directed towards individuals at platforms is likely to be more effective at reducing gull-platform interactions than management of the breeding population on Sable. Note, however, that all Herring Gull 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.

Seasonally, platform and vessel interactions were most common in July and August with fewer events recorded in September and October, a pattern that was consistent across years and tagging methods. This pattern was also generally consistent across species, but Great Black-backed Gull interactions occurred across a longer temporal window, from July through December. The timing of these interactions coincides with chick rearing (mid-June through early August for this population; Lock 1973) and post-breeding periods, suggesting that platforms may provide important food sources for rearing young and for foraging prior to migration. The cessation of Herring Gull interactions after October, and continuation of some Great Black-backed Gull interactions until December reflect species differences in migration strategies -- all tagged Herring Gulls in this study migrated south, whereas some Great Black-backed Gulls over-wintered on Sable Island.

Diel patterns of detections also reveal difference in interaction behaviour between species. While for both species, most interaction events occurred at night, the duration of Herring Gulls interactions were usually longer than Great Black-backed Gulls. Day-time sightings of wing-tagged birds indicate that gulls use platforms and vessels for roosting during the day, whereas sustained nocturnal VHF tag detections (with varying signal strengths) suggest that individuals are foraging behind vessels at night (from vessel based-observations gulls have been observed feeding on sand lance illuminated by vessel lights; Ronconi pers. observation). The satellite tracking data and short duration of Great Black-backed Gull interactions suggest that most platform interactions for this species are brief or in transit to other offshore foraging areas.

Spatially, patterns of gull interactions were similar among species but differed among platforms. Both VHF and satellite tracking data confirm that interaction events are primarily associated with the Deep Panuke and Thebaud platforms, and secondarily the Alma platform. Of the satellite tag locations obtained within 200 m of platforms, 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 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. Thebaud and Deep Panuke platforms are also the only two platforms with continuous presence of supply vessels, possibly contributing to the overall spatial patterns of interaction. This study clearly showed gull interactions with supply vessels (VHF data) and platforms (satellite tracking data), and fine-scale temporal analysis of gull movements between the two may reveal further details about the proximate mechanism of interaction which make the platform areas attractive to gulls.

***Leach's Storm-petrels* –** In 2013, 1 of 20 VHF tagged petrels from the Country Island colony was detected by a supply vessel near the Deep Panuke platform indicating that at least some of their foraging trips pass by the offshore platforms. Geolocation sensor (GLS) tags recovered from Leach's Storm-petrels at the three study colonies revealed that the foraging areas of Country Island and Bird Island petrels overlapped with the platform area during their > 2000 km round trip foraging excursions. While only about 1% of their offshore locations were within 10 km of platforms, approximately 10% of trips passed by the platforms in the Sable Island area on their way to more distant foraging grounds. For colonies of thousands of individuals making upwards of 20 foraging trips during the breeding season, this means that large numbers of petrels are likely to transit through the platform area, potentially subjecting them to risk. Seabirds may be attracted to offshore structures/vessels from as far away as 11 km (Bodey et al. 2014) and storm-petrels are particularly susceptible to attraction to structures at night (Wiese et al. 2001). While GLS tags confirm that petrels from the Eastern Shore of Nova Scotia transit through the platform area around Sable, the low precision and infrequent time-steps (only two locations daily) make it difficult to assess the precise timing at which birds transit through the platform area.

Six dead storm petrels were found on the Deep Panuke platform in May 2014, confirming that some individuals are attracted to and killed at platforms. The birds were desiccated and decomposed and had likely been stranded in the past year. These low numbers are in agreement with annual incidental reports of dead petrels found on platforms in Newfoundland (Baillie et al. 2005). However, there is uncertainty in the total estimates of seabird mortality (including storm-petrel) associated with offshore platforms in Atlantic Canada (Ellis et al. 2013). The stranded birds found on the Deep Panuke platform in May 2014 indicate that current monitoring and reporting of avian mortality on offshore platforms is missing birds, the detection probability of stranded and dead birds is unknown, and so total annual mortality is being underestimated. Though we have identified the likely source of storm-petrels to become stranded on Nova Scotia oil and gas platforms (i.e. colonies along the Eastern Shore), the population level effect of platform related mortalities is uncertain because of a) uncertainty related to platform mortality estimates, and b) uncertainty of total population size in this region. Surveys in 1998 estimated 50,000 breeding pairs of petrels nesting on Country Island which is above the global population threshold for this species to trigger an Important Bird Area designation at this site (http://www.ibacanada.ca/site.jsp?siteID=NS028), but recent surveys in 2012 estimated only 8,700 pairs (S. Wilhelm pers. comm. cited in Pollet et al. 2014). Reasons for population decline at Country Island are unknown. Moreover, population sizes of colonies on other parts of the Eastern Shore are unknown.

Bon Portage Island petrels also foraged on long-distance trips, capable of reaching the platforms around Sable, however, their trajectories were southward and, thus, not overlapping with platform areas. The risk of platform interactions for the Bon Portage Island colony is low.

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 9 km from Sable, and the Common Tern detection occurred post-breeding in August, more than 100 km from any platform or Sable Island. Neither of these detection events were for sustained periods. 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.

In the spring of 2013, 2 of 21 tagged individuals migrating from mainland Nova Scotia to Sable Island 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 Island, indicating that the individual successfully completed 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. In May of 2014, one Ipswich Sparrow and 13 other sparrows were observed on the Deep Panuke platforms indicating that temporary stop-overs and mortalities (one Savannah Sparrow) occur during the spring migration period. 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) of tagged Ipswich Sparrows 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 fates 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 were interested in the potential frequency, timing and duration of bird interactions with offshore platforms (Objectives 1 and 2), such information indicates when individuals may potentially interact with offshore platforms and vessels. Conversely, data on colony attendance indicates 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 of Herring Gulls 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 for the season in the second half of July. Mainland sightings of wing tagged Herring and Great Black-backed Gulls increased in August and early September, consistent with the VHF data. By November, wing-tagged Great Black-backed Gulls and Herring Gulls were seen in Maine and Massachusetts, respectively. 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 Herring and Great Black-backed Gulls typically arrive on the mainland sometime in August/September, though with considerable variation among individuals; and
c) Herring Gulls move further south for the winter than do Great Black-backed Gulls.

Moreover, winter-tagged Great Black-backed Gulls were not observed on Sable Island or offshore areas around Sable Island in the spring, summer or fall, suggesting that some wintering Great Black-backed Gulls on Sable do not breed there. Some VHF and satellite Great Black-backed Gulls tagged in spring 2013 were subsequently detected on Sable in December/January of 2013/2014, demonstrating that some summer breeders also return to the island in winter.

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 individuals are capable of 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 exceeded 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. 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. 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 overlap with the Sable area.

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. Stobo and McLaren (1975) reported 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. VHF data suggest that although juveniles arrive on the mainland at the more northerly sites, that they move southwest along the shore, and may accumulate at the Conrad's & Martinique Beach areas. However, the proximity of these places to the Halifax area may have biased perceptions on bird densities (Stobo and McLaren 1975) since more people are looking for birds in this region. In contrast to the juveniles, the first detections of adult Ipswich Sparrows on the mainland typically occurred from Conrad's Beach and areas south-west, 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 westerly and south-westerly, 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.

During spring migration, most departures of successful migrants occurred between 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 fact that two migrants were detected by vessels, suggests a potential 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 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.

In 2013, none of the 50 individual Blackpoll Warblers tagged at Glasgow Head (Canso Peninsula) were detected by Sable Island or supply vessel receivers. Many individuals were detected moving south-west along the coastline of Nova Scotia, 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.

7. Relative Risk and Recommendations

In consideration of the above results and discussion, the following summarizes the relative risk from platform interactions for each species (or species group), and recommendations for future analysis, research, and management. This assessment is based on the results measured in this study, plus applicable information from other studies. Therefore, we are only able to quantify risk related to offshore platforms and supply vessels in this study area, though some of the identified risks may also be applicable to other marine user groups in Atlantic Canada, such as cruise ships, container vessels, fishing vessels, etc. Comparison of relative risk to birds among these various marine activities is not feasible but should be considered in the interpretation of results and recommendations. See also Calvert et al. (2013) for information on other sources of avian mortality in Canada where current evidence suggests that mortality associated with offshore oil and gas production is low in comparisons with other sources of avian mortality in Canada.

Also, see recommendations 1 and 2 of Section 8.4 regarding continued use of VHF receivers for research and monitoring of bird-platform interactions.

7.1 Risk assessment matrix

This risk assessment is based on a methodology adapted from Encana's Environmental, Health and Safety Risk Matrix. The three step process is described here.

Step 1
- **Impact Evaluation**
- Critical - Serious - Moderate - Minor

Step 2
- **Probability Estimation**
- Frequent - Likely - Unlikely - Remote

Step 3
- **Determine Risk Level**
- Impact × Probability = Risk
- Risk levels: Extreme - High - Medium - Low

Important Caveats – Encana's Risk Matrix was developed to assess risks associated with Environment, Health and Safety, but not to assess impacts and risks related specifically to wildlife populations. The evaluation criteria had to be slightly modified for this exercise. The purpose of the resulting risk levels is to rank the relative risk from platform interactions for each species and prioritize follow-up activities. Steps 4 and 5 from the Encana Risk Matrix (Risk Level Check and Take Action) are not applicable in that context. An alternate approach, being implemented internationally, is the use of Open Standards (Miradi Adaptive Management Software for Conservation Projects; www.miradi.org) developed by Conservation Measures Partnership, a consortium of conservation NGOs (www.conservationmeasures.org). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Environment Canada use these measures in some aspects of their assessments and management planning. Full implementation of this approach was beyond the scope of this project. Other wildlife risk assessment approaches may also be applicable, but were not researched as part of this project. Quantifiable risk assessment should also take into consideration population level impacts (i.e. what proportion or geographic extent of the population is impacted). Our study was not designed to specifically assess population level impacts, though we discuss potential population level impacts where relevant data is available.

Step 1 – Impact Evaluation. Columns 1 and 2 are taken directly from the Encana risk matrix but modified by removing criteria that are not relevant to avian interactions (e.g. groundwater impacts). The evaluation matrix provides few criteria specifically related to "wildlife" impacts, therefore, we have added a column with examples of what might be considered impacts to wildlife at each of the levels. SARA = Species At Risk Act

Impact Level	Environment	Examples
4 – Critical	• Severe long-term environmental damage • Wide-spread impacts to sensitive environments, wildlife and/or major water bodies	• Population level impact [a] on any species • Mortality of 10 or more [b] individuals of an Endangered or Threatened species (SARA Schedule 1 species)
3 – Serious	• Severe short-term environmental damage • Significant off lease/site surface impacts	• Mortality of 10 or more [b] individuals of a species of Special Concern, or of 1 or more Endangered or Threatened species (SARA Schedule 1 species)
2 – Moderate	• Moderate environmental damage • Localized off lease/site surface impacts	• Mortality of 10 or more [b] individuals of any species or of 1 or more species of Special Concern (SARA Schedule 1 species) • Disturbance or interactions with migratory or resident wildlife
1 – Minor	• Minor environmental damage • Localized on lease/site surface impacts	• Mortality of < 10 individuals of any species • No mortality, disturbance, or interactions

a – Assessment of population level impacts are beyond the scope of this project, however, population level impact considerations have been included to provide some context in this risk assessment when relevant data was available (see "Caveats" above in this section).

b – A mortality threshold of 10 individuals (during a single event or day) was selected since this is currently used as the criteria by Environment Canada and the Canada Nova Scotia Offshore Petroleum Board, which would require carcass collection and incident investigation.

Step 2 – Probability Estimation. Taken directly from the Encana risk matrix.

Probability Level	Description	Likelihood
D - Frequent	Event is expected to occur in most circumstances	One of more occurrences per year
C - Likely	Event will probably occur at some time based on current practices	One occurrence every 1 – 5 years
B – Unlikely	Event should occur at some time based on current practices	One occurrence every 5 – 20 years
A - Remote	Event could occur at some time based on current practices	Once in the life of the facility

Step 3 – Determine Risk Level. Taken directly from the Encana risk matrix where Impact × Probability = Risk Level.

Risk Level	Low	Medium	High	Extreme

4 – Critical	Medium	High	Extreme	Extreme
3 - Serious	Medium	Medium	High	Extreme
2 - Moderate	Low	Low	Medium	High
1 - Minor	Low	Low	Low	Medium
	A – Remote	B – Unlikely	C – Likely	D – Frequently

7.2 Risk assessment of platform interactions by species

Gulls – Medium Risk (minor impact, frequent probability)

Summary of interactions:

- Herring and Great Black-backed Gulls show high probability of interaction with offshore platforms and vessels around Sable Island.
- Interactions are restricted seasonally to chick-rearing and post-breeding periods, and primarily associated with manned platforms attended by support vessels.
- High variability of rates of interactions among individuals suggests individual specialization in use of platform and/or supply vessel areas.
- Nocturnal interactions and observations from supply vessels suggest that platform and vessel lights may attract fish or large invertebrates, providing foraging opportunities that attract gulls to platform areas.

Population level impacts:

- Of the Sable Island population, approximately 30-50% of Herring Gulls and 5-30% of Great Black-backed Gulls interact with platforms and/or supply vessels.
- Interactions from other gull populations are unknown.
- Although probability of interaction is frequent, impacts are thought to be low because interactions do not cause mortality.
- Interactions may be beneficial to gulls by providing access to food and roosting sites, though the degree to which these interactions affect reproductive success, survival, or local population trends is unknown.
- Both species have shown population declines on Sable Island since surveys in 1969/1970, though the numbers of breeding gulls on Sable Island is small compared to mainland populations (Ronconi, in review)

Risk assessment

Species (group or population)	Impact	Probability	Risk	Comments
Herring Gulls (Sable Island)	Minor	Frequent	Medium	Expected impacts are low because interactions may be beneficial to local populations providing food or resting sites.
Great Black-backed Gulls (Sable Island)	Minor	Frequent	Medium	Expected impacts are low because interactions may be beneficial to local populations providing food or resting sites.

Recommendations for management and research

- The risk assessment matrix determined a "medium" risk for gulls, primarily due to the high frequency of interactions. However, because the interactions are not lethal, and may be beneficial, this matrix may not be applicable to assess the environmental risks posed to these species.
- In contrast, if we were assessing risk to the health and safety of workers and infrastructure, the impacts of gull interactions with offshore platforms may instead be "moderate" or "serious", thus resulting in a "high" or "extreme" risk rating. This risk quantification would require a separate assessment from the perspective of an Occupational Safety and Health team.
- Gulls roosting on platforms can cause fouling of equipment and sometimes cause risk to helicopter safety during landings. In some cases, platform operators may need or want to manage this risk.
- Efforts to manage gull interactions around platforms should focus on individual-level and site-specific management of gulls at platform areas rather than population-level management of the Sable Island colony**.**
- Mitigation strategies to reduce gull-platform and gull-vessel interactions would require further literature review, assessment of proximate mechanisms of attraction, and experimentation.

Terns – Low Risk (minor impact, unlikely probability)

Summary of interactions:

- Both Common and Arctic Terns are unlikely to forage as far away as the most distant platforms (Deep Panuke, Alma, and North Triumph).
- Nearshore platforms (Thebaud, Venture, and South Venture) are within tern foraging ranges, however, very few birds were detected in the vicinity of platforms and most birds likely forage around nearshore waters of Sable Island.
- The east and west spits of Sable Island are frequently used by breeding and post-breeding terns.
- Though some individuals show evidence of post-breeding staging behaviour on Sable, most terns show a rapid post-breeding dispersal from the island to Cape Cod (Common Terns) or other unidentified areas (Arctic Terns).

Population level impacts:

- The current population of terns on Sable Island is approximately as large as all terns breeding on mainland Nova Scotia (Ronconi, in review).
- Very low frequency of detection near platforms suggests low population level impact.

Risk assessment

Species (group or population)	Impact	Probability	Risk	Comments
Common Terns (Sable Island)	Minor	Unlikely	Low	Probability of high impact interactions (e.g. strandings or mortality) is unlikely based on current evidence of foraging activities.
Arctic Terns (Sable Island)	Minor	Unlikely	Low	Probability of high impact interactions (e.g. strandings or mortality) is unlikely based on current evidence of foraging activities.

Recommendations for management and research

- Efforts for tern conservation and management around Sable Island would be better directed towards monitoring and enhancement of the breeding colony rather than additional study of interactions with offshore platforms.
- Quantifying important foraging habitats for Sable Island terns could be enhanced by nearshore vessel surveys or tracking with miniaturized GPS tags.
- The east and west spits of the island appear to be important foraging and roosting habitat for terns during the breeding and post-breeding periods – additional study could investigate the significance of these sites relative of nearshore waters along the island

Leach's Storm-petrels – Low to High Risk (minor to moderate impact, unlikely [Bon Portage Island] to frequent [Country Island] probability)

Summary of interactions:

- Storm-petrels were the most frequent species found dead on the Deep Panuke platform during a site visit in early May, 2014 (less than 10 mortalities recorded but total annual mortality rate is unknown).
- For colonies in southern Nova Scotia, the likelihood of storm-petrel interactions with offshore platforms around Sable Island is low.
- For colonies along the eastern shore of Nova Scotia, key foraging areas show limited overlap with current platforms but a high proportion tracks transit through the platform area to distant foraging areas; the likelihood of interaction between these individuals and the platform area is high.
- Tracks from all study colonies overlap with existing and future offshore oil and gas exploration licenses (http://www.cnsopb.ns.ca/lands-management/search-licences).

Population level impacts:

- An estimated 8,700 pairs of Leach's Storm-petrels were breeding on Country Island in 2013 (Pollet et al. 2014), down from an estimated 50,000 pairs in 1998 (http://www.ibacanada.ca/site.jsp?siteID=NS028). 50,000 pairs are estimated to be breeding on Bon Portage Island (Oxley 1999). These are the two largest colonies known in Nova Scotia (though large number may also be present on Scaterie and St. Paul Islands). These colonies are considerably smaller than some of the largest colonies in Newfoundland (100,000's to 1,000,000's of pairs).
- A high proportion of the Country Island colony may transit through the current area of offshore platforms in Nova Scotia.
- For the Bon Portage Island colony, population level impact is unlikely. For the Country Island colony, and surrounding region of the Eastern Shore, population level impact of oil and gas related mortalities is uncertain (see discussion above) though likely greater than for Bon Portage Island.
- "Moderate" impact determined for Country Island / Eastern Shore populations due to a) greater likelihood of interaction than Bon Portage population, b) observed mortality and known live strandings on the platforms, c) uncertainty over industry-wide annual mortality estimates, and d) apparent population declines occurring in this region.

Risk assessment

Species (group or population)	Impact	Probability	Risk	Comments
Leach's Storm-petrels (Bon Portage Is.)	Minor	Unlikely	Low	Very low probability of overlap with existing oil and gas development in Nova Scotia.
Leach's Storm-petrels (Country Island)	Moderate	Frequent	High	Low annual mortality rate recorded but unknown total mortality. Population level effect uncertain. Impact contribution of offshore platforms versus other ocean users unknown.

Recommendations for management and research

- Systematic bird surveys should be implemented onboard offshore platforms and vessels to increase detection rate of stranded petrels and implement existing stranded bird rescue protocols.
- Assessment of storm-petrel risk to current and future offshore oil and gas development could be quantified by modeling offshore density distributions from existing tracking and at-sea survey data. Density distribution models can assess spatial and seasonal overlap with offshore oil and gas licenses.
- Population level effects could be quantified through larger sample sizes of tagged birds from other colonies along the Eastern Shore of Nova Scotia. Additional VHF telemetry studies would improve our understanding of the spatial and temporal overlap between petrels and platforms (e.g. precise nature, timing, and duration of interactions). Other technologies (miniaturized GPS, satellite VHF) will in future allow us to obtain more accurate trajectories and timing of transits across platform areas.

Ipswich Sparrow – Low to High Risk (unlikely probability and minor impact [fall migration]; frequent probability and moderate impact [spring migration])

Summary of interactions:

- For juveniles during fall migration, high detection rates along the eastern shore and north-easterly routes of over-water crossing suggest direct migration to coastal Nova Scotia and low risk of platform interaction.
- For adults during fall migration, lower rates of detection in coastal Nova Scotia and more westerly routes suggest migration towards the coastal USA and higher potential for transit across the Deep Panuke platform.
- For adults during spring migration, relatively high detection rates from platform supply vessels, low rates of successful crossings to Sable Island, and some observations of birds on platforms and supply vessels suggest high risk of platform interactions during this period. VHF equipment onboard the Deep Panuke platform was installed in 2014 therefore could not capture 2013 migration movements.
- Species has Special Concern status under the *Species at Risk Act* and nests almost exclusively on Sable Island.

Population level impacts:

- Current global population is estimated to be about 6000 mature individuals (COSEWIC 2009a).
- A low rate of spring migration success was observed from mainland Nova Scotia to Sable Island, with one likely mortality associated with an oil and gas supply vessel; the low sample size from this study period (21 individuals) increases the uncertainty around this estimate.
- Population level impact from current oil and gas platforms during fall migration is likely low, though causes for the low rates of migration success of adults is unknown.

