Revised
2010 Annual Report
Offshore Environmental Effects Monitoring Program
ExxonMobil Canada Properties - Sable Offshore Energy Project

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report is a compilation of results for the 2010 Sable Offshore Energy Project (SOEP) Environmental Effects Monitoring (EEM) program.

Components of the 2010 EEM Program included:

- Chemical and Toxicity analysis of produced water from Thebaud, Venture, South Venture and Alma platforms
- Air quality monitoring on Sable Island
- Flare monitoring on the Thebaud platform
- Seabird monitoring by vessel transect
- Beached bird surveys on Sable Island
- Mussel body burden analysis

Produced water samples were collected by ExxonMobil Canada (EMC) staff. Chemical analysis was conducted by SGS Laboratories. Harris Industrial Testing Services and Aquatox conducted the toxicity testing and Hurley Environment Ltd. prepared the discussion in Section 2 of this report.

Flare monitoring data was compiled by EMC staff. Environment Canada with support from Nova Scotia Environment will compile the data and provide a report on Sable Island Air Quality once audited data becomes available.

Seabird monitoring observations were made by Canadian Wildlife Service-nominated observers, contracted by EMC. The Seabird monitoring section was prepared by a technical resource, suggested by CWS and contracted by EMC. Beached bird survey data and section were provided by Zoe Lucas, under contract to EMC.

Mussels were collected by AMEC Earth and Environmental, contracted by EMC and analyzed by the Canadian Institute of Fisheries Technology (CIFT) and Maxxam Analytics Laboratory. The mussel health and body burden section was prepared by AMEC.

The SOEP offshore EEM program was designed principally to verify predictions made during the SOEP Environmental Assessment (EA) process. Overall, the EA process concluded that any residual effects of routine project activities (after mitigation) on Valued Ecosystem Components (VECs) in the marine environment would be minor or insignificant and would be restricted to within the 500 m-radius safety zones around offshore platforms.

Since surveys began in 1998, EEM results have validated these predictions as the underlying assumptions of the EA were purposefully conservative. Several mitigative measures beyond those identified in the EA have been undertaken by EMC to further reduce the likelihood of environmental impacts. Some examples from 2010 include:

- All non-essential lighting was turned off at the unmanned platforms to minimize potential attraction of marine birds;
- Strict monitoring and management of diesel fuel used in the offshore supply vessels, which yielded major emissions reductions for the fleet; and
- Achieving the annual volume-weighted OIW target of 30mg/L in produced water for the offshore platforms.

The 2010 offshore EEM program was developed by building on the results and lessons learned to date and following recommendations made by the CNSOPB EEM Review Committee which includes representation of Fisheries and Oceans Canada, Environment Canada, and the Canadian Environmental Assessment Agency. Since the SOEP offshore EEM is intended to be adaptive, efficient and meaningful, the monitoring plan is adjusted periodically. This includes removing or adding monitoring components or sampling sites with the prior approval of the CNSOPB EEM Review Committee based on the latest monitoring results and scientific information, or to address new Project activities.

Notable results of the 2010 program include:

Produced Water Chemistry and Toxicity (Section 2)

- TPH levels in produced water samples for toxicity analyses were below the OWTG (2002) limit (60 mg/L over 24-hrs).
- PW at all SOEP platform locations was interpreted as being 'toxic' based on 2010 bioassay results of EMC samples.
- While petroleum hydrocarbon compounds such as PAHs and phenols and heavy metals such as lead are known to be toxic, they were likely to have contributed little to the overall toxicity of PW due to their low concentrations.
- Potentially toxic constituents notably iron and ammonia, which were found in relatively high concentrations at all platforms particularly Venture, more likely contributed to PW toxicity.
- High salinity levels (up to 185 ppt) may also have contributed to the toxicity observed in samples although toxicity continued to occur in concentrations diluted to normal salinity values in bioassay tests.
- High toxicity of produced water samples from SOEP platforms is not considered an environmentally relevant factor of concern based on findings in a 2009 DFO COOGER research study. The COOGER study also concluded that potential contaminants in the relatively small PW discharges from SOEP platforms are diluted rapidly to no-effects concentration levels within a few metres of the mouth of the discharge caisson located below the sea surface.

Air Quality/Flare Monitoring (Section 3)

- Based on results reported in 2009, the monitoring program and past observations of various emission producing activities on and around Sable Island do not yet allow for confirmation as to whether the effects of offshore oil and gas activities can be measured on the Island.
- EMC is participating in an ESRF funded study led by Environment Canada and Dalhousie University entitled "Data Display and Source Apportionment of Volatile Organic Compounds and Particulate Matter on Sable Island". This project will provide regulators, industry and researchers with necessary data to evaluate the impacts attributable to contaminant emissions to ambient air from petroleum related activities.
- Environment Canada is currently awaiting audited air quality data from Nova Scotia Environment. Once they have received the final data set for the recent years they will be able to proceed with and report on the data results from the Sable Island monitoring equipment. This Environment Canada report will be included in a future submission. Flaring data for the Thebaud platform is included in the Appendix for reference.

Seabird Monitoring (Section 4)

- The most abundant species observed during moving vessel Scotian Shelf surveys in 2010/11 were the Dovekie (39.3% of 1038), Black-legged Kittiwake (11.3% of 1038), Great Shearwater (10.6% of 1038) and Herring Gull (6.3% of 1038).
- Dovekies were encountered most frequently during watches (9.6% of watches), accounted for 39% of all bird sightings, and had the highest average densities of 1.58 birds per km2.
- For areas within 25 km of platforms and comparison between 2010/2011 and 2006-2009 periods:

    - Overall bird density showed no significant changes within seasons
    - During winter periods Dovekie