Risk assessment

Species (group or population)	Impact	Probability	Risk	Comments
Ipswich Sparrow (spring migration)	Moderate	Frequent	High	Species status: special concern. Low proportion of migration success and evidence of platform interactions. Some evidence of mortality. Frequency of platform interactions unknown but likely one or more occurrence per year. Impact contribution of offshore platforms versus other ocean users is unknown.
Ipswich Sparrow (autumn migration)	Minor	Unlikely	Low	Adult migration route may cross some areas with offshore platforms. No evidence of mortality associated with oil and gas activities.

Recommendations for management and research

- To improve our understanding of the high risk during spring migration, and the spatial and temporal dynamics of sparrow-platform interactions, we recommend additional VHF spring tracking of Ipswich Sparrows from mainland Nova Scotia or from wintering areas in the coastal USA, using VHF receivers on supply vessels and the Deep Panuke platform (see Section 8.4 regarding additional offshore platforms and vessels).
- Additional study of adult sparrow during fall migration could help determine reasons for low detection rates on mainland Nova Scotia; these studies would clarify whether individual adults experience high mortality rates or depart on SW trajectories direct to overwintering areas.

Blackpoll Warbler – Low Risk (unlikely probability, moderate impact)

Summary of interactions:

- Tracking of birds from southern and north-eastern Nova Scotia showed high rates of landscape scale movements within the region prior to autumn migration.
- Some individuals initiate over-water migratory flights from Bon Portage Island, Nova Scotia, while others were last detected along the southern shore of Nova Scotia. Direct over-water migrations from these regions of Nova Scotia are unlikely to overlap with current offshore platforms in Nova Scotia.
- Previous occurrence of Blackpoll Warbler mortality events at platforms around Sable Island (CCWHC 2009) suggest that interactions occur, but may be rare, unpredictable, and difficult to quantify during a short-term study. Moreover, the origin of these birds is unknown.

Population level impacts:

- Total North American population estimate is approximately 60,000,000 with 40,000,000 in Canada (Partners in Flight Science Committee 2013). Population trends indicate possible moderate to large population declines (Partners in Flight Science Committee 2013).
- The largest known mortality event in the Nova Scotia oil and gas sector was ~40 individuals which is a very low population level impact, assuming that all mortality events are accurately documented.

Risk assessment

Species (group or population)	Impact	Probability	Risk	Comments
Blackpoll Warbler (Nova Scotia)	Moderate	Unlikely	Low	Large population, low frequency of mortality events, and low annual mortality.

Recommendations for management and research

- Tracking of populations further east (e.g. Newfoundland) would determine if over-water migratory routes from here are more likely to overlap with offshore platform areas and exploration licenses.
- The development of migration forecasting models based on regional weather patterns would allow better prediction of episodic bird-platform interactions.

8. 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 the VHF equipment was completed in April 2014.

8.1 VHF receiver

The VHF receiver was installed on the Deep Panuke platform in early April 2014. Two omni-directional antennas were mounted on the platform. One antenna mounted to the top of the platform on the instrument deck (above the accommodations unit) was intended to detect birds that would be flying in the airspace above the platform, while the other antenna was mounted to a railing next to the helicopter landing area, providing better coverage for detecting birds low to the water surface.

On 13 April 2014, a Herring Gull (tag ID 448; deployed on Sable Island in June 2013) was detected by both antennas for a brief period of time (Figure 7.1-1). This confirms the ability of the on-board receiver system to detect free-ranging birds.

Between 30 April and 07 May, an observer was aboard the platform and used activated tags to perform testing and optimization of the receiver system. Tag ID 492 was used on April 30 to confirm receiver functioning before and after the equipment software was updated. Prior to the update, the receiver was recording high quantities of pulse detections, especially from the upper antenna on the instrument deck (~10,000 pulses/min compared with ~150 pulses/min on the lower antenna). Receiver settings were modified to filter out this “noise” which reduced the incoming pulse detections by a factor of about 3 from ~10,000 to ~3,000 pulses/minute.

During three days, 03 May 2014 16:12 UTC until 05 May 2014 22:13 UTC, tag ID 500 was activated and carried around the platform by the observer during all platform census work (Section 5.3) to test the efficacy of the receiver system. Both antennas detected tag 500 almost continuously during all census work, indicating that the system can effectively detected VHF tagged birds virtually anywhere on the platform (Figure 7.1-2). Assuming that the brief detection of Herring Gull 488 was of a bird passing by the platform area, differences in signal strength between the free-ranging Herring Gull and the test tags (Figure 7.1-1) suggest that the receiver may also be able to distinguish between birds at sea and those on the platform. These tests confirm the feasibility of the VHF monitoring system for quantifying the frequency, timing, and duration of bird interactions with platforms equipped with SensorGnome receivers.

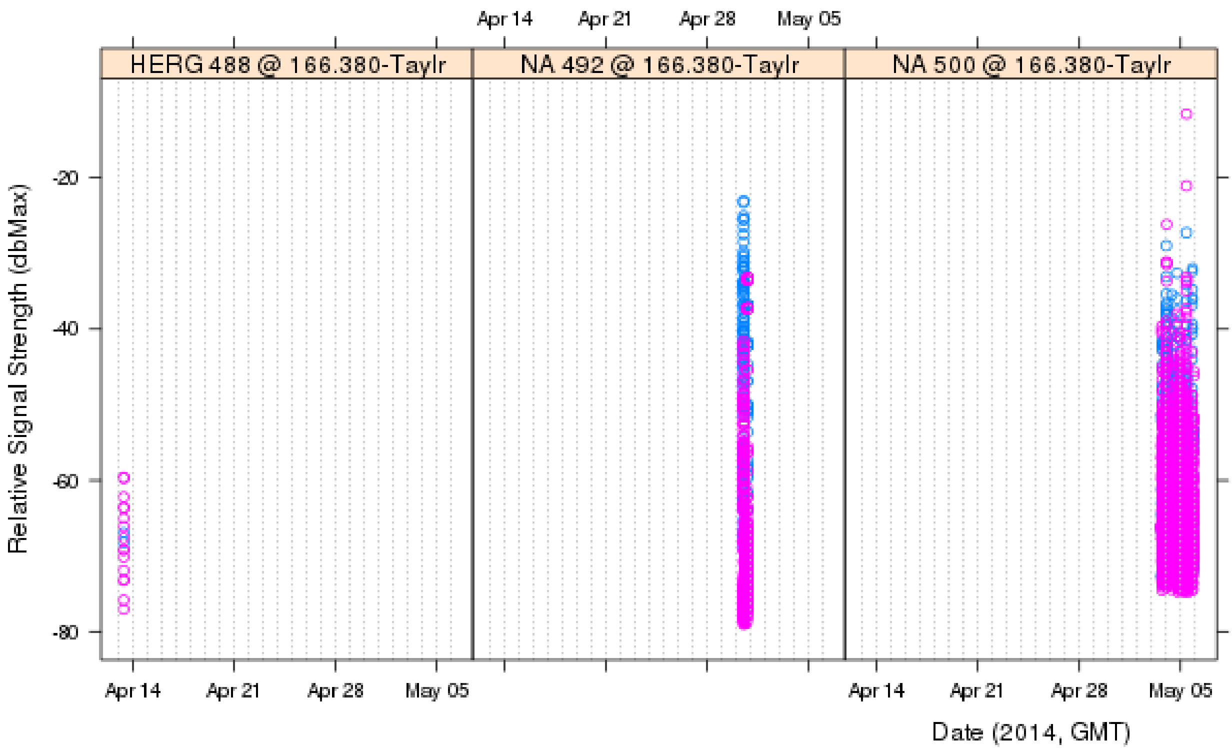


Figure 7.1-1 – Detections of VHF tags from the receiver deployed on the Deep Panuke platform, 12 April to 07 May, 2014. HERG 448 was a tag deployed on a Herring Gull in 2013. Tag IDs 492 and 500 were test tags brought to the platform for equipment testing between 30 April and 07 May. Dots represent tag pulse detections from the upper (blue) and lower (pink) antennas.

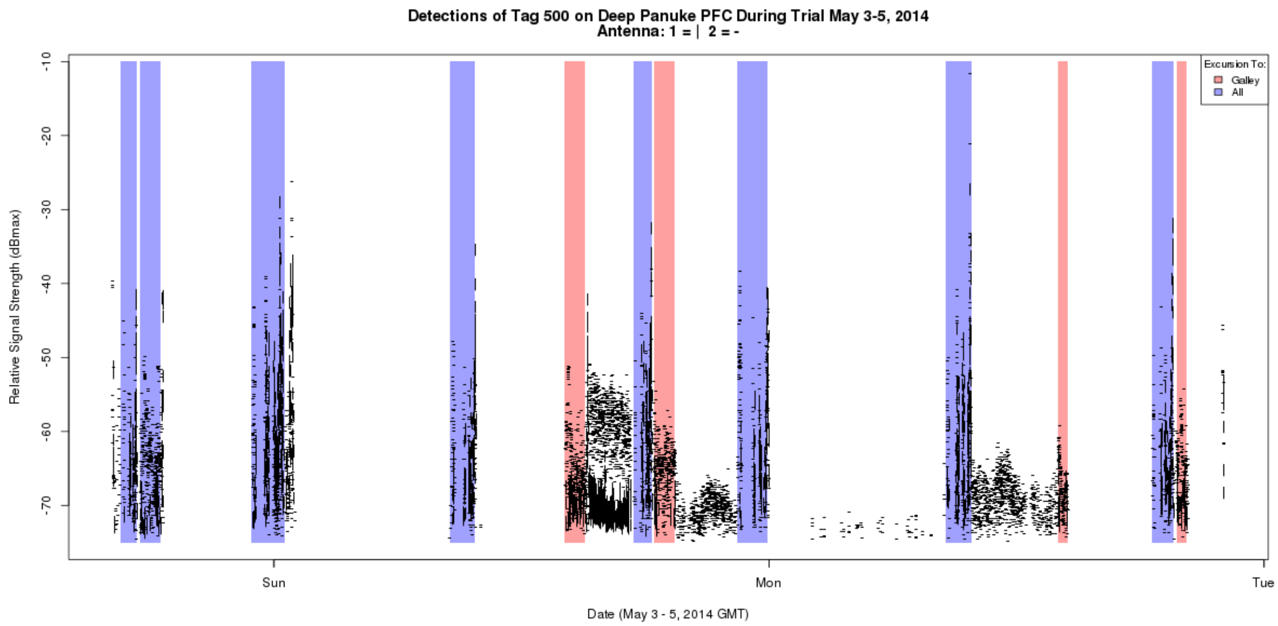


Figure 7.1-2 – Detections of VHF tag 500 used for testing receiver system on board the Deep Panuke platform, 03 to 05 May, 2014. Shaded sections indicate periods when tag was carried outside of the accommodations during full platform census when observer was walking around the platform (blue) and during sea watch census when observer was stationed at the landing near the galley (pink). During other periods the tag was "indoors" in the accommodations unit and was sometimes still detected by the outdoor antennas.

8.2 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 set-backs that precluded 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.

8.2.1 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.

8.2.2 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, the most important being inability to test various digitizing options on an equivalent system on-shore. Tapping the existing digital feed (i.e. NavNet) on the S-band surveillance radars would require commercial licensing of this proprietary data format, which was beyond the scope of the project. Also, the radar signature of a bird is likely to more closely resemble clutter that is typically filtered out, than a large moving target such as a ship, for which the surveillance radars are optimized. Therefore, custom digitization of the raw radar video signal was deemed necessary (and is standard practice for bird radar work). However, we were unable to test any of our digitization options (Rutter Sigma S6 radar processing card; Russell Technologies Inc. XIR3000 radar digitizer; Ettus Research USRP-1-based open source digitizer) against a radar system matching that on the PFC. Because attaching a digitizer to a signal line can affect the quality of the signal seen by other attached devices (i.e. the PFC's radar consoles), testing digitizing solutions on the PFC itself presented a major safety concern. It was also not clear what kind of safety certification would be required in advance to permit installation of such a digitizing “tap” on PFC radars.

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. For example, it is possible that a passive radar sensor could be used to synchronize a receive-only radar installed on the PFC. The receive-only radar would rotate in synchrony with the surveillance S-band radars, and would begin a listening period each time the radar sensor detected the start of an outgoing S-band pulse (by seeing the large magnitude signal from short-range clutter). This is not a solution we have attempted, but it seems feasible and due to its passive nature and non-connection to the existing PFC radar, should not pose any risk to the PFC radar.

We recommend that new platforms are equipped with stand-alone radar, prior to offshore installation, to be used solely for bird monitoring. If such a system were engineered into the platform design, safety and other issues outlined above would be eliminated.

8.2.3 Radar trials at Point Tupper flare stack

Since we were 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. EMC 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.

8.3 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. During a visit to the platform in April/May 2014, an observer was able to briefly test the use of passive infra-red images to monitor the flare stack and the water surface. IR camera (iGen 20/20 Digital Viewer; www.igen2020.com) was used to capture images (no video) from various angles to test the feasibility of using IR technology to monitor the flare stack. Flare stack and waters below the platform were easily imaged by IR camera using ambient light from the platform without the need for external IR light source (Figure 7.3-1). No birds were observed during the period of the camera trials, therefore, it is not possible to assess the effectiveness for detecting avian targets. The resolution of this particular camera is likely too coarse for detecting small birds at the height of the flare, but would be adequate for monitoring marine birds on the water surface below the platform. The high amount of ambient light around the flare and the water surface would likely enable the use of regular, high definition cameras to capture images of birds; however, this remains untested.

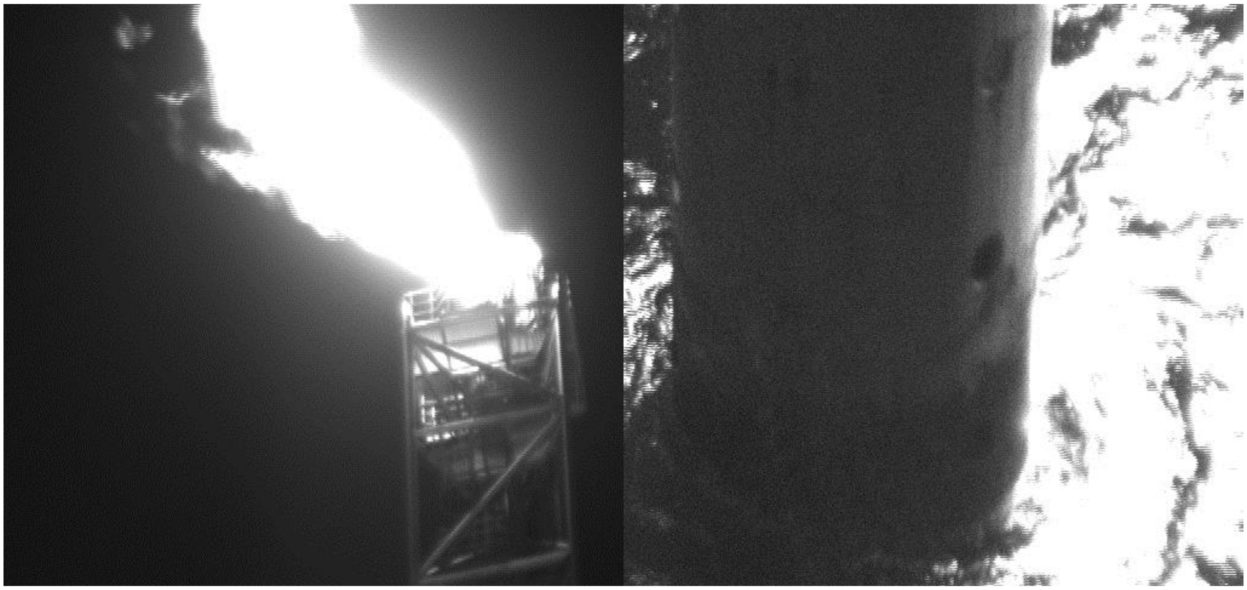


Figure 7.3-1 - Infra-red (IR) images captured from the Deep Panuke platform at night on 05 May 2014. Left shows an image of the flare and the top of the flare stack taken from an area adjacent to the helicopter deck. Right shows an image of the platform leg and surrounding waters taken from the side deck.

Problems likely to be encountered during implementation of imaging and acoustic sensors 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.

8.4 Summary and recommendations for potential platform sensors

Based on the considerations above (Sections 8.1 to 8.3) and the limited ability to test sensors on the Deep Panuke platform, we can make few concrete recommendations about specific sensors to adequately monitor birds at platforms. However, we do recommend the following to improve bird monitoring at offshore platforms in Atlantic Canada.

1) **Continued operation of automated VHF receivers.** The Sensorgnome receiver was successfully installed and tested on the Deep Panuke platform demonstrating its ability to quantify the frequency, timing, and duration of bird interactions. A regional network of permanent VHF receivers is now being established in Atlantic Canada and New England (www.motus-wts.org) to track a wide range of avian and other wildlife species equipped with radio tags. Continued operation of the Deep Panuke VHF receiver will enable the platform to participate in the network, allowing Encana to:
    a. Conduct continued studies of target species for additional follow up research on bird-platform interactions.
    b. Record detections (or lack of detections) for a broad suite of species that will be tracked by various independent research projects over the next 5 to 10 years – this will allow Encana to assess species-specific bird-platform interactions for a broader set of species and over longer time periods than would otherwise be possible under a single research program.
    c. Facilitate migration tracking in remote offshore areas, thus increasing knowledge of avian migration ecology
2) **Installation of VHF receivers on other offshore platforms/vessels.** Four offshore supply vessels are currently equipped with automated VHF receivers, expanding the telemetry network's ability to monitor birds migrations in the offshore. We recommend the participation of other offshore platforms and vessels to enhance spatial extent of the telemetry network over the next 5 to 10 years. Ultimately, this will improve our understanding of the timing and routes of over-water migrations by birds in Atlantic Canada. Together these data will allow us to better predict the risks of bird-platform interactions in the offshore.
3) **Use of existing cameras.** Currently, one Nova Scotia offshore platform is already equipped with intrinsically safe video cameras used to monitor various locations on platforms. We recommend testing the feasibility of these cameras for monitoring birds near flare stacks and the air-space around platforms. Video imagery could be processed automatically with target detection software (e.g. RadR; Taylor et al. 2010).
4) **On-shore testing and refinement of automated sensors.** Our preliminary tests and a wide body of scientific literature suggests that various instrument-based approaches could be used to monitor birds at offshore platforms (Ronconi et al. 2015). However, the logistical and financial constraints associated with development and testing of sensors (above) suggest that these should first be tested at on-shore facilities, such as oil and gas refineries, in locations where bird migrations are known to occur.
5) **Early development and deployment of sensors.** Due to the logistical, safety, and financial constraints associated with post-hoc installation of sensors on offshore platforms, we

recommend that new platforms in Atlantic Canada be designed and constructed with radar, cameras, and/or other sensor dedicated to bird monitoring. Building simple, low-cost avian monitoring sensors into platform design would significantly reduce the engineering and safety issues outlined above.

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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 EMC.

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 EMC.* 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 EMC. No data = days of equipment malfunction. Notes: PSEA was unplugged on 19 April 2014, terminating tracking in that year; VSEA was out of study area for 35 days in 2013 (see results for details).

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	1-Jun-14	0	411
Panuke Sea	SOEP platforms	PSEA	omni (1)	n/a	8-Jul-13	19-Apr-14	0	285
Venture Sea	SOEP platforms	VSEA	omni (1)	n/a	24-Apr-13	1-Jun-14	24	379
Totals	**Islands**				19-Mar-13	9-Feb-14	75	1214
	Mainland				8-Apr-13	12-Mar-14	59	3228
	Vessels				16-Apr-13	1-Jun-14	71	1353
	Grand Total				**19-Mar-13**	**1-Jun-14**	**205**	**5795**

APPENDIX E

Sable Island Beached Bird Survey 2014

OFFSHORE ENVIRONMENTAL EFFECTS MONITORING PROGRAM
SABLE OFFSHORE ENERGY PROGRAM
SUMMARY REPORT for Year 2014

COMPONENT: beached seabird surveys on Sable Island

REPORTING ORGANIZATION: Zoe Lucas, Sable Island

1. Background:

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

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

2. Goal:

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

3. Objectives:

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

4. 2014 Sampling:

Contractor: Zoe Lucas, Sable Island.

- During 2014, nine surveys for beached seabirds were conducted on Sable Island, with no surveys during March, September and December.

- All surveys were conducted by Zoe Lucas.

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

- The oiling rate is the fraction of oiled birds of the total number of birds coded for oil (i.e., with >70% of body intact) during 2014.

5. Analyses

5.a. Lab Analyses

Samples of oiled feathers were collected from beached bird corpses for analysis and generic identification of oil type. Oil samples were packaged in aluminum foil, labeled, kept frozen for periods ranging from one week to several months, and delivered to the laboratory for gas chromatographic analysis (Maxxam Analytics). Interpretation of GC/FID results were conducted by MacGregor & Associates (Halifax) Ltd.

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

5.b. Data Analyses

For oiling rate and number of clean birds/km (see Section 9, Figures 1 - 7), annual trends were first analyzed with generalized linear models (with Poisson links for densities and binomial links for oiling rate), but yielded excessive overdispersion even after corrections. Thus instead data were transformed (log transformation for densities, arcsine transformation for oiling rate) and analyzed by least squares regression. Statistically significant trends ($P < 0.05$) are marked with an asterisk (*).

6. Results

Results are presented in Section 9, Table 9.1 and Figures 9.1 to 9.7.

7. Summary

- During 2014, the corpses and fragments of 352 beached seabird corpses were collected on Sable Island. Alcids accounted for 54% of total corpses recovered (Table

- Seasonal occurrence of *clean* complete corpses (Code 0) varied by bird group and species (Table 9.1). More Larus gulls and alcids occurred in winter (58.8% and 84.3%, respectively). More Northern Fulmars (63.2%) and Northern Gannets (78.6%), and all shearwaters, occurred in summer.

- The overall oiling rate for all species combined (based on complete corpses, Codes 0 to 3) was 3.2% (compared with <0.5% in 2013). A total of six oiled corpses were recovered in 2014, and all were alcids (1 Atlantic Puffin, 3 Thick-billed Murre, 1 murre not identified to species, and 1 Dovekie). The oiling rate for alcids was 7.9% (compared with 0% in 2013).

- The six oiled bird corpses occurred during the first week of February, and samples of oiled feathers were collected from five of the corpses. The samples were determined to be moderately weathered Heavy Fuel Oil most typical of residuals or sludge from fuel tanks.

8. References

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

[2] Lucas, Z., A. Horn, and B. Freedman. 2012. *Beached bird surveys on Sable Island, Nova Scotia, 1993 to 2009, show a decline in the incidence of oiling.* Proceedings of the Nova Scotian Institute of Science 47, Part 1, 91-129.

9. Table & Figures

Table 9.1.
Beached seabird corpses collected on Sable Island during 2014. Totals & linear densities for clean complete corpses (Code 0) for winter (November-April) and summer (May-October), and annual oiling rate based on complete corpses (i.e. with >70% of body intact, Codes 0 - 3).

Bird species & groups	Total [1] number corpses	Code 0 number Winter	Code 0 number Summer	Code 0 number/km Winter	Code 0 number/km Summer	Oiling rate %
Common Loon	1	1	0	0.0031	0	0
Northern Fulmar	23	7	12	0.0219	0.0300	0
Shearwater	57	0	37	0	0.0925	0
Northern Gannet	16	3	11	0.0094	0.0275	0
Larus Gulls	46	20	14	0.0625	0.0350	0
Alcids [2]	190	59	11	0.1844	0.0275	7.9
Common & Thick-billed Murres	65	22	8	0.0688	0.0200	11.8
Dovekie	72	13	0	0.0406	0	7.1
other species [3]	19	2	7	0.0063	0.0175	0

[1] Codes 0 - 4 combined.
[2] All alcid species combined (Razorbill, Atlantic Puffin, Common and Thick-billed Murre, Dovekie, and unidentified large alcids).
[3] Includes Leach's Storm-petrel, Black-legged Kittiwake, and Double-crested Cormorant.

Figure 9.1. Northern Fulmar
Number/km: $F_{1,20}$=2.03, P=0.17
Oiling rate: $F_{1,20}$=16.71, P=0.0006*

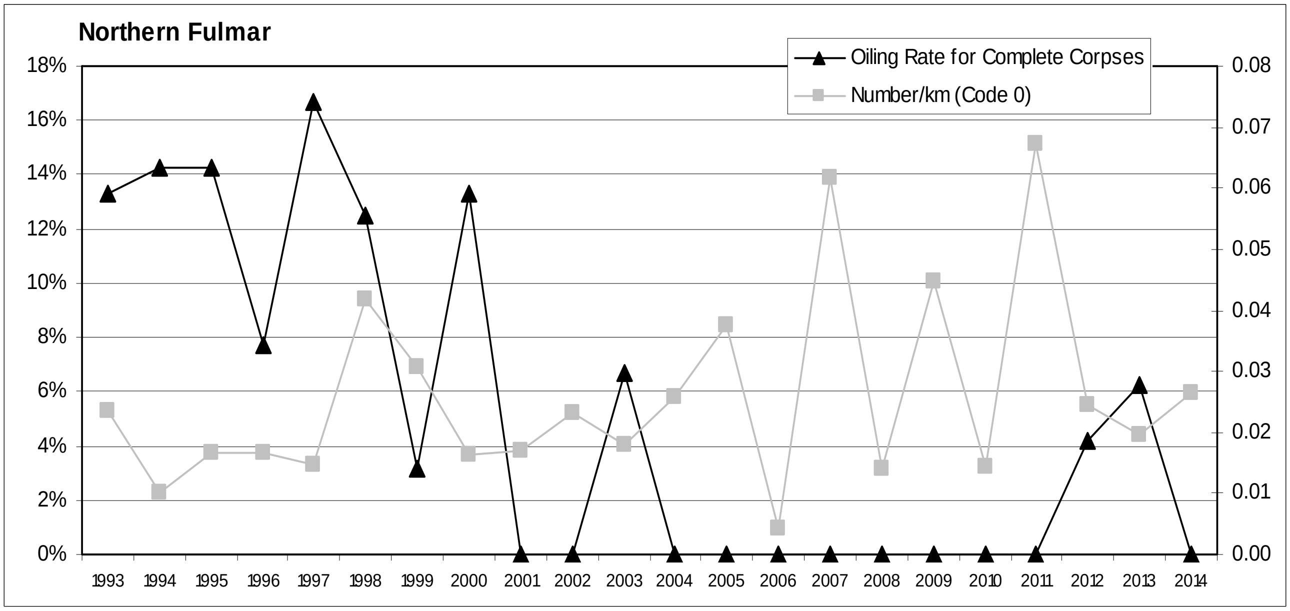


Figure 9.2. Shearwaters
Number/km: $F_{1,20}$=0.04, P=0.84
Oiling rate: $F_{1,20}$=7.06, P=0.0151*

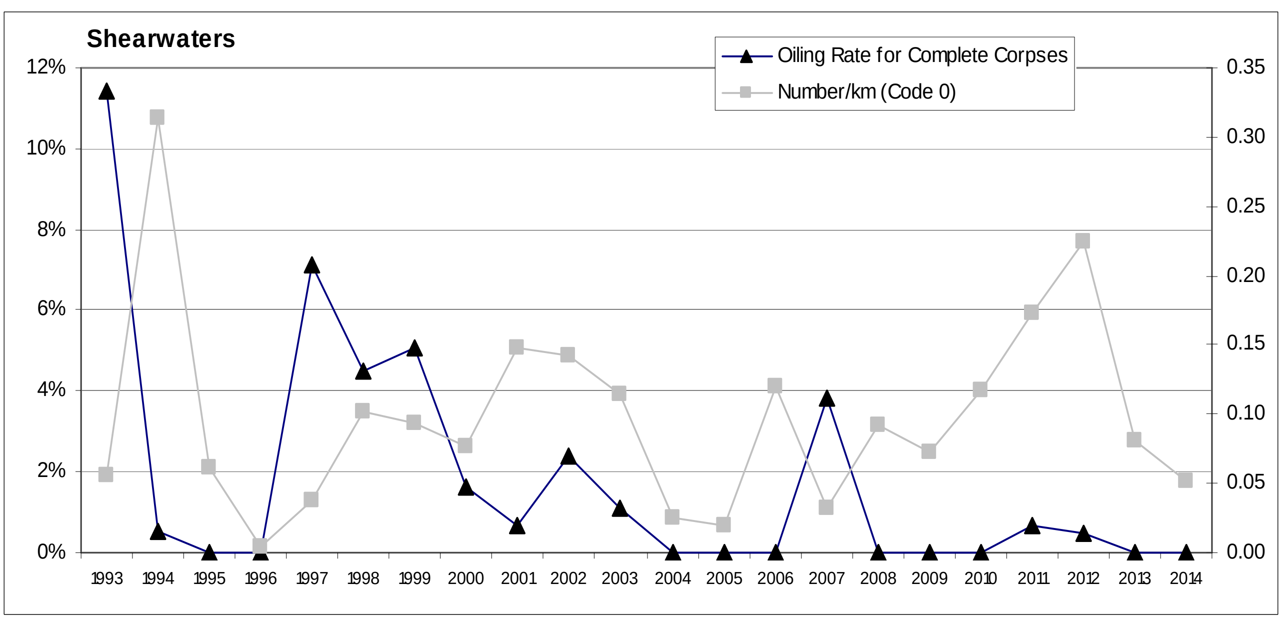


Figure 9.3. Northern Gannet
Number/km: $F_{1,20}$=0.02, P=0.90
Oiling rate: $F_{1,20}$=7.41, P=0.0131*

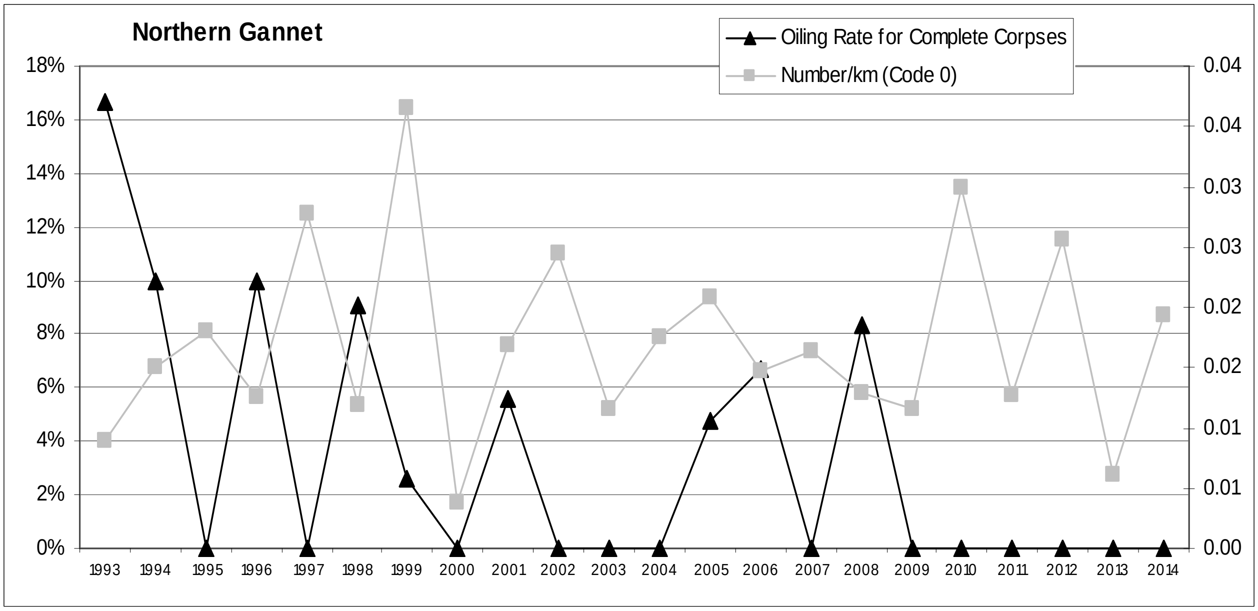


Figure 9.4. Larus Gulls
Number/km: $F_{1,20}$=0.00, P=0.99
Oiling rate: $F_{1,20}$=12.06, P=0.0024*

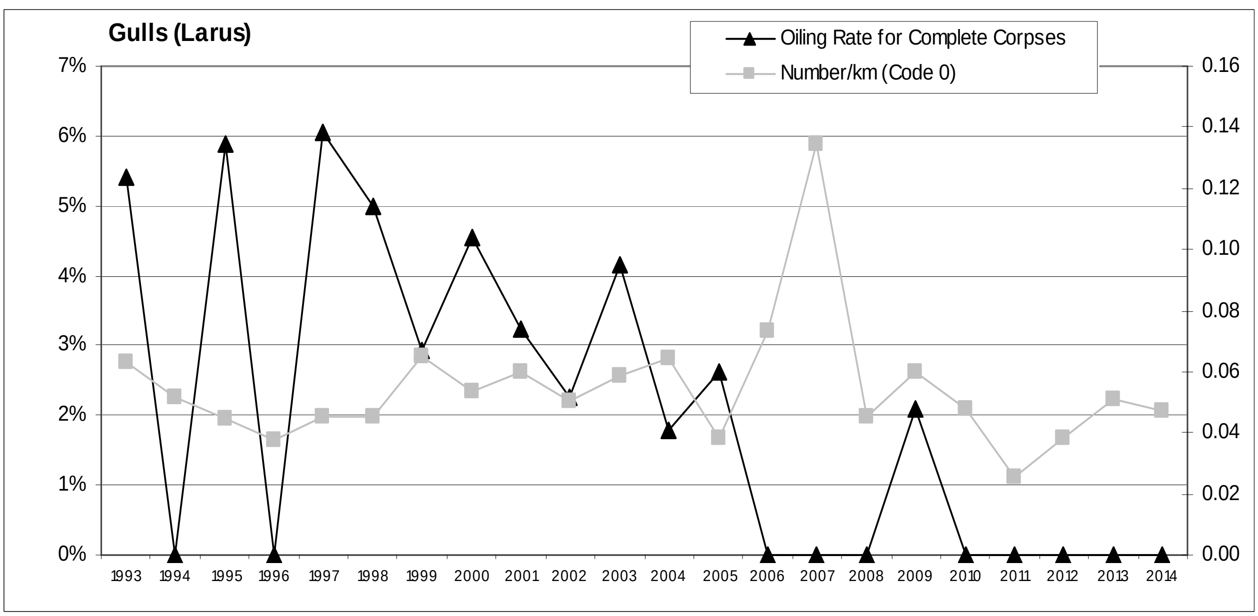


Figure 9.5. Alcids (all species combined)
Number/km: $F_{1,20}=0.04$, $P=0.85$
Oiling rate: $F_{1,20}=39.46$, $P<0.0001$*

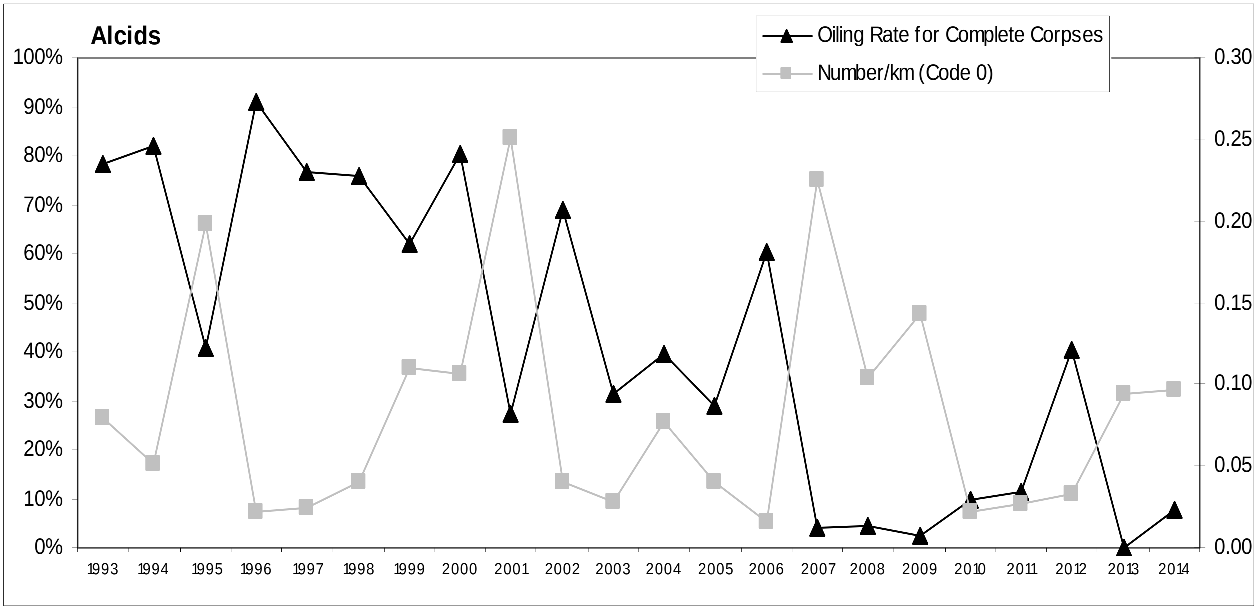


Figure 9.6. Common & Thick-billed Murres
Number/km: $F_{1,20}=0.04$, $P=0.85$
Oiling rate: $F_{1,20}=16.24$, $P=0.0007$*

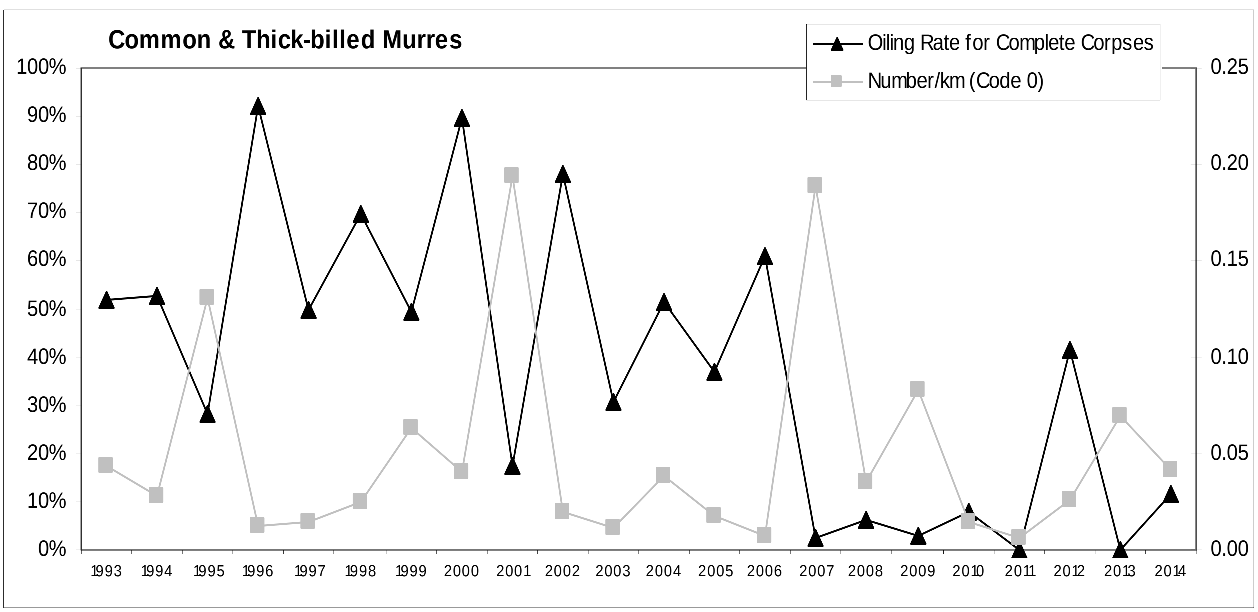
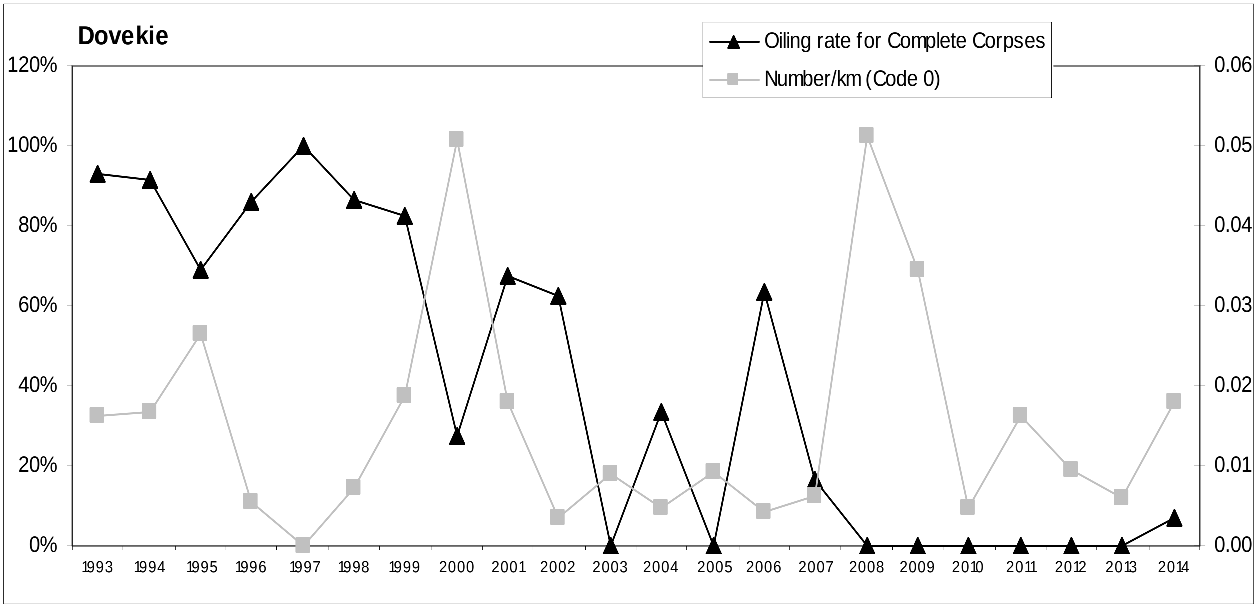


Figure 9.7. Dovekie
Number/km: $F_{1,20}$=0.00, P=1.00
Oiling rate: $F_{1,20}$=51.01, P<0.0001*



APPENDIX F

Live Seabird – 2014 Salvage 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, 2014 to December 31, 2014 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 ___ Digitally signed by marielle.thillet@encana.com DN: cn=marielle.thillet@encana.com Date: 2015.01.30 13:36:16 -04'00' ______________________________ DATE ________ January 30, 2015____

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) Production Field Centre (PFC) Commissioning and production [Jan 1, 2014 - ongoing]

Vessel Name: PFC and two support (supply and standby) vessels (Ryan Leet replaced by Atlantic Tern in January 2014; Atlantic Hawk used in interim from January 8-26; 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 at all times; and
- dedicated bird observer (trained bird biologist) on the PFC from April 30 to May 6, 2014

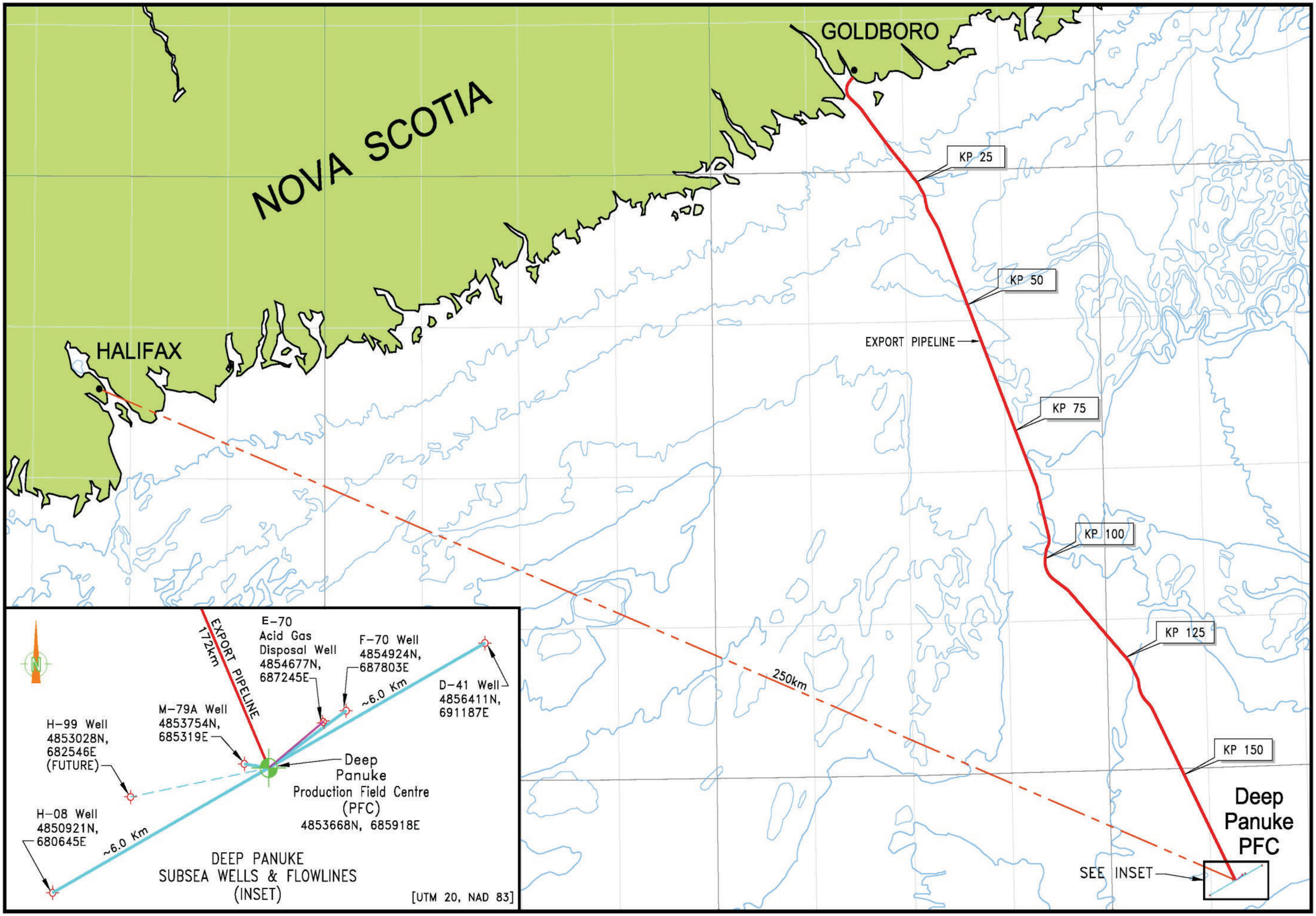
(b) Subsea Asset Inspection Survey [Feb-Dec 2014]

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



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

Instructions:

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

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

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

Table:

Complete 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 Deep Panuke PFC Year 2014

Date (2014)	Species	Total	Found Dead		Captured Alive				Comments
					Un-oiled		Oiled*		
			DOAS	Oiled*	DIC	Rls'd	DIC	SFR	Condition / Action Taken / Fate of Bird
01-May (see **Note 1**)	Magnolia Warbler	1	Y	N					Roof of acid gas house; desiccated but not decomposed, likely from spring migration this year; adult male, breeding plumage (see photo 1)
01-May (see **Note 1**)	European Starling	1	Y	N					Roof of acid gas house; desiccated & decomposed, likely from migration period last fall (2013); juvenile (see photo 2)
02-May (see **Note 1**)	Red-winged Blackbird	1	Y	N					Essential generator deck; trapped under walkway, decomposed (see photo 3)
02-May (see **Notes 1&2**)	LHSP	1	Y	N					Essential generator deck; desiccated, likely from last fall; wedged in bracket, appeared to have a broken wing (see photos 4a and 4b)
02-May (see **Notes 1&2**)	LHSP	5	Y	Y					Essential generator deck; trapped under walkway, decomposed, likely from last fall; oily water (see photos 5a to 5e)
03-May (see **Note 1**)	Savannah sparrow	1	Y	N					Riser deck; recent, intact with no apparent injuries. On the morning census a live Savannah Sparrow was found about 15 m from this location where it was resting under a stairwell. Best guess is that it arrived the night of May 2-3 and died sometime in the afternoon/evening of May 3. Bird was weighed at 14 g, underweight for this species (~20 g) so bird probably died of dehydration and/or starvation. (see photo 6)
04-May (see **Note 1**)	Gray Catbird	1	Y	N					Module 1, level 2; recent, intact; fresh carcass with no apparent injuries. This bird was seen alive the previous day (03-May) during morning and mid-day census. When found dead it weighed 22g. Typical weight for this species is ~35-40g so bird likely died of dehydration and/or starvation. (see photo 7)
05-May (see **Note 1**)	American Redstart	1	Y	N					Module 5, level 3; very decomposed, likely from last year (see photo 8)
05-May	UNKN	1	N	N					Main deck, inaccessible under walkway; no access to

Date (2014)	Species	Total	Found Dead DOAS	Found Dead Oiled*	Captured Alive Un-oiled DIC	Captured Alive Un-oiled Rls'd	Captured Alive Oiled* DIC	Captured Alive Oiled* SFR	Comments: Condition / Action Taken / Fate of Bird
(see **Note 1**)									confirm species, appears Red-winged Blackbird, old carcass. Could not dispose at sea (bird not accessible).
06-May (see **Note 1**)	Gray Catbird	1					Y		Module 2, level 3; found live, died awaiting transport; weight 23g, light oil on 2cm tips of tail. Bird was underweight for this species (~37g) so likely died of dehydration and/or starvation. When found alive in the morning, was put in a box and arranged to have sent on helicopter the next day. After bird died in the evening, was flown back to shore and sent for necropsy by CWS.
03-Aug	LHSP	1						Rl's	Petrel found by deck crew at 2:50 pm; on level 1 seeking shelter under machinery; oil on its feathers. Was brought to Radio Operator. CWS advised to remove bulk of oil with paper towel (but no cleaning) and let him rest in box before release. Bird released at night.
30-Aug	LHSP	1				Y			Storm petrel got in Jackhouse. Caught it, allowed it to rest in box for day and released it at night. No oil, no injuries.
09-Sep	Semi-palmated Sandpiper	1	Y	N					Sandpiper was discovered on lifeboat landing in the morning (see photo 9)
09-Dec	LHSP	1	Y	N					Found on deck; dead, dry, disposed of at sea (see photo 10)

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.**

Note 1:
Birds observations on the PFC were conducted by Rob Ronconi from April 30 to May 6, 2014, as part of a bird monitoring research study conducted with Acadia University.

Note 2:
The birds identified on May 2 were found in an inaccessible area of the PFC under the walkway around the essential generator deck. Maintenance crew had to be brought in to provide access to the area to Rob Ronconi so that he could identify the birds. They all looked to be old carcasses probably from last fall and a necropsy would have been pointless given the advanced state of decomposition. There doesn't seem to be an obvious way that the birds are getting into this space since it is well sealed below the walkway as it is meant to capture oil/fuel that could leak from the essential generator container.

FOR INFORMATION: Unusual Observations of Non-Stranded Birds

- 30-Aug: Brown Hawk was at PFC for several days before moving on. Apparently a healthy bird; was hunting gulls
- 06-Nov: Juvenile Peregrine Falcon on PFC (see photo 11)
- 19-Dec: Blue heron spotted from Atlantic Tern at 11:30; not stranded or injured. Heron flew past vessel and proceeded North (see photo 12)


Photo 1


Photo 2


Photo 3


Photo 4a


Photo 4b

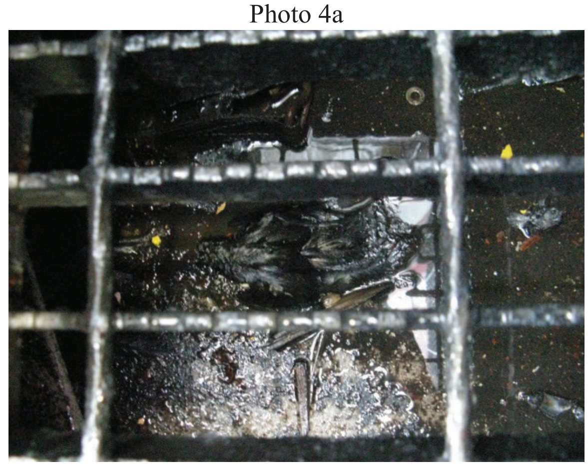


Photo 5a


Photo 5b


Photo 5c


Photo 5d


Photo 5e


Photo 6


Photo 7


Photo 8


Photo 9


Photo 10

Photo 11

Photo 12

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 G

2014 Observations from Supply Vessels and PFC of Marine Wildlife

Ryan Leet	
EnCana Midnight Report-Jan 1, 2013.xls	: N
EnCana Midnight Report-Jan 2, 2013.xls	: N
EnCana Midnight Report-Jan 3, 2013.xls	: N
EnCana Midnight Report-Jan 4, 2013.xls	: N
EnCana Midnight Report-Jan 5, 2013.xls	: N
EnCana Midnight Report-Jan 6, 2013.xls	: N
EnCana Midnight Report-Jan 7, 2013.xls	: N
EnCana Midnight Report-Jan 8, 2013.xls	: N
EnCana Midnight Report-Jan 9, 2013.xls	: N

Atlantic Hawk	
EnCana 2400 - Jan 8,2014.xls	N
EnCana 2400 - Jan 9,2014.xls	N
EnCana 2400 - Jan 10,2014.xls	N
EnCana 2400 - Jan 11,2014.xls	N
EnCana 2400 - Jan 12,2014 -.xls	N
EnCana 2400 - Jan 13,2014.xls	N
EnCana 2400 - Jan 14,2014.xls	N
EnCana 2400 - Jan 15,2014.xls	N
EnCana 2400 - Jan 16,2014.xls	N
EnCana 2400 - Jan 17,2014.xls	N
EnCana 2400 - Jan 18,2014.xls	N
EnCana 2400 - Jan 19,2014.xls	N
EnCana 2400 - Jan 20,2014.xls	N
EnCana 2400 - Jan 21,2014.xls	N
EnCana 2400 - Jan 22,2014.xls	N
EnCana 2400 - Jan 23,2014.xls	N
EnCana 2400 - Jan 24,2014.xls	N

2400 MVR Atlantic Tern January 25.xls	NA
2400 MVR Atlantic Tern January 26.xls	NA
2400 MVR Atlantic Tern January 27.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern January 28.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern January 29.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern January 30.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern January 31.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern February 01.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern February 02.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern February 03.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern February 04.xls	Untaged Sea Gulls
2400 MVR Atlantic Tern February 05.xls	NA
2400 MVR Atlantic Tern February 06.xls	NA
2400 MVR Atlantic Tern February 07.xls	NA
2400 MVR Atlantic Tern February 08.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 09.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 10.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 11.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 12.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 13.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 14.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 15.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 16.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 17.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 18.xls	Untaged sea gulls
2400 MVR Atlantic Tern February 19.xls	Gulls
2400 MVR Atlantic Tern February 20.xls	NA
2400 MVR Atlantic Tern February 21.xls	Un-Taged Gulls
2400 MVR Atlantic Tern February 22.xls	One seal, Un-Taged Gulls
2400 MVR Atlantic Tern February 23.xls	Un-Taged Gulls
2400 MVR Atlantic Tern February 24 2014.xls	Un-Taged Gulls
2400 MVR Atlantic Tern February 25 2014.xls	Un-Taged Gulls
2400 MVR Atlantic Tern February 26 2014.xls	Un-Taged Gulls
2400 MVR Atlantic Tern February 27 2014.xls	1 whale, Un-Taged Gulls
2400 MVR Atlantic Tern February 28 2014.xls	N/A
2400 MVR Atlantic Tern March 1 2014.xls	N/A
2400 MVR Atlantic Tern March 2 2014.xls	N/A
2400 MVR Atlantic Tern March 3 2014.xls	N/A
2400 MVR Atlantic Tern March 4 2014.xls	N/A
2400 MVR Atlantic Tern March 5 2014.xls	N/A
2400 MVR Atlantic Tern March 6 2014.xls	N/A
2400 MVR Atlantic Tern March 7 2014.xls	N/A
2400 MVR Atlantic Tern March 8 2014.xls	N/A
2400 MVR Atlantic Tern March 9 2014.xls	N/A
2400 MVR Atlantic Tern March 10 2014.xls	N/A
2400 MVR Atlantic Tern March 11 2014.xls	N/A
2400 MVR Atlantic Tern March 12 2014.xls	N/A
2400 MVR Atlantic Tern March 13 2014.xls	N/A
2400 MVR Atlantic Tern March 14 2014.xls	N/A
2400 MVR Atlantic Tern March 15 2014.xls	N/A
2400 MVR Atlantic Tern March 16 2014.xls	N/A

2400 MVR Atlantic Tern March 17 2014.xls	N/A
2400 MVR Atlantic Tern March 18 2014.xls	N/A
2400 MVR Atlantic Tern March 19 2014.xls	N/A
2400 MVR Atlantic Tern March 20 2014.xls	N/A
2400 MVR Atlantic Tern March 21 2014.xls	N/A
2400 MVR Atlantic Tern March 22 2014.xls	N/A
2400 MVR Atlantic Tern March 23 2014.xls	N/A
2400 MVR Atlantic Tern March 24 2014.xls	N/A
2400 MVR Atlantic Tern March 25 2014.xls	N/A
2400 MVR Atlantic Tern March 26 2014.xls	N/A
2400 MVR Atlantic Tern March 27 2014.xls	N/A
2400 MVR Atlantic Tern March 28 2014.xls	N/A
2400 MVR Atlantic Tern March 29 2014.xls	N/A
2400 MVR Atlantic Tern March 30 2014.xls	N/A
2400 MVR Atlantic Tern March 31 2014.xlsx	N/A
2400 MVR Atlantic Tern April 1 2014.xlsx	N/A
2400 MVR Atlantic Tern April 2 2014.xlsx	N/A
2400 MVR Atlantic Tern April 3 2014.xlsx	Untaged Seagulls, Gannets
2400 MVR Atlantic Tern April 4 2014.xlsx	Untaged Seagulls, Seals
2400 MVR Atlantic Tern April 5 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 6 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 7 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 8 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 9 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 10 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 11 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 12 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 13 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 14 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 15 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 16 2014.xlsx	1 minki whale, Untaged Seagulls
2400 MVR Atlantic Tern April 17 2014.xlsx	Untaged Seagulls
2400 MVR Atlantic Tern April 18 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 19 2014.xlsx	Seals,Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 20 2014.xlsx	Seals, Untaged Seagulls
2400 MVR Atlantic Tern April 21 2014.xlsx	Seals, Untaged Seagulls
2400 MVR Atlantic Tern April 22 2014.xlsx	,Seals, Untaged Seagulls
2400 MVR Atlantic Tern April 23 2014.xlsx	,Seals, Untaged Seagulls
2400 MVR Atlantic Tern April 24 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 25 2014.xlsx	Gannets, Untaged Seagulls
2400 MVR Atlantic Tern April 26 2014.xlsx	N/A
2400 MVR Atlantic Tern April 27 2014.xlsx	N/A
2400 MVR Atlantic Tern April 28 2014.xlsx	N/A
2400 MVR Atlantic Tern April 29 2014.xlsx	N/A
2400 MVR Atlantic Tern April 30 2014.xlsx	N/A
2400 MVR Atlantic Tern May 1 2014.xlsx	Whales, Untagged Gulls
2400 MVR Atlantic Tern May 2 2014.xlsx	Whales, Untagged Gulls
2400 MVR Atlantic Tern May 3 2014.xlsx	Whales, Seals
2400 MVR Atlantic Tern May 4 2014.xlsx	Whales, Seals
2400 MVR Atlantic Tern May 5 2014.xlsx	Cormorants,Gannets, Gulls
2400 MVR Atlantic Tern May 6 2014.xlsx	Seal,Gannets, Gulls
2400 MVR Atlantic Tern May 7 2014.xlsx	Gannets, Gulls

2400 MVR Atlantic Tern May 8 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 9 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 10 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 11 2014.xlsx	Gannets
2400 MVR Atlantic Tern May 12 2014.xlsx	Gannets, Seals
2400 MVR Atlantic Tern May 13 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 14 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 15 2014.xlsx	Gannets, Gulls,Seal
2400 MVR Atlantic Tern May 16 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 17 2014.xlsx	Gannets, Gulls,Seals
2400 MVR Atlantic Tern May 18 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 19 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 20 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 21 2014.xlsx	Gannets, Gulls
2400 MVR Atlantic Tern May 22 2014.xlsx	None
2400 MVR Atlantic Tern May 23 2014.xlsx	None
2400 MVR Atlantic Tern May 24 2014.xlsx	None
2400 MVR Atlantic Tern May 25 2014.xlsx	None
2400 MVR Atlantic Tern May 26 2014.xlsx	None
2400 MVR Atlantic Tern May 27 2014.xlsx	None
2400 MVR Atlantic Tern May 28 2014.xlsx	None
2400 MVR Atlantic Tern May 29 2014.xlsx	None
2400 MVR Atlantic Tern May 30 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern May 31 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 1 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 2 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 3 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 4 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 5 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 6 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 7 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 8 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 9 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 10 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 11 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 12 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 13 2014.xlsx	Shearwaters, Untagged Gulls
2400 MVR Atlantic Tern June 14 2014.xlsx	Shearwaters
2400 MVR Atlantic Tern June 15 2014.xlsx	NA
2400 MVR Atlantic Tern June 16 2014.xlsx	Seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 17 2014.xlsx	Seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 18 2014.xlsx	Gulls, Shearwater
2400 MVR Atlantic Tern June 19 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 20 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 21 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 22 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 23 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 24 2014.xlsx	seal, Gulls, Shearwater
2400 MVR Atlantic Tern June 25 2014 edit RC.xlsx	Gulls
2400 MVR Atlantic Tern June 25 2014 (2).xlsx	Gulls
2400 MVR Atlantic Tern June 25 2014.xlsx	Gulls
2400 MVR Atlantic Tern June 26 2014 edit RC.xlsx	Gulls, Seal, Whale
2400 MVR Atlantic Tern June 26 2014 (2).xlsx	Gulls, Seal, Whale

2400 MVR Atlantic Tern June 26 2014.xlsx	Gulls, Seal, Whale
2400 MVR Atlantic Tern June 27 2014 edit RC.xlsx	Gulls
2400 MVR Atlantic Tern June 27 2014.xlsx	Gulls
2400 MVR Atlantic Tern June 28 2014 edit RC.xlsx	Gulls
2400 MVR Atlantic Tern June 28 2014.xlsx	Gulls
2400 MVR Atlantic Tern June 29 2014 ed RC.xlsx	Gulls,Seals
2400 MVR Atlantic Tern June 29 2014.xlsx	Gulls,Seals
2400 MVR Atlantic Tern June 30 2014 ed RC.xlsx	Gulls
2400 MVR Atlantic Tern June 30 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 1 2014 edit RC.xlsx	Gulls
2400 MVR Atlantic Tern July 1 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 2 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 3 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 4 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 5 2014.xlsx	Gulls,Seals
2400 MVR Atlantic Tern July 6 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 7 2014.xlsx	Gulls,Seals
2400 MVR Atlantic Tern July 8 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 9 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 10 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 11 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 12 2014.xlsx	Gulls,Seal,Sun Fish, Porpoise, Sea Turtle, Shark
2400 MVR Atlantic Tern July 13 2014.xlsx	Gulls,Seal, Porpoise,Shark
2400 MVR Atlantic Tern July 14 2014.xlsx	Gulls,Porpoise
2400 MVR Atlantic Tern July 15 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 16 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 17 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 18 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 19 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 20 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 21 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 22 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 23 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 24 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 25 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 26 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 27 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 28 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 29 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 30 2014.xlsx	Gulls
2400 MVR Atlantic Tern July 31 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 1 2014.xlsx	Gulls, Dolphins
2400 MVR Atlantic Tern Aug 2 2014.xlsx	Gulls, Dolphins, Sharks
2400 MVR Atlantic Tern Aug 3 2014.xlsx	Gulls,
2400 MVR Atlantic Tern Aug 4 2014.xlsx	Gulls, Dolphins, Shearwaters
2400 MVR Atlantic Tern Aug 5 2014.xlsx	Gulls, 1 shark, Shearwaters, 1 seal
2400 MVR Atlantic Tern Aug 6 2014.xlsx	Gulls, shearwaters, one tagged gull
2400 MVR Atlantic Tern Aug 7 2014.xlsx	Gulls, shearwaters,
2400 MVR Atlantic Tern Aug 8 2014.xlsx	Gulls, shearwaters,
2400 MVR Atlantic Tern Aug 9 2014.xlsx	Gulls, shearwaters,
2400 MVR Atlantic Tern Aug 10 2014.xlsx	Gulls, shearwaters,
2400 MVR Atlantic Tern Aug 11 2014.xlsx	Gulls, shearwaters,

2400 MVR Atlantic Tern Aug 12 2014.xlsx	Gulls, shearwaters,
2400 MVR Atlantic Tern Aug 13 2014.xlsx	Gulls, shearwaters, whales
2400 MVR Atlantic Tern Aug 14 2014.xlsx	Gulls, shearwaters, whales, Terns
2400 MVR Atlantic Tern Aug 15 2014.xlsx	NA
2400 MVR Atlantic Tern Aug 16 2014.xlsx	NA
2400 MVR Atlantic Tern Aug 17 2014.xlsx	NA
2400 MVR Atlantic Tern Aug 19 2014.xlsx	NA
2400 MVR Atlantic Tern Aug 20 2014- Revised.xlsx	NA
2400 MVR Atlantic Tern Aug 20 2014.xlsx	NA
2400 MVR Atlantic Tern Aug 21 2014- Revised.xlsx	Gulls and Porpoise
2400 MVR Atlantic Tern Aug 21 2014.xlsx	Gulls and Porpoise
2400 MVR Atlantic Tern Aug 22 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 22 2014-Revised.xlsx	Gulls
2400 MVR Atlantic Tern Aug 23 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 23 2014-Revised.xlsx	Gulls
2400 MVR Atlantic Tern Aug 24 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 24 2014-Revised.xlsx	Gulls
2400 MVR Atlantic Tern Aug 25 2014.xlsx	Gulls & Porpoises
2400 MVR Atlantic Tern Aug 25 2014-Revised.xlsx	Gulls & Porpoises
2400 MVR Atlantic Tern Aug 26 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 26 2014-Revised.xlsx	Gulls
2400 MVR Atlantic Tern Aug 27 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 28 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 29 2014.xlsx	Gulls & Whales
2400 MVR Atlantic Tern Aug 30 2014.xlsx	Gulls
2400 MVR Atlantic Tern Aug 31 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 1 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 2 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 3 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 4 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 5 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 6 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 7 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 8 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 9 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 10 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 11 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 12 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 13 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 14 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 15 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 16 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 17 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Sept 18 2014.xlsx	Gulls
2400 MVR Atlantic Tern Sept 19 2014.xlsx	Gulls, Shearwaters
2400 MVR Atlantic Tern Sept 20 2014.xlsx	Gulls, Shearwaters
2400 MVR Atlantic Tern Sept 21 2014.xlsx	Gulls, Shearwaters
2400 MVR Atlantic Tern Sept 22 2014.xlsx	Gulls, Shearwaters
2400 MVR Atlantic Tern Sept 23 2014.xlsx	Shearwaters
2400 MVR Atlantic Tern Sept 24 2014.xlsx	lots of Shearwaters
2400 MVR Atlantic Tern Sept 25 2014.xlsx	Seagulls,Shearwaters, 1 seal
2400 MVR Atlantic Tern Sept 26 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Sept 27 2014.xlsx	Seagulls,Shearwaters,

2400 MVR Atlantic Tern Sept 28 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Sept 29 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Sept 30 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 01 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 02 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 03 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 04 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 05 2014.xlsx	Seagulls,Shearwaters,
2400 MVR Atlantic Tern Oct 06 2014.xlsx	Seagulls,Shearwaters, 2 whales
2400 MVR Atlantic Tern Oct 07 2014.xlsx	Seagulls,Shearwaters
2400 MVR Atlantic Tern Oct 08 2014.xlsx	Seagulls,Shearwaters
2400 MVR Atlantic Tern Oct 09 2014.xlsx	Seagulls,Shearwaters
2400 MVR Atlantic Tern Oct 10 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 11 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 12 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 13 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 14 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 15 2014.xlsx	N/A
2400 MVR Atlantic Tern Oct 16 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 17 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 18 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 19 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 20 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 21 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 22 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 23 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 24 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 25 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 26 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 27 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 28 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 29 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 30 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Oct 31 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 1 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 2 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 3 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 4 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 5 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 6 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 7 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 8 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 9 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 10 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 11 2014.xlsx	Various Gulls
2400 MVR Atlantic Tern Nov 12 2014.xlsx	N/A
2400 MVR Atlantic Tern Nov 13 2014.xlsx	N/A
2400 MVR Atlantic Tern Nov 14 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 15 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 16 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 17 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 18 2014.xlsx	Gulls

2400 MVR Atlantic Tern Nov 19 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 20 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 21 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 22 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 23 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 24 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 25 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 26 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 27 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 28 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 29 2014.xlsx	Gulls
2400 MVR Atlantic Tern Nov 30 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 1 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 2 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 3 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 4 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 5 2014.xlsx	Gulls
2400 MVR Atlantic Tern Dec 6 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 7 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 8 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 9 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 10 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 11 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 12 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 13 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 14 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 15 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 16 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 17 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 18 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 19 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 20 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 21 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 22 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 23 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 24 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 25 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 26 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 27 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 28 2014 (2).xlsx	NA
2400 MVR Atlantic Tern Dec 29 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 30 2014.xlsx	NA
2400 MVR Atlantic Tern Dec 31 2014.xlsx	NA

Atlantic Condor 2400 Report Jan 1 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 2 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 3 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 4 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 5 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 6 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 7 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 8 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 9 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 10 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 11 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 12 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 13 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 14 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 15 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 16 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 17 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 18 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 19 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 20 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 21 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 22 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 23 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 24 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 25 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 26 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 27 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 28 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 29 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 30 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Jan 31 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 01 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 02 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 03 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 04 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 05 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 06 2014.xls	Untagged gulls
Atlantic Condor 2400 Report Feb 07 2014.xls	2 seals
Atlantic Condor 2400 Report Feb 08 2014.xls	NA
Atlantic Condor 2400 Report Feb 09 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 10 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 11 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 12 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 13 2014 (Recovered).xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 14 2014 (Recovered).xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 15 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 16 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 17 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 18 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 19 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 20 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report Feb 21 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 22 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 23 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 24 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 25 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 26 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 27 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Feb 28 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 01 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 02 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 03 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 04 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 05 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 06 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 07 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 08 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 09 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report Mar 18 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 19 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 20 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 21 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 22 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 23 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 24 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 25 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 26 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 27 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 28 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 29 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Mar 30 2014.xls	1 x Whale in vicinity of PFC
Atlantic Condor 2400 Report Mar 31 2014.xls	None observed
Atlantic Condor 2400 Report Apr 01 2014.xls	None observed
Atlantic Condor 2400 Report Apr 02 2014.xls	None observed
Atlantic Condor 2400 Report Apr 03 2014.xls	None observed
Atlantic Condor 2400 Report Apr 04 2014.xls	None observed
Atlantic Condor 2400 Report Apr 05 2014.xls	None observed
Atlantic Condor 2400 Report Apr 06 2014.xls	None observed
Atlantic Condor 2400 Report Apr 07 2014.xls	None observed
Atlantic Condor 2400 Report Apr 08 2014.xls	None observed
Atlantic Condor 2400 Report Apr 09 2014.xls	None observed
Atlantic Condor 2400 Report Apr 10 2014.xls	None observed
Atlantic Condor 2400 Report Apr 11 2014.xls	None observed
Atlantic Condor 2400 Report Apr 12 2014.xls	None observed
Atlantic Condor 2400 Report Apr 13 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report Apr 14 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 15 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 16 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 17 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 18 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 19 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 20 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 21 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report Apr 23 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 24 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report Apr 29 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report Apr 30 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report May 01 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report May 02 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report May 03 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report May 28 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report May 30 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report May 31 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 01 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 02 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 03 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 04 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report June 05 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 06 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 07 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 08 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 09 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 10 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 11 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report June 13 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 14, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report June 20, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report June 28, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 29, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report June 30, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 1, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 2, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 3, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 7, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 9, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 11, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 14, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 16, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 18, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 20, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 21, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 22, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report July 24, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 25, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 26, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 27, 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report July 28, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 29, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 30, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report July 31, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 01, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 02, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 03, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 04, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 05, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 06, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 07, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 08, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 09, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 10, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 11, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 12, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 13, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 14, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 15, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 16, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 17, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 18, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 19, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 20, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 21, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 22, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 23, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 24, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 25, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 26, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 27, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 28, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 29, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 30, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report August 31, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 1, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 2, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 03, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 04, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 05, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 06, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 07, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 08, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 09, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 10, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 11, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 12, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 13, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 14, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 15, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 16, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 17, 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report September 18, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 19, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 20, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 21, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 22, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 23, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 24, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 25 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 26, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 27, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 28, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 29, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report September 30, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 1, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 2, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 03, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 04, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 05, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 06, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 07, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 08, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 09, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 10, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 11, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 12, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 13, 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report October 18, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 19, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 20, 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 21 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report October 25 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report October 29 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 30 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report October 31 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 01 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 02 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 03 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 04 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 05 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 06 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 07 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 08 2014.xls	Various untagged gulls

Atlantic Condor 2400 Report November 09 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 10 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 11 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 12 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 13 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 14 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 15 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 16 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 17 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 18 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report November 29 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report November 30 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 1 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report December 3 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 04 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report December 20 2014.xls	Various untagged gulls
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Atlantic Condor 2400 Report December 23 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 24 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 25 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 26 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 27 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 28 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 29 2014 (2).xls	Various untagged gulls
Atlantic Condor 2400 Report December 30 2014.xls	Various untagged gulls
Atlantic Condor 2400 Report December 31 2014.xls	Various untagged gulls

APPENDIX H

2014 Flare Plume Observations

	Morning		Afternoon	
	Flare colour	Observations	Flare colour	Observations
DPE-2014-02-20.xls	1	Flare was clean	1	0
DPE-2014-02-21.xls	0	Flare was clean	0	0
DPE-2014-02-22.xls	0	Flare was clean	0	0
DPE-2014-02-23.xls	0	Flare was clean	0	0
DPE-2014-02-24.xls	0	Flare was clean	0	0
DPE-2014-02-25.xls	0	Flare was clean	0	0
DPE-2014-02-26.xls	0	Flare was clean	0	0
DPE-2014-02-27.xls	0	Flare is clear	0	0
DPE-2014-02-28.xls	0	Flare is clear	0	0
DPE-2014-03-01.xls	0	Flare is clear	0	0
DPE-2014-03-02.xls	0	Flare is clear - Dilution gas up and down	0	0
DPE-2014-03-03.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-04.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-05.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-06.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-07.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-08.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-09.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-10.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-11.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-12.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-13.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-14.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-15.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-16.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-17.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-18.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-19.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-20.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-21.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-22.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-23.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-24.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-25.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-26.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-27.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-28.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit

DPE-2014-03-29.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-30.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-03-31.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-01.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-02.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-03.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-04.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-05.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-06.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-07.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-08.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-09.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-10.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-11.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-12.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-13.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-14.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-15.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-16.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-17.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-18.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-19.xls	0	Flare is clear - Dilution gas adjusted to suit	0	Flare is clear - Dilution gas adjusted to suit
DPE-2014-04-20.xls	2	Occasionally smoking - Dilution gas adjusted accordingly and faultfing	2	0
DPE-2014-04-21.xls	2	Occasionally smoking - Dilution gas adjusted accordingly and faultfing	2	0
DPE-2014-04-22.xls	2	Occasionally smoking - Dilution gas adjusted accordingly and faultfing	2	0
DPE-2014-04-23.xls	0	0	0	0
DPE-2014-04-24.xls	2	Occasionally smoking - Dilution gas adjusted accordingly and faultfing	2	0
DPE-2014-04-25.xls	1	Occasionally smoking - Dilution gas closed	1	0
DPE-2014-04-26.xls	1	Occasionally smoking - Dilution gas closed	1	0
DPE-2014-04-27.xls	1	Occasionally smoking - Dilution gas closed	1	0
DPE-2014-04-28.xls	1	Occasionally smoking - Dilution gas closed	1	0
DPE-2014-04-29.xls	1	Occasionally smoking - Dilution gas closed	1	0
DPE-2014-04-30.xls	0	No smoking visible from flare	0	0
DPE-2014-05-01.xls	0	No smoking visible from flare	0	0
DPE-2014-05-02.xls	0	No smoking visible from flare	0	0
DPE-2014-05-03.xls	0	No smoking visible from flare	0	0

DPE-2014-05-04.xls	0	No smoking visible from flare	0	0
DPE-2014-05-05.xls	0	No smoking visible from flare	0	0
DPE-2014-05-06.xls	0	No smoking visible from flare	0	0
DPE-2014-05-07.xls	0	No smoking visible from flare	0	0
DPE-2014-05-08.xls	0	No smoking visible from flare	0	0
DPE-2014-05-09.xls	0	No smoking visible from flare	0	0
DPE-2014-05-10.xls	0	No smoking visible from flare	0	0
DPE-2014-05-11.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-12.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-13.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-14.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-15.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-16.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-17.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-18.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-19.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-20.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-21.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-22.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-23.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-24.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-25.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-26.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-27.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-28.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-29.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-30.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-05-31.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-01.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-02.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-03.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-04.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-05.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-06.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-07.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-08.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-09.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-10.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-11.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-12.xls	0	No smoking visible from flare	0	No smoking visible from flare

DPE-2014-06-13.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-14.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-15.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-16.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-17.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-18.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-19.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-20.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-21.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-22.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-23.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-24.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-25.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-26.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-27.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-28.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-29.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-06-30.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-01.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-02.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-03.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-04.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-05.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-06.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-07.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-08.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-09.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-10.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-11.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-12.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-13.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-14.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-15.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-16.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-17.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-18.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-19.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-20.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-21.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-22.xls	0	No smoking visible from flare	0	No smoking visible from flare

DPE-2014-07-23.xls	0	No smoking visible from flare	0	No smoking visible from flare
DPE-2014-07-24.xls	1	slight signs of smoke.	1	0
DPE-2014-07-25.xls	1	slight signs of smoke.	1	0
DPE-2014-07-26.xls	1	slight signs of smoke.	1	0
DPE-2014-07-27.xls	3	slight signs of smoke.	3	0
DPE-2014-07-28.xls	1	slight signs of smoke.	1	0
DPE-2014-07-29.xls	1	slight signs of smoke.	1	0
DPE-2014-07-30.xls	1	slight signs of smoke.	1	0
DPE-2014-07-31.xls	3	slight signs of smoke.	2	0
DPE-2014-08-01.xls	1	slight signs of smoke.	1	0
DPE-2014-08-02.xls	1	slight signs of smoke.	1	0
DPE-2014-08-03.xls	0	No smoke - process off line	0	0
DPE-2014-08-04.xls	1	slight signs of smoke.	1	0
DPE-2014-08-05.xls	0	Off line	0	0
DPE-2014-08-06.xls	0	Off line	0	0
DPE-2014-08-07.xls	0	Off line	0	0
DPE-2014-08-08.xls	0	Off line	0	0
DPE-2014-08-09.xls	3	Smoke from the flare occasionally black otherwise grey	3	0
DPE-2014-08-10.xls	3	Smoke from the flare occasionally black otherwise grey	2	0
DPE-2014-08-11.xls	3	Grey smoke	3	0
DPE-2014-08-12.xls	3	Grey smoke	3	0
DPE-2014-08-13.xls	3	Grey smoke	3	0
DPE-2014-08-14.xls	1	Slight Grey smoke	1	0
DPE-2014-08-15.xls	2	Slight Grey smoke with black patches every now and then	2	0
DPE-2014-08-16.xls	2	Slight Grey smoke with black patches every now and then	2	0
DPE-2014-08-17.xls	2	Black smoke	2	0
DPE-2014-08-18.xls	2	Black to Grey smoke	2	0
DPE-2014-08-19.xls	2	Black to Grey smoke	2	0
DPE-2014-08-20.xls	2	Black to Grey smoke	2	0
DPE-2014-08-21.xls	2	Black to Grey smoke	2	0
DPE-2014-08-22.xls	2	Black to Grey smoke	2	0
DPE-2014-08-23.xls	1	Light Grey smoke	1	0
DPE-2014-08-24.xls	1	Light Grey smoke	1	0
DPE-2014-08-25.xls	1	Light Grey smoke	1	0
DPE-2014-08-26.xls	1	Light Grey smoke	1	0
DPE-2014-08-27.xls	1	Light Grey smoke	1	0
DPE-2014-08-28.xls	1	Light Grey smoke	1	0

DPE-2014-08-29.xls	1	Light Grey smoke	1	0
DPE-2014-08-30.xls	1	Light Grey smoke	1	0
DPE-2014-08-31.xls	1	Light Grey smoke	1	0
DPE-2014-09-01.xls	1	Light Grey smoke	1	0
DPE-2014-09-02.xls	1	Light Grey smoke	1	0
DPE-2014-09-03.xls	1	Light Grey smoke	1	0
DPE-2014-09-04.xls	1	Light Grey smoke	1	0
DPE-2014-09-05.xls	1	Light Grey smoke	1	0
DPE-2014-09-06.xls	1	Light Grey smoke	1	0
DPE-2014-09-07.xls	1	Light Grey smoke	1	0
DPE-2014-09-08.xls	1	Light Grey smoke	1	0
DPE-2014-09-09.xls	1	Light Grey smoke	1	0
DPE-2014-09-10.xls	1	Light Grey smoke	1	0
DPE-2014-09-11.xls	1	Light Grey smoke	1	0
DPE-2014-09-12.xls	3	Light Grey smoke	3	0
DPE-2014-09-13.xls	1	Light Grey smoke	1	0
DPE-2014-09-14.xls	1	Light Grey smoke	1	0
DPE-2014-09-15.xls	1	Light Grey smoke	1	0
DPE-2014-09-16.xls	1	Light Grey smoke	1	0
DPE-2014-09-17.xls	1	0	1	0
DPE-2014-09-18.xls	1	0	1	0
DPE-2014-09-19.xls	1	0	1	0
DPE-2014-09-20.xls	1	0	1	0
DPE-2014-09-21.xls	2	0	2	0
DPE-2014-09-22.xls	2	0	2	0
DPE-2014-09-23.xls	2	0	2	0
DPE-2014-09-24.xls	1	0	1	0
DPE-2014-09-25.xls	0	AGC offline	0	0
DPE-2014-09-26.xls	0	SD	0	0
DPE-2014-09-27.xls	0	SD	0	0
DPE-2014-09-28.xls	0	SD	0	0
DPE-2014-09-29.xls	0	SD	0	0
DPE-2014-09-30.xls	0	SD	0	0
DPE-2014-10-01.xls	0	SD	0	0
DPE-2014-10-02.xls	0	SD	0	0
DPE-2014-10-03.xls	0	SD	0	0
DPE-2014-10-04.xls	0	SD	0	0
DPE-2014-10-05.xls	0	SD	0	0
DPE-2014-10-06.xls	0	SD	0	0
DPE-2014-10-07.xls	0	SD	0	0

DPE-2014-10-08.xls	0	SD	0	SD
DPE-2014-10-09.xls	0	SD	0	SD
DPE-2014-10-10.xls	0	SD	0	SD
DPE-2014-10-11.xls	0	SD	0	SD
DPE-2014-10-12.xls	0	SD	0	SD
DPE-2014-10-13.xls	0	SD	0	SD
DPE-2014-10-14.xls	0	SD	0	SD
DPE-2014-10-15.xls	0	SD	0	SD
DPE-2014-10-16.xls	0	SD	0	SD
DPE-2014-10-17.xls	0	SD	0	SD
DPE-2014-10-18.xls	0	SD	0	SD
DPE-2014-10-19.xls	0	SD	0	SD
DPE-2014-10-20.xls	0	SD	0	SD
DPE-2014-10-21.xls	0	SD	0	SD
DPE-2014-10-22.xls	0	SD	0	SD
DPE-2014-10-23.xls	0	SD	0	SD
DPE-2014-10-24.xls	0	SD	0	SD
DPE-2014-10-25.xls	0	SD	0	SD
DPE-2014-10-26.xls	0	SD	0	SD
DPE-2014-10-27.xls	0	SD	0	SD
DPE-2014-10-28.xls	0	SD	0	SD
DPE-2014-10-29.xls	0	SD	0	SD
DPE-2014-10-30.xls	0	SD	0	SD
DPE-2014-10-31.xls	0	SD	0	SD
DPE-2014-11-01.xls	0	SD	0	SD
DPE-2014-11-02.xls	0	SD	0	SD
DPE-2014-11-03.xls	0	SD	0	SD
DPE-2014-11-04.xls	0	SD	0	SD
DPE-2014-11-05.xls	0	SD	0	SD
DPE-2014-11-06.xls	0	SD	0	SD
DPE-2014-11-07.xls	0	SD	0	SD
DPE-2014-11-08.xls	0	SD	0	SD
DPE-2014-11-09.xls	0	SD	0	SD
DPE-2014-11-10.xls	0	SD	0	SD
DPE-2014-11-11.xls	0	SD	0	SD
DPE-2014-11-12.xls	0	SD	0	SD
DPE-2014-11-13.xls	0	SD	0	SD
DPE-2014-11-14.xls	0	SD	0	SD
DPE-2014-11-15.xls	0	SD	0	SD
DPE-2014-11-16.xls	0	SD	0	SD

DPE-2014-11-17.xls	0	SD	0	SD
DPE-2014-11-18.xls	0	SD	0	SD
DPE-2014-11-19.xls	0	SD	0	SD
DPE-2014-11-20.xls	0	SD	0	SD
DPE-2014-11-21.xls	0	SD	0	SD
DPE-2014-11-22.xls	0	SD	0	SD
DPE-2014-11-23.xls	0	SD	0	SD
DPE-2014-11-24.xls	0	SD	0	SD
DPE-2014-11-25.xls	0	SD	0	SD
DPE-2014-11-26.xls	0	SD	0	SD
DPE-2014-11-27.xls	0	SD	0	SD
DPE-2014-11-28.xls	0	SD	0	SD
DPE-2014-11-29.xls	0	SD	0	SD
DPE-2014-11-30.xls	0	SD	0	SD
DPE-2014-12-01.xls	0	SD	0	SD
DPE-2014-12-02.xls	0	SD	0	SD
DPE-2014-12-03.xls	0	0	0	0
DPE-2014-12-04.xls	0	0	0	0
DPE-2014-12-05.xls	0	0	0	0
DPE-2014-12-06.xls	0	0	0	0
DPE-2014-12-07.xls	0	0	0	0
DPE-2014-12-08.xls	0	0	0	0
DPE-2014-12-09.xls	0	0	0	0
DPE-2014-12-10.xls	0	0	0	0
DPE-2014-12-11.xls	0	0	0	0
DPE-2014-12-12.xls	0	0	0	0
DPE-2014-12-13.xls	0	0	0	0
DPE-2014-12-14.xls	0	0	0	0
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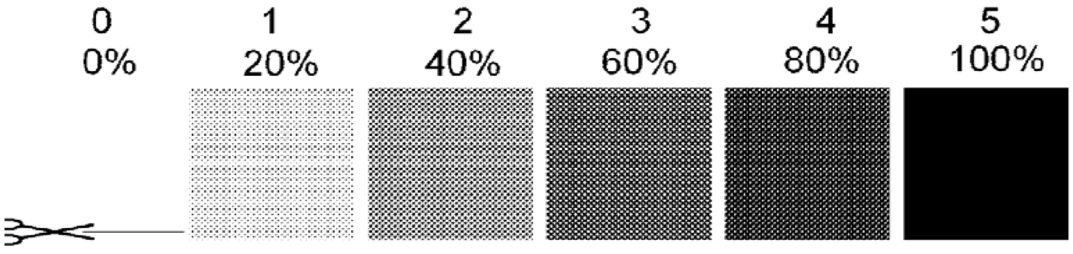
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APPENDIX I

2014 Sable Island Air Quality Monitoring

EXXONMOBIL / Encana AIR EMISSIONS ANALYSIS FOR 2014

March 2nd 2015

Submitted By: Dr. Mark Gibson
CEO, Kingfisher Environmental Health Consultants
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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 was 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 2014, 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)
- sulphur dioxide (SO_2)
- hydrogen sulphide (H_2S)
- fine airborne particulate matter with a median aerodynamic diameter ≤ 2.5 microns ($PM_{2.5}$)
- non-methane hydrocarbons (equivalent to the total-volatile organic compound species concentration)
- black carbon (BC).

It was found that the average wind vector for 2014 was 252° which is consistent with prevailing winds on the Scotian shelf and advecting over Sable Island. Pollution rose analysis revealed that the average wind directional dependence of the air pollution metrics was as follows: NO_x 252°, SO_2 254°, $PM_{2.5}$ 241°, O_3 251°, H_2S 240°, BC 263° and NMHC 241°. The general agreement between the annual average wind directional dependence with the average wind direction suggests that long-range transport (LRT) from the continent as the main source of these air pollution metrics on Sable Island. However, some spikes in $PM_{2.5}$ are likely due to sea salt spray on stormy days.

The most important feature of the air pollution data acquired in 2014 was the recording of a H_2S emission threshold breach of 3.4 ppb (threshold 3.11 ppb) observed at 4 am on August 7 that lasted for 1-hour. After an investigation by facility management it was determined that it was likely related to an issue with acid gas flaring a few hours earlier on Deep Panuke natural gas production platform (Personal communication from Marielle Thillet, Encana, August 14, 2014). This breach is well below any health regulation standard, e.g. Canadian Ambient Air Quality Objective (1-hr average of 30 ppb). There were no other threshold breaches for the remaining air pollutant metrics in 2014.

The mean (min:max) air pollution metric concentrations observed on Sable Island during 2014 were as follows:

Non methane hydrocarbons	0.001 (0.0 : 0.061) ppm
BC	0.082 (0.0 : 22.34) μg/m^3
SO_2	0.65 (0.1 : 4.3) ppb
NO_x	0.87 (0.0 : 44.1) ppb
$PM_{2.5}$	8.1 (0.0 : 69.0) μg/m^3
O_3	35.8 (15.0 : 65.0) ppb
H_2S	0.68 (0.1 : 3.4) ppb

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.

NOAA HYSPLIT air mass back trajectory system, NASA Aqua and Terra MODIS satellites and the Canadian Wildland Fire Information System were used to further investigate, and aid the identification of spikes in the air pollution metrics (~ 3x standard deviation above the mean). Spikes in NO_x, $PM_{2.5}$, and O_3 originate from known source regions in the Ohio valley, Ontario, Quebec, NE US and Nova Scotia prior to arriving on Sable Island. Spikes in H_2S seen on June 15 and July 16 are likely due to H_2S acid gas emissions from Deep Panuke by virtue of local wind directional analysis. The spike on August 7 was attributed to acid gas emissions from Deep Panuke natural gas production platform as mentioned above. Spikes in SO_2 were likely a result of continental outflow from known source regions with possible input from Deep Panuke and Thebaud due to the local wind crossing these platforms on the day of the spikes. However, attributing SO_2 to the total concentration observed on Sable Island from theses O&G platforms is impossible at present without conducting source apportionment and dispersion modelling efforts (outside the scope of this report). From scrutiny of the NRCan Canadian Wildland Fire Maps online, together with air mass back trajectory analysis, pointed to the spikes seen for BC on April 19, July 13 and July 20 likely being associated with wildland fire smoke plumes advected to Sable Island on these dates. There is intriguing evidence (stagnant marine air flow) that the spikes in NMHC on May 26, June 9 and June 23 through 28 are associated with marine biogenic emissions and neither continental outflow or O&G production operations.

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. 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.

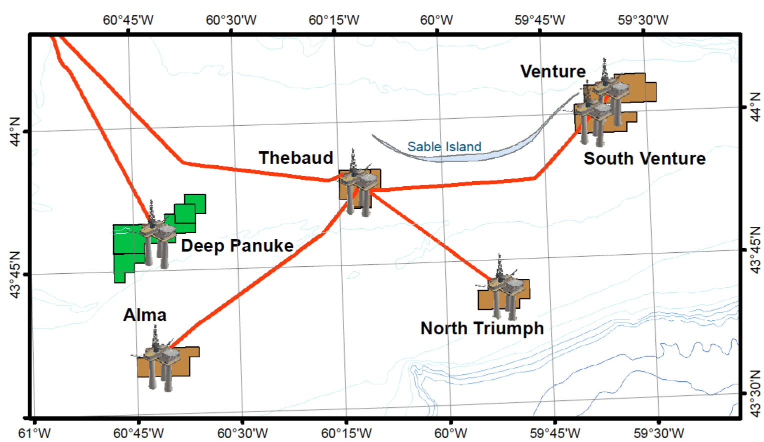


Figure 1. Location of the O&G platforms surrounding Sable Island

Platform Name	Platform Centre Location - NAD83			
	Geographic		UTM (Zone 20)	
	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 Name	Platform Centre Location - NAD27			
	Geographic		UTM (Zone 20)	
	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

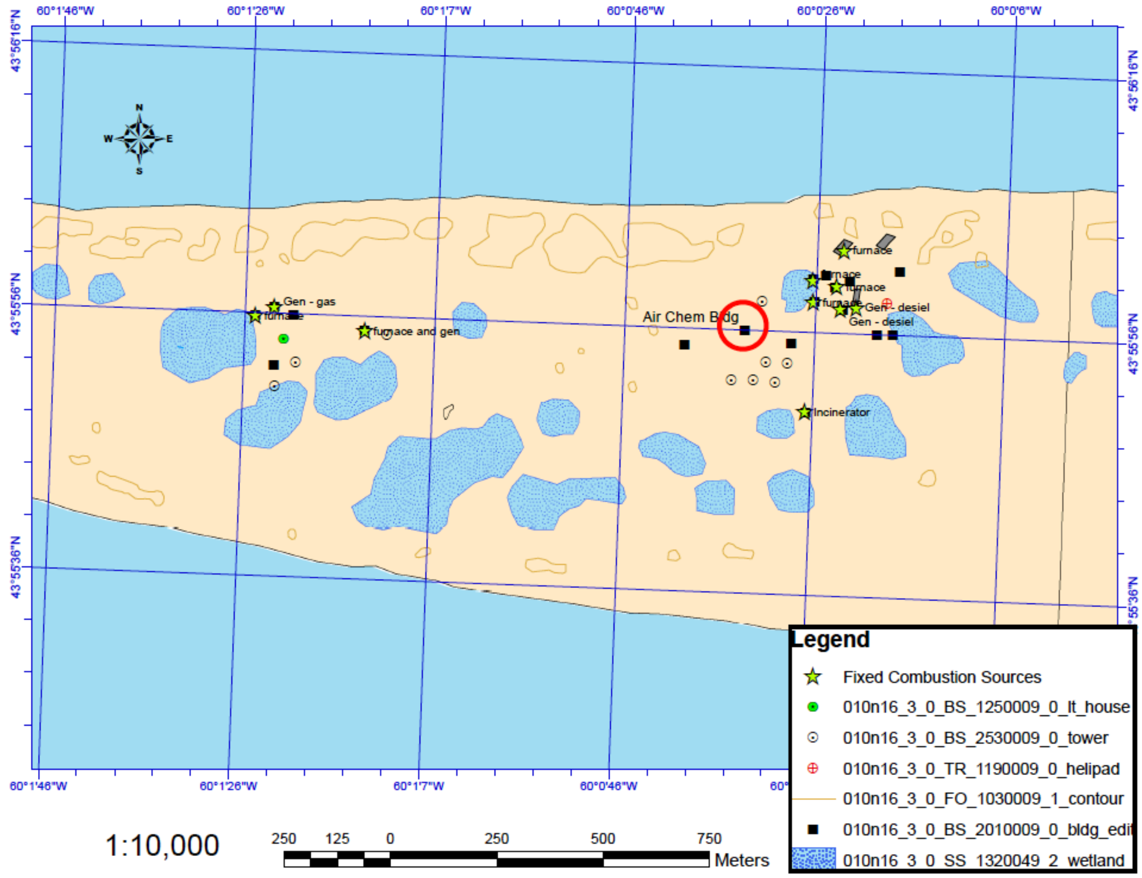


Figure 2. Location of facilities and on-Island combustion sources on Sable Island.

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 2014 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 January 14, 2015 for detailed information regarding the maintenance, management and QA/QC of the instruments on Sable Island. Feedback has yet to be received.

It has been indicated that Nova Scotia Environment will discontinue to manage air emissions monitoring on Sable Island from January 1st 2015. This pertains to the measurement of NO_x, H_2S, SO_2, O_3 and $PM_{2.5}$. An alternate to conduct this air monitoring is currently being sought.

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 2015, 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 2015***	15-min
TSI 3321 Aerodynamic Particle Sizer	ESRF Funding (Gibson/Craig) ***To be deployed in 2015***	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 2015***	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 2015 if power can be installed in the air chemistry building***	Hourly

1.5 ANALYSES

1.5.1 Data Acquisition

Air quality data for 2014 thus far was obtained from two sources, Nova Scotia Environment and Dr. Gibson's data collection on Sable Island for of BC and NMHC. Black carbon and NMHC analysis began in May 2013. All data were cleaned, negative baseline drift corrected, calibration values removed and text flags removed.

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 - µg/m^3 (ppb))

Pollutant and units (alternative units in brackets)	Averaging Time Period	Nova Scotia	Canada				
		Maximum Permissible Ground Level Concentration	Canada Wide Standards	Ambient Air Quality Objectives			World Health Organization (WHO)
				Maximum Desirable	Maximum Acceptable	Maximum Tolerable	
Nitrogen dioxide µg/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 µg/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) µg/m^3	24 hour	120	-	-	120	400	
	Annual	70 (geometric mean)	-	60	70	-	
PM2.5 (fine) µg/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) µg/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 µg/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 µg/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 2014 Air Quality Data

Table **4** contains the descriptive statistics and data completeness for 2014 air pollutant metrics for the hourly non-QA/QC'd data.

Table 4. Descriptive statistics and data completeness for hourly 2014 air pollutant metrics

Metric	NMHC *[ppm]*	BC *[µg m^{-3}]*	SO_2 *[ppb]*	NO_x *[ppb]*	NO *[ppb]*	NO_2 *[ppb]*	$PM_{2.5}$ *[µg m^{-3}]*	O_3 *[ppb]*	H_2S *[ppb]*
n	6001	7197	5854	8711	8695	8701	5035	8576	5522
Mean	0.001	0.082	0.654	0.867	0.404	0.468	8.113	35.778	0.682
Std Dev	0.005	0.472	0.792	1.069	0.420	0.714	5.057	7.223	0.291
Max	0.061	22.34	4.3	44.1	22.4	24.4	69	65	3.4
99pct	0.032	0.727	4	3.29	1	2.4	25	53	1.3
98pct	0.008	0.404	3.5	2.5	0.8	1.8	22	50	1.258
95pct	0	0.23	2.7	1.7	0.6	1.2	18	47	1.2
75pct	0	0.078	0.7	0.9	0.5	0.6	10	41	0.9
Median	0	0.038	0.3	0.7	0.4	0.3	7	36	0.6
25pct	0	0.012	0.2	0.6	0.3	0.2	5	31	0.5
Min	0	0	0.1	0	0	0	0	15	0.1
Data Completeness	68.50%	82.16%	66.83%	99.44%	99.26%	99.33%	57.48%	97.90%	63.04%

pct = percentile

From Table **4** it can be seen that the data completeness for 2014 is poor for $PM_{2.5}$ (57.48%), H_2S (63.04%), SO_2 (66.83%), and NMHC (68.50%). These poor data completeness results are a reflection of the difficulties gaining access to the Island for instrument maintenance due to intermittent flights and bad weather. This is a major challenge conducting air quality measurements on Sable Island. In terms of the instruments managed by Dr. Gibson's group, it has been difficult to find a flight to transport carrier gas to the Island for the NMHC analyzer. It is recommended that a N_2 carrier gas generator be purchased for the Thermo 55i total-VOC (NMHC) instrument. This would improve data completeness for this instrument.

However, it can be seen in Table **4** that the data completeness during 2014 for O_3 (97.90%), BC (82.16%) and NO_x, NO & NO_2 (99.44%, 99.26% and 99.33%) was excellent.

When annual data completeness is below 75% it impairs robust seasonal statistical analysis of the data.

As can be seen in Table **4** the mean (minimum : maximum) NO_x concentration was found to be 0.87 (0.0 : 44.1) ppb; SO_2 0.65 (0.1 : 4.3) ppb; H_2S 0.68 (0.1 : 3.4) ppb; $PM_{2.5}$ 8.11 (0.0 : 69.0) µg/m^3; O_3 35.78 (15.0 : 65.0) ppb; BC 0.082 (0.0 : 22.34) µg/m^3; NMHC 0.001 (0.0 : 0.061) ppm. All but SO_2, O_3 and H_2S recorded minimums with a concentration of 0.0 ppb/ µg/m^3.

The observed maximum hourly H_2S concentration of 3.4 ppb was likely due to an operational issue on the Deep Panuke facility related to dilution gas dosing problem that resulted in incomplete combustion of acid gas on August 7. Marielle Thillet (Encana) relayed this information on August 14, 2014. In addition, further evidence pointing to Deep Panuke as the source of the H_2S spike was obtained from air mass back trajectory modelling. This modelling revealed that the airflow crossed Deep Panuke en route to Sable Island during this period, with the likely consequence of advecting H_2S emissions to the Island. In addition, the ExxonMobil Thebaud platform reported a smell of 'sour gas' on the same day. Thebaud is roughly inline, and between, Deep Panuke and Sable Island. This evidence points toward Deep Panuke as being the likely source of the H_2S during the threshold breach. This is the only occurrence of a H_2S threshold breach (set at 3.11 ppb) in 2014. This breach is well below any health regulation standard, e.g. Canadian Ambient Air Quality Objective (1-hr average of 30 ppb). There were no other threshold breaches for the remaining air pollutant metrics in 2014.

Figure **3** provides a non-parametric visualization (box-whisker plot) of the daily average air pollution data for 2014. Box plots provide insight into the central tendency, variance and range of data by means of a non-parametric visualization.

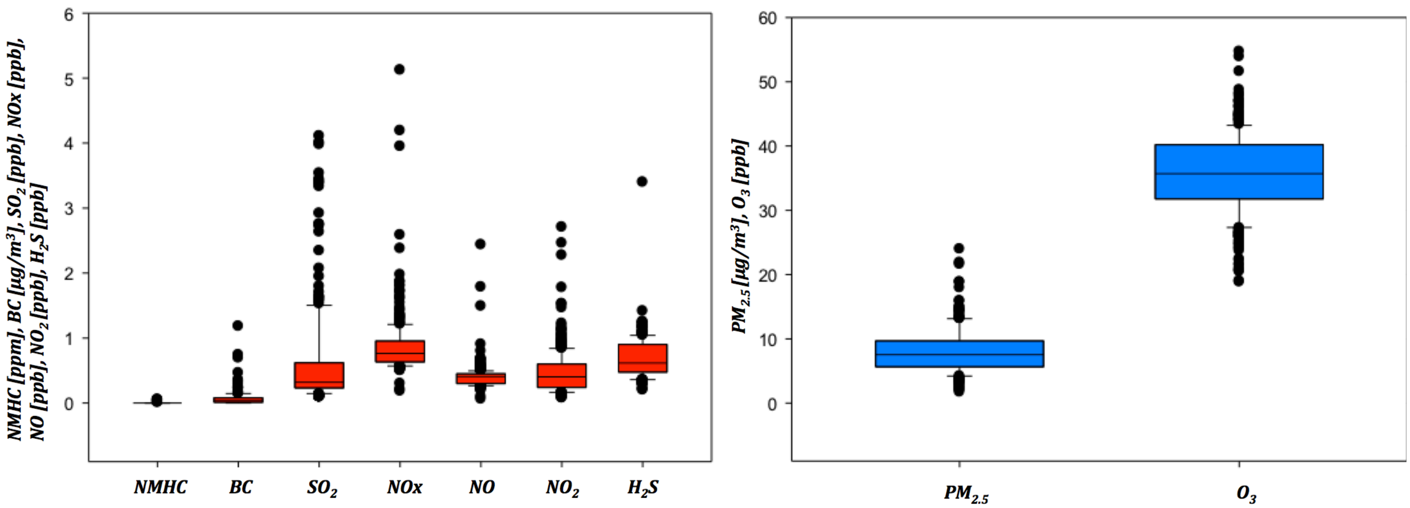


Figure 3. Box-whisker plot of the daily average air pollution data for 2014

Figure 4 provides a time series plot of the available NO, NO_2 and NO_x daily averages data for 2014.

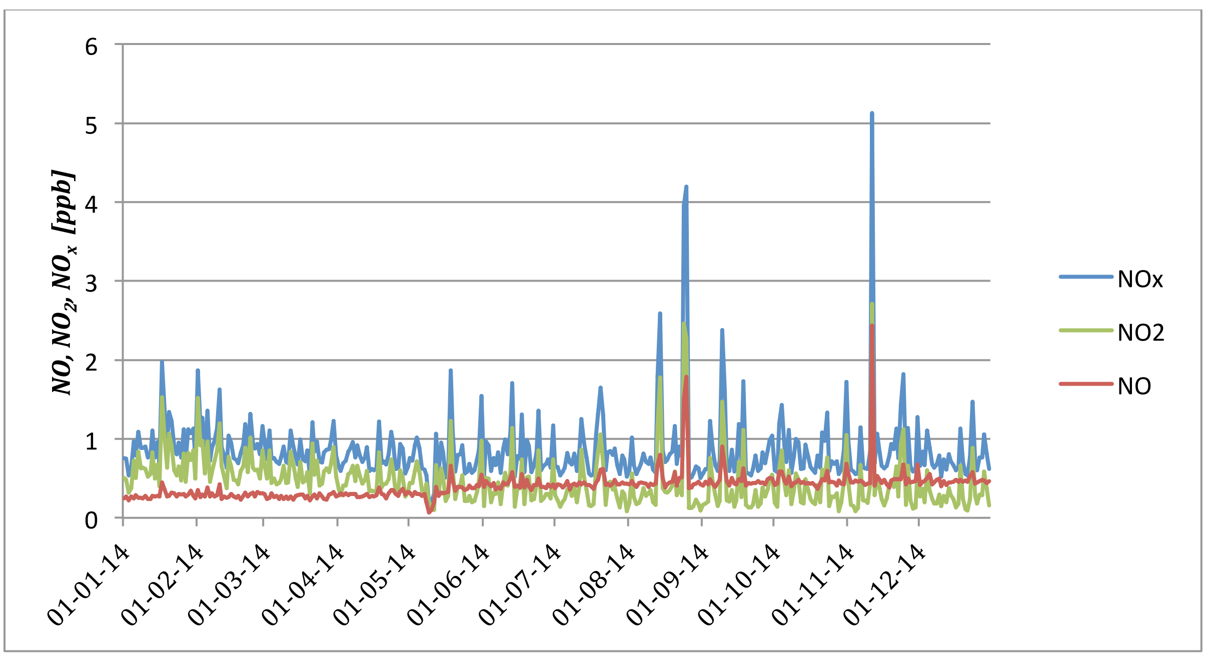


Figure 4. Time series plot of the available NO, NO_2 and NO_x daily averages data for 2014

The time series shown in Figure 4 shows three NO, NO_2 and NOx 'spikes' that occurred on August 14 (0.8, 1.78 and 2.59 ppb respectively), August 25 (1.79, 2.28, 4.19 ppb respectively) and November 11 (2.44, 2.71, 5.13 ppb respectively). Scrutiny of the HYSPLIT 5-day air mas back trajectories in the Appendix show that the air parcels on August 14th and 25th originated from the N and NE prior to arriving on Sable Island and therefore these spikes are not likely to be associated with O&G production or on Island combustion. The air mass back trajectories on November 11th originate from the NW, crossing Ontario, Quebec, NE US and Nova Scotia prior to arriving on Sable Island. Therefore the spike in NO_x observed on this date is most likely due to LRT of mainland combustion related emissions and not associated with O&G production or on Island combustion.

Figure 5 provides a time series plot of the available SO_2 daily average data for 2014.

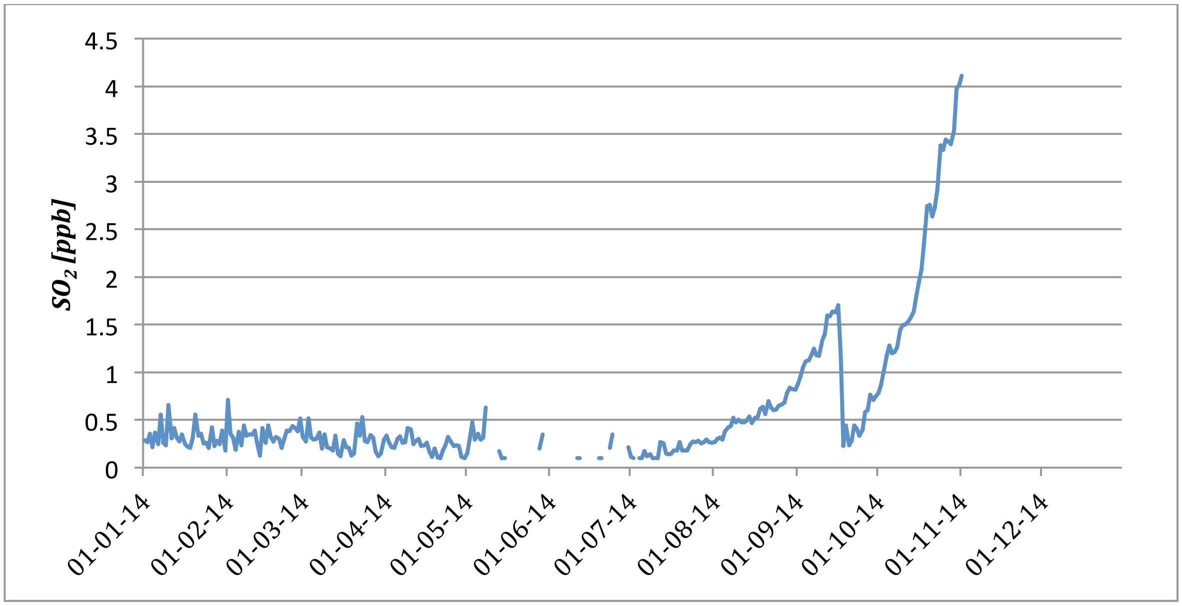


Figure 5. Time series plot of the available SO_2 daily average data for 2014

From the time series of SO_2 provided in Figure **5** it can be seen that the instrument drifted from approximately August 1 onwards with a re-calibration on September 20. Scutiny of the data prior to August 1, 2014 shows a pike in SO_2 on January 10, February 1 and May 8. Scrutiny of the NOAA HYSPLIT 5-day air mass back trajectories show that prior to January 10 the air parcel crossed known source regions of SO_2 in the Ohio valley, Windsor – Québec corridor and the NE USA and therefore the spike in SO_2 was unlikely to be due to O&G production operations. The 5-day air mass back trajectories related to February 1 show that the air parcel crossed known source regions of SO_2 in the Ohio valley, Ontario, NE USA, Deep Panuke and Thebaud en route to Sable Island. It is therefore possible that a contribution to the SO_2 spike observed on February 1 was from O&G production, but mostly likely a result of LRT from the continent. Dispersion modelling of SO_2 from these O&G platforms would confirm this hypothesis. However, this is outside the scope of this report. The 5-day air mass back trajectories for May 8 show that the air parcel crossed over Sydney and the Langan coal fired power station in Cape Breton Nova Scotia. In addition, there was a marine inversion on this day that likely trapped the SO_2 emissions from Langan coal fired power station close to the surface prior to reaching Sable Island. Therefore, the SO_2 spike on May 8 was unlikely to be due to O&G production operations.

Figure **6** provides a time series plot of the available $PM_{2.5}$ daily average data for 2014.

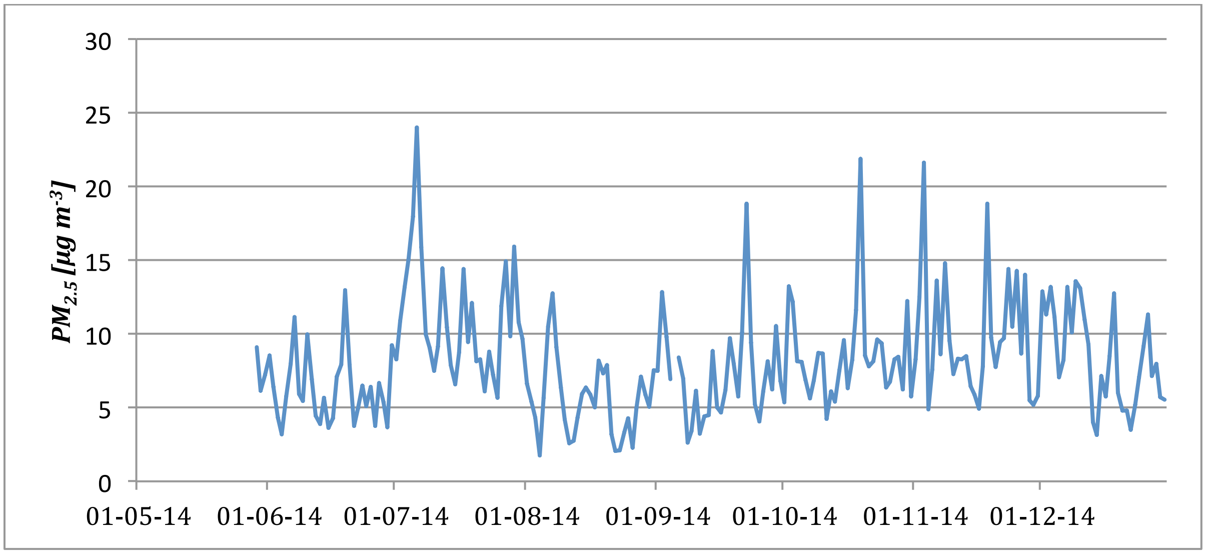


Figure 6. Time series plot of available $PM_{2.5}$ daily average data for 2014

The time series plot of $PM_{2.5}$ shown in Figure **6** shows spikes in $PM_{2.5}$ on July 6, October 19 and November 11. The $PM_{2.5}$ spikes on all of these dates appear to be related to westerly continental outflow from known upwind source regions, e.g. NE US and Southern Ontario (Gibson et al., 2015; Gibson et al., 2013).

Figure **7** provides a time series plot of the available O_3 daily average data for 2014.

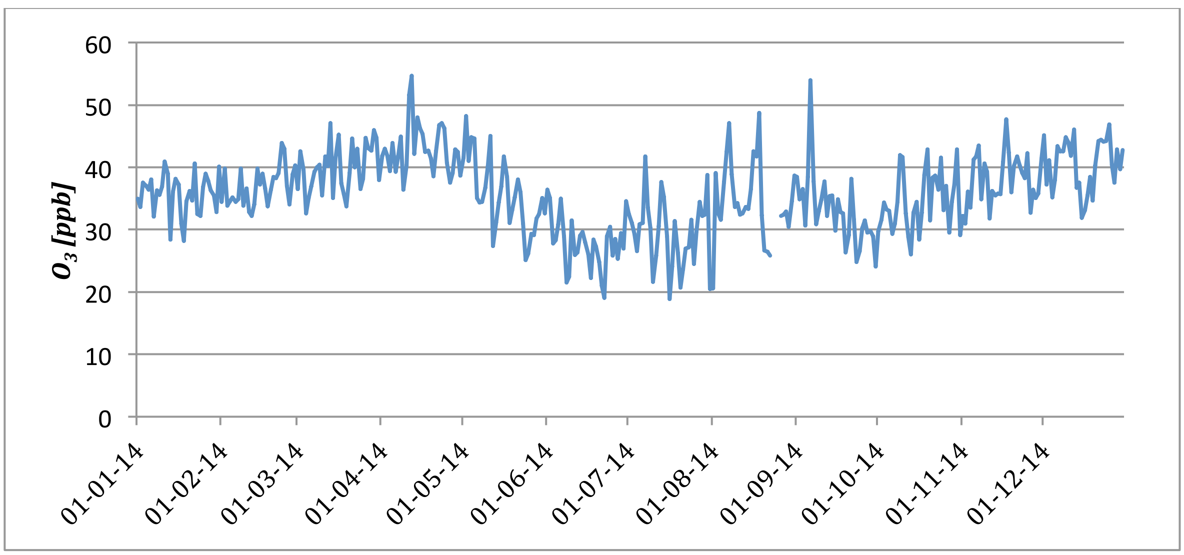


Figure 7. Time series plot of the available O_3 daily average data for 2014

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.

The annual spring maximum O_3 concentration is typically found between mid-March and mid-April (Gibson et al., 2009a). Figure **7** also displays characteristic episodic spikes during the summer due to LRT smog outflow 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. The spike on April 11 and September 6 were related to air flow crossing known source regions of ozone pre-cursors (VOCs and NO_x) in Ontario and the Ohio valley, and given the season, likely related to the photochemical formation of secondary ozone which was then advected to Sable Island on these dates.

Figure **8** provides a time series plot of the available H_2S daily average data for 2014.

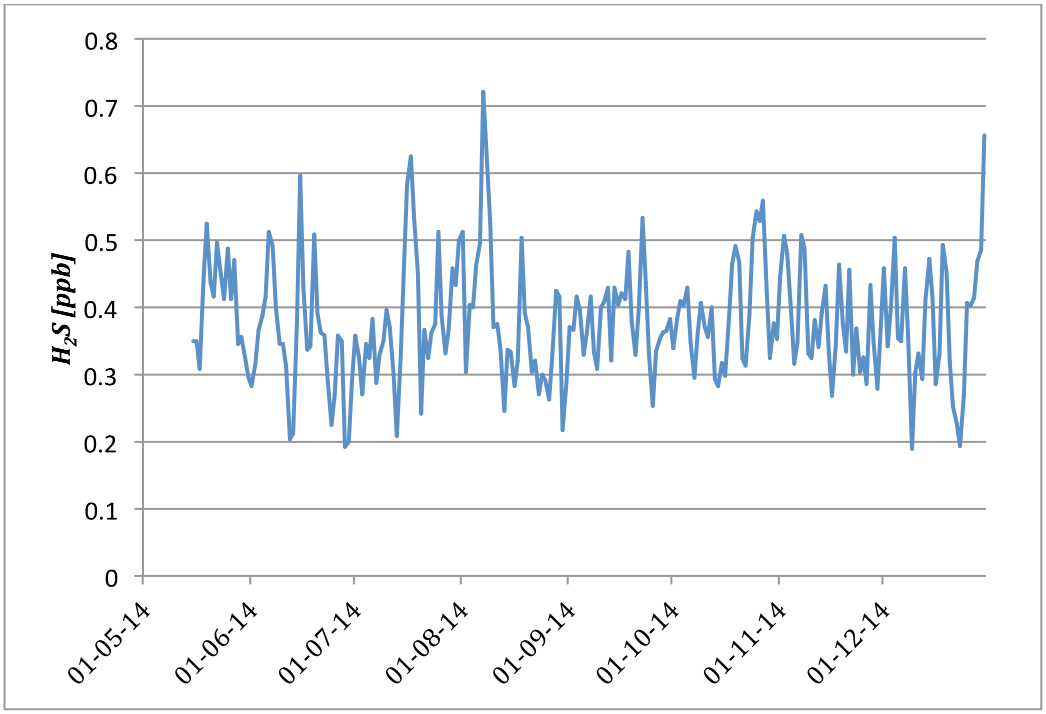


Figure 8. Time series plot of the available H_2S daily average data for 2014 that has been corrected for instrument drift beginning on June 25, 2014.

Figure **8** shows three H_2S spikes on June 15, July 16 and August 7. Local wind directional analysis and 5-day air mass back trajectories show that air flow on these dates was from the SW and crossed the Deep Panuke and Thebaud O&G production facilities prior to reaching Sale Island. It is known that there was an issue with the acid gas flaring on August 7 on Deep Panuke that caused a 1-hour threshold breach. The spikes on the other two days were also likely due to H_2S acid gas emissions from Deep Panuke. However, these spikes are well below any regulatory and health standards so of minor environmental or health concern.

Figure **9** provides a time series plot of the available black carbon daily average data for 2014.

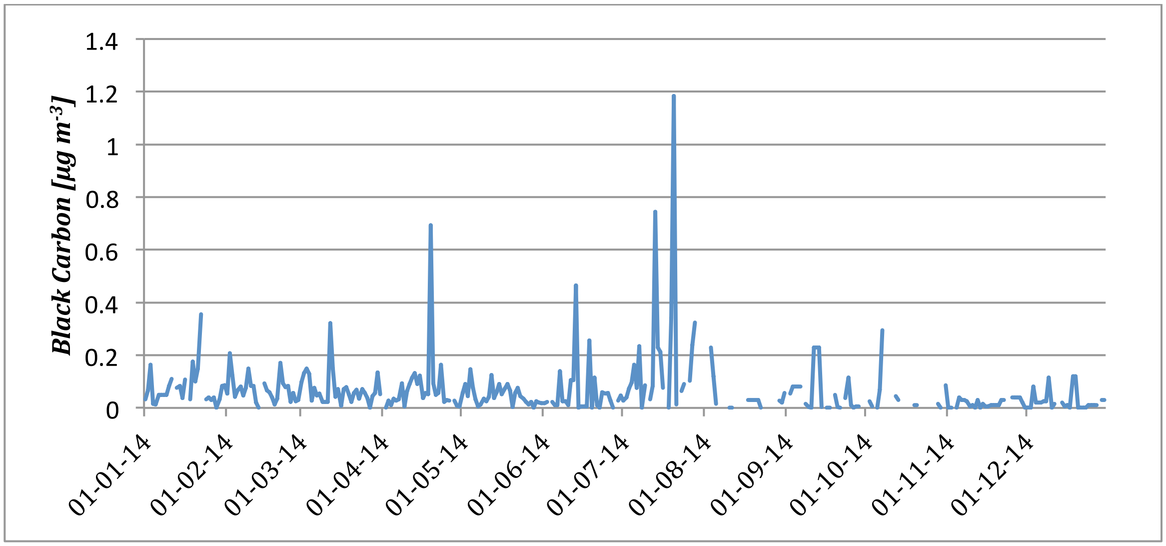


Figure 9. Time series plot of the available black carbon daily average data for 2014

The time series plot for BC shown in Figure **9** shows spikes in the BC data on observed on April 19, July 13 and July 20. Air mass back trajectories related to April 19 and July 13 show that the air parcels both originated in Northern Manitoba and Ontario prior to arrival at Sable Island. The air mass back trajectory related to July 20 crossed Québec and New Brunswick prior to reaching Sable Island. Using the online Canadian Wildland Fire Information System (http://cwfis.cfs.nrcan.gc.ca/maps/fm3?type=fwih&year=2014&month=7&day=20) it was possible to determine that all the air parcels associated with these dates crossed know regions experiencing wild fires and this is the likely cause of the spikes in BC on those days.

Figure **10** provides a time series plot of the available NMHC daily average data for 2014.

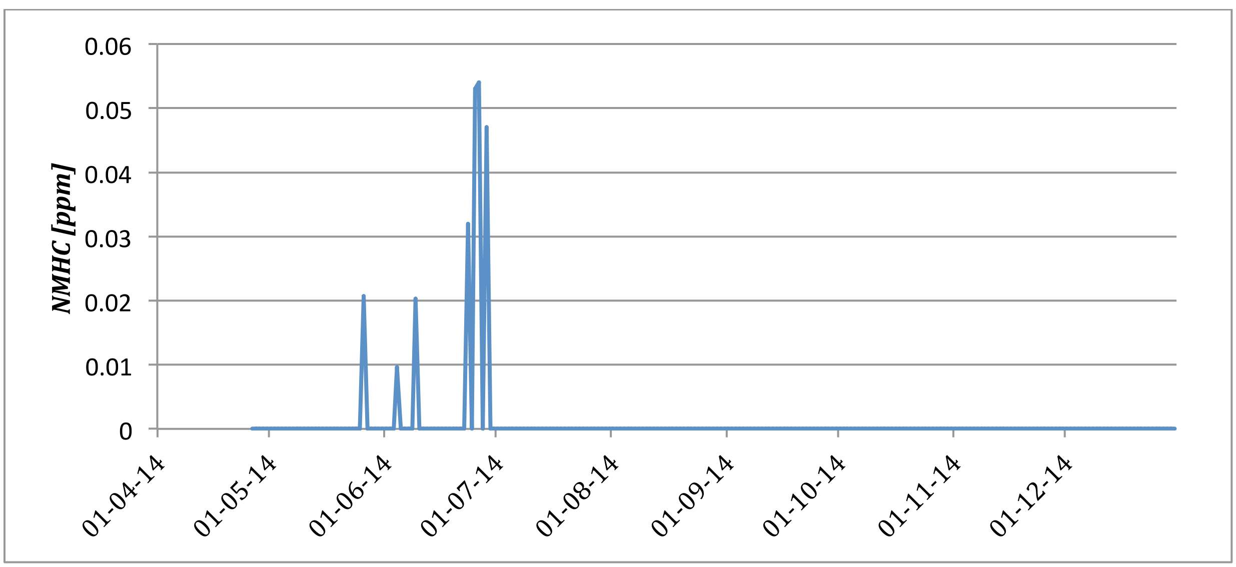
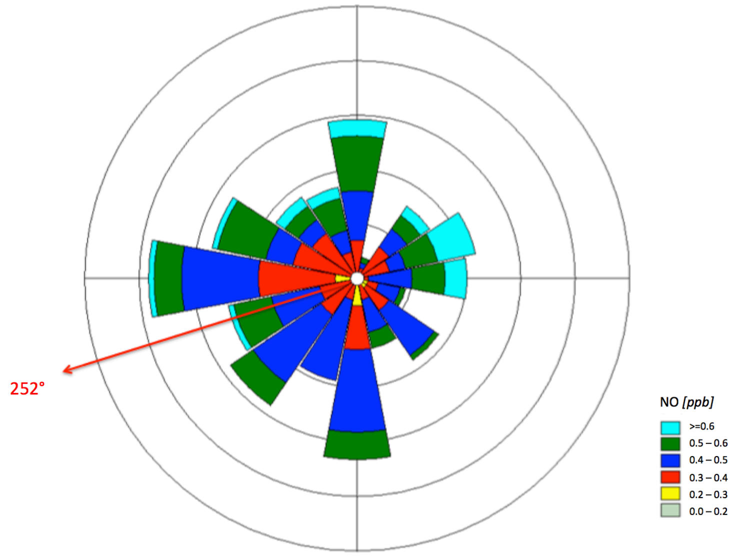
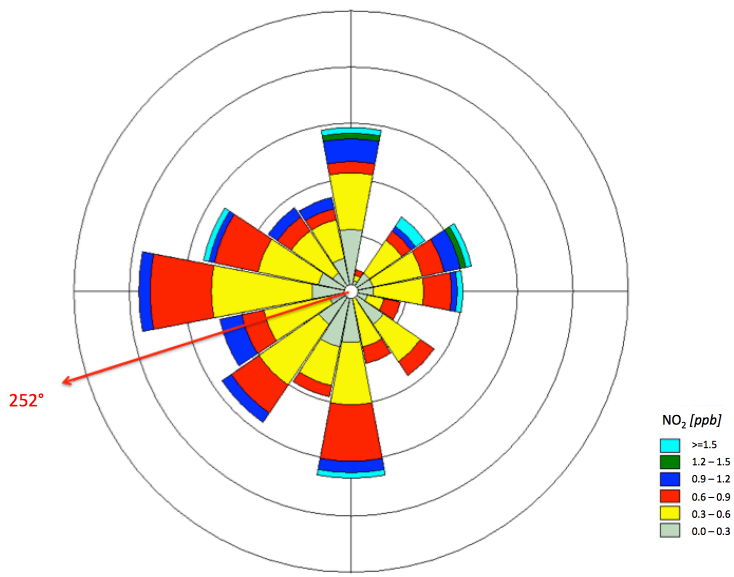


Figure 10. Time series plot of the available NMHC daily average data 2014

The time series plot shown in Figure **10** shows spikes in NMHC on May 26, June 9 and June 23 through 28. The air mass back trajectories for these dates show that the air parcel stagnated over the Scotian shelf prior to reaching Sable Island. It is therefore likely that these spikes in NMHC concentrations observed on Sable Island during these dates is due to marine biogenic emissions and neither continental outflow or O&G production operations.

Figure **11** shows a pollution rose for NO, NO_2 and NO_x in 2014.





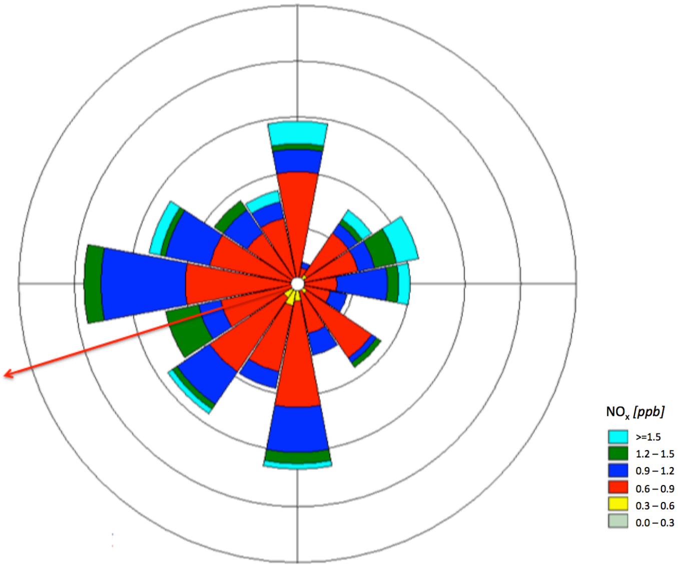


Figure 11. Pollution rose for NO, NO_2 and NO_X in 2014

Figure **11** shows that the average NO, NO_2 and NO_X vector for 2014 was 252° which aligns with the Deep Panuke and Thebaud O&G platforms, but also LRT from the mainland. In future, source apportionment of VOC species and $PM_{2.5}$ species would offer a robust method to aid with the identification of the source of the NO_x wind directional dependence on Sable Island.

Figure **12** shows a pollution rose for SO_2 in 2014.

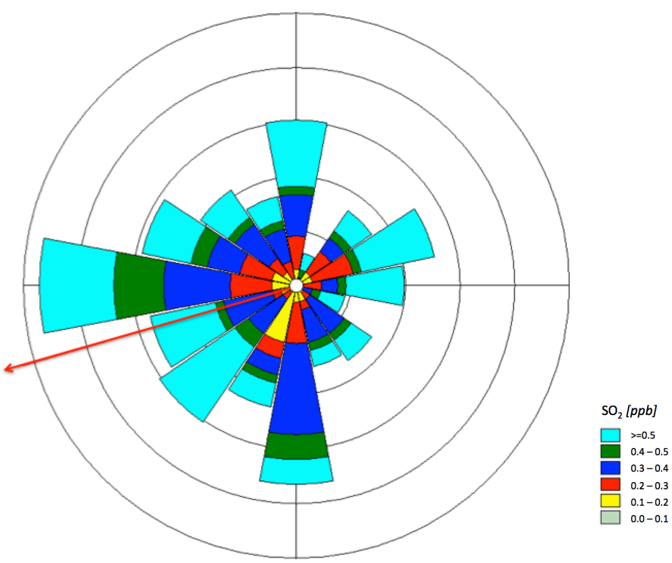


Figure 12. Pollution rose for SO_2 in 2014

Figure **12** shows that the average SO_2 vector for 2014 was 254˚ which is roughly in line with the Deep Panuke and Thebaud O&G platforms. The SW SO_2 wind directional dependence may be related to the O&G platforms, but more likely a result of prevailing winds advecting SO_2 from mainland sources to Sable Island. Source apportionment, dispersion modelling and remote sensing work would need to be conducted to determine the exact source of the SO_2.

Figure **13** shows a pollution rose for $PM_{2.5}$ in 2014.

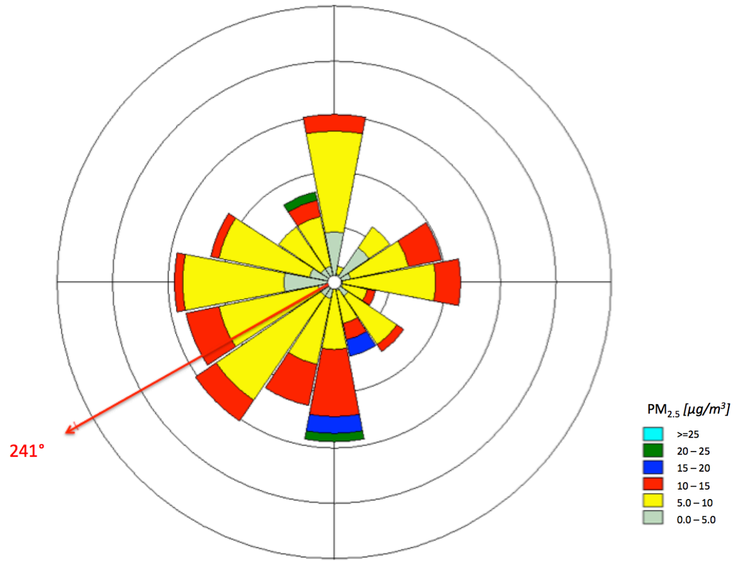


Figure 13. Pollution rose for $PM_{2.5}$ in 2014

Figure **13** shows that the average directional dependence for $PM_{2.5}$ was from 241°. The $PM_{2.5}$ pollution rose also shows elevated concentrations (> 15 µg/m^3) from the South and NW. The S direction is in line with the North Triumph platform. However, the elevated $PM_{2.5}$ from the S is more likely related to sea spray $PM_{2.5}$ during stormy weather.

The directional dependence from the N is likely continental smog outflow or wildfire smoke plumes advected to Sable Island. Further analysis of air mass back trajectories, facility operations, on-Island operations and $PM_{2.5}$ chemistry would be required before associating the $PM_{2.5}$ directional dependence to any particular source.

Figure **14** shows a pollution rose for O_3 in 2014.

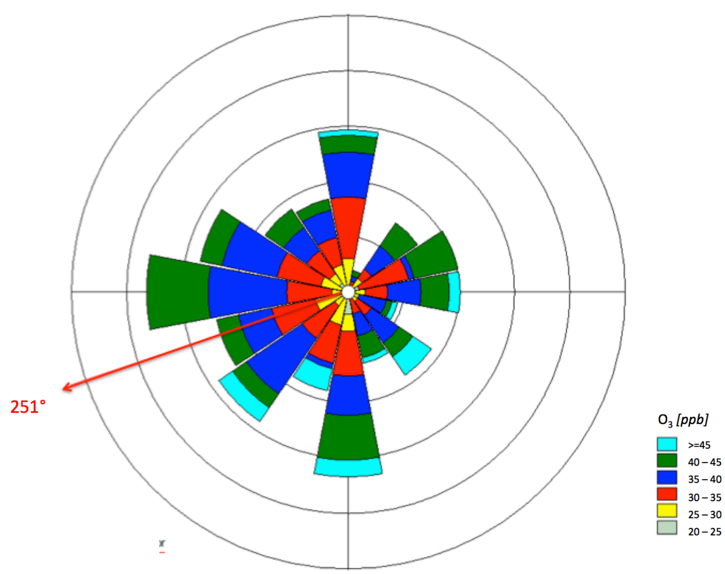


Figure 14. Pollution rose for O_3 in 2014

Figure **14** demonstrates that the average O_3 vector for 2014 was from 251°. As O_3 is a known LRT air pollutant it is likely not to be related to any O&G production activity. The average wind vector from the SW is the same as the prevailing wind that advects ozone pre-cursors (NO_x and VOCs) and O_3 to Sable Island from mainland anthropic and natural biogenic sources.

Figure **15** shows a pollution rose for H_2S in 2014.

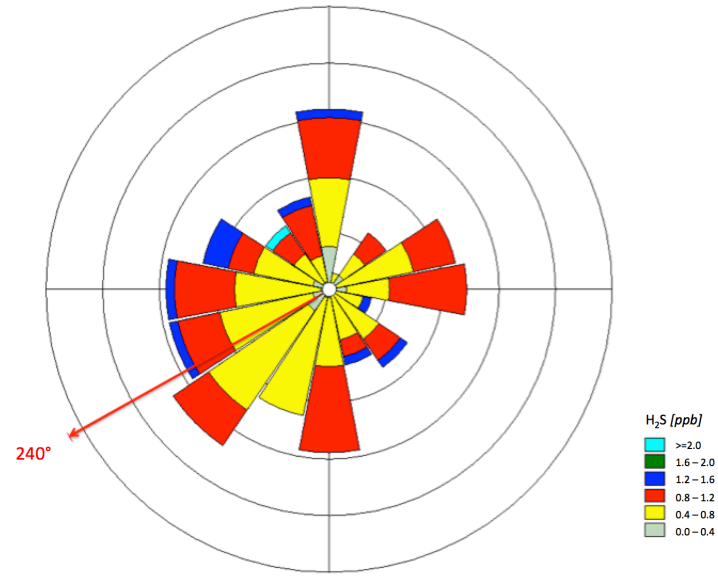


Figure 15. Pollution rose for H_2S in 2014

Figure **15** shows that the average H_2S vector for 2014 was 240° which is in line with the Thebaud, Alma, Deep Panuke O&G platforms. Deep Panuke is a known source of low concentrations of H_2S that impact Sable Island, concentrations significantly lower than Canadian Air Quality standards.

Figure **16** shows a pollution rose for BC in 2014.

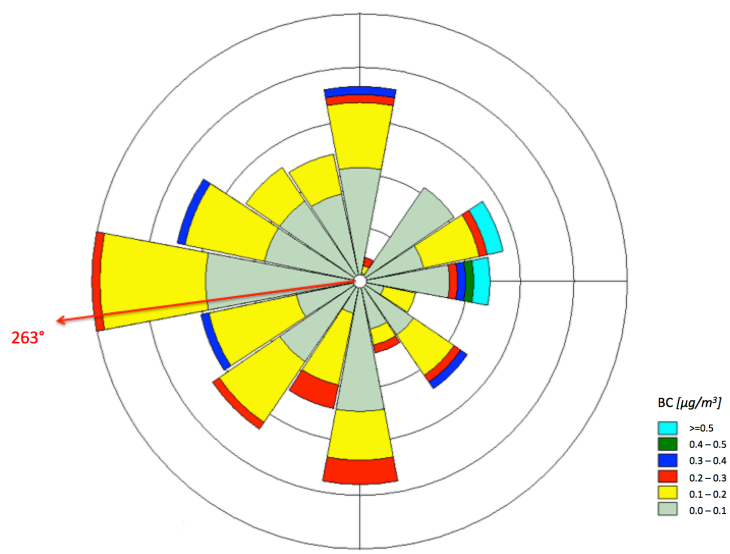


Figure 16. Pollution rose for BC in 2014

Figure **16** shows that the average BC direction vector for 2014 was 263°. It can be seen that there is an Easterly directional dependence for BC concentrations above 0.5 µg/m^3. 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.

Figure **17** shows a pollution rose for NMHC in 2014.

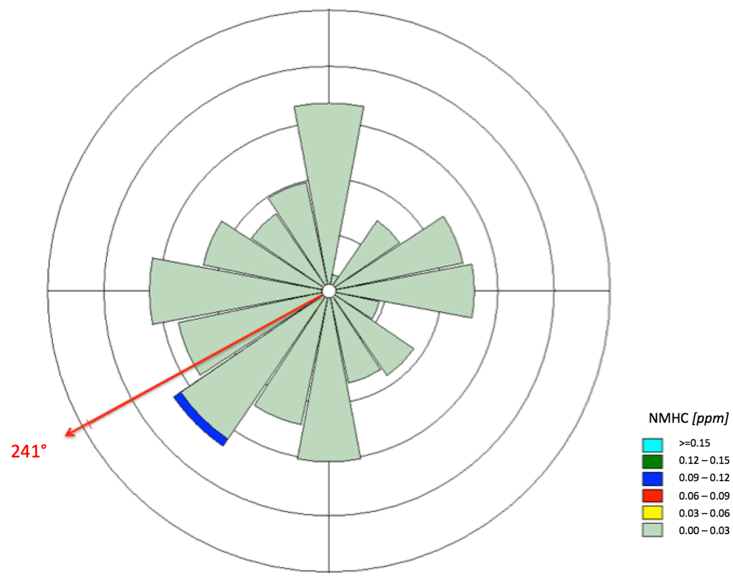


Figure 17. Pollution rose for NMHC in 2014

Figure **17** demonstrates an average wind directional dependence for NMHC from 241° with the highest concentration (> 0.09 ppm) from the SW which is roughly in line with Deep Panuke and Thebaud, but also continental air pollution outflow. Without conducting source apportionment analysis utilizing source marker VOC species and dispersion modelling from theses O&G facilities it is not possible to state if they are the source of the increase in NMHC seen from this wind vector.

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 **5**). 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 **5** provides the threshold values chosen for the air emission evaluation of O&G operations.

Table 5. 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
NO_x [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)
NMHC (Total VOC)	1/year return threshold data available from 01/01/14 to 31/12/14 (1-hr data period)	0.07 (ppmv)	N/A
BC	1/year return threshold data available from 01/01/14 to 31/12/14 (1-hr data period)	1.5 μg/m^3	N/A

Note 1: An extreme value analysis was conducted on air emissions data available between 2007 and 2011 (2014 data for BC and NMHC). 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: 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 **6** below summarizes the number of hourly spikes that exceeded the selected concentration thresholds.

Table 6. Air emission ‘spike’ thresholds for Sable Island and threshold exceedances in 2014

Metric	Suggested threshold value (1-hr)	Number of spikes over threshold	Total hours over threshold	Time and date of start of spike	Highest value during spike
NOx	17.0 ppbv	0	0		
SO_2	6.0 ppbv	0	0		
H_2S	3.11 ppbv	1	1	4.00pm, Aug 7 2014	3.4 ppb
$PM_{2.5}$	168.0 μg/m^3	0	0		
Ozone	104.0 ppbv	0	0		
BC	1.5 μg/m^3	0	0		
NMHC (total VOC)	0.07 ppm	0	0		

Table **6** shows that there was only one spike where H_2S exceeded the operational threshold. This threshold breach only lasted 1-hour. Encana communicated that this H_2S threshold spike was related to an issue with acid gas flaring on their Deep Panuke platform.

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 **7** provides the descriptive statistics for the meteorological variables for the period January 1, 2014 to December 31, 2014.

Table 7. Meteorological Variable Descriptive Statistics for 2014

Variables	Temperature (°C)	Wind Speed (km/h)	Wind Direction (°)
n	5720	7902	7902
Mean	13.09	24.6	252
Std Dev	6.02	12.0	N/A
Max	24	85.2	N/A
99pct	23	57.4	N/A
98pct	22.0	53.7	N/A
95pct	22	46.3	N/A
75pct	18	31.5	N/A
Median	14	22.2	N/A
25pct	8	14.8	N/A
Min	1	0	N/A
Data Completeness	65.3%	90.21%	90.21%

Figure **18** provides a wind rose for 2014. The average wind vector for 2014 was 252°.

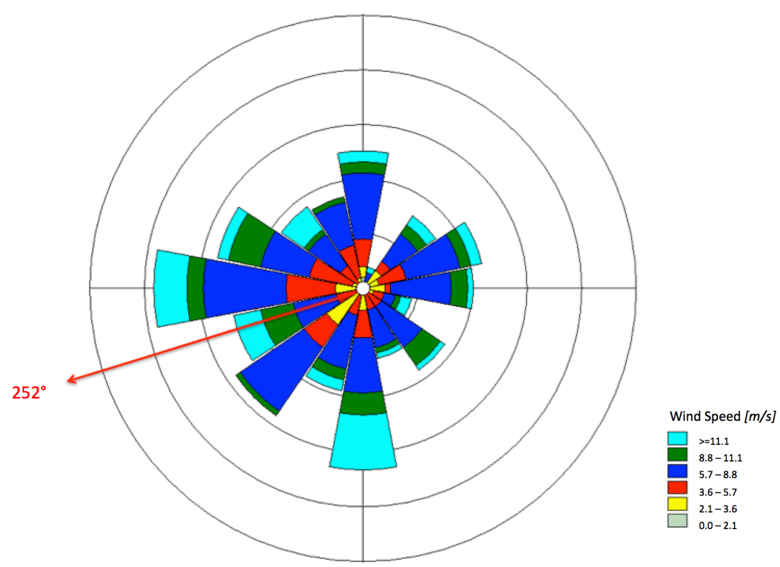


Figure 18. Wind rose for 2014

1.8 DISCUSSION

Wind rose analysis showed that the average wind vector for 2014 was 252° which is consistent with the known prevailing winds from the SW advecting over the Scotian shelf (Gibson et al., 2009a, Gibson et al., 2013b). NOAA HYSPLIT air mass back trajectory system, NASA Aqua and Terra MODIS satellites and the Canadian Wildland Fire Information System were used to aid the identification of spikes in the air pollution metrics typically observed (~ 3x standard deviation above the mean). Spikes in NO_x, $PM_{2.5}$ and O_3 originate from known source regions in the Ohio valley, Ontario, Quebec, NE US and Nova Scotia prior to arriving on Sable Island. Three spikes in H_2S spikes (June 15, July 16 and August 7) are likely due to H_2S acid gas emissions from Deep Panuke (only one was above the operational spike threshold). However, these spikes are well below any regulatory and health standards so of minor environmental or health concern. Spikes in the BC on April 19, July 13 and July 20 were likely related to wildland fires smoke advected to Sable Island on these dates. There is intriguing evidence that the spikes in NMHC on May 26, June 9 and June 23 through 28 are associated with marine biogenic emissions and neither continental outflow or O&G production operations.

1.9 CONCLUSIONS

The most important feature of the air quality data acquired on Sable Island for 2014 is that there was one operational threshold breach for H_2S (3.4 ppbv, 1-hr period; threshold at 3.11 ppb) on August 7. This threshold breach was likely a result of a short-term acid gas flaring issue on the Deep Panuke natural gas production facility (Encana communication).

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.

Currently, $PM_{2.5}$ chemical data is only collected once every 6th days and as such, 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. This data would complement the $PM_{2.5}$, black carbon, size-resolved particle number and NMHC (total VOC) data. Together, these measurements would provide a full suite of air pollutants with which to optimize the identification of local and LRT sources of air pollution that can be use to provide better air quality surveillance on Sable Island.

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.

The discontinuation of Nova Scotia Environment's management of the NO_x, SO_2, H_2S, O_3 and $PM_{2.5}$ 1-hourly air pollution monitoring on Sable Island will impact the ability to provide this report in future. Therefore, it is recommended that these measurements be continued in order for these data to be made available for future analysis and reporting.

1.11 REFERENCES

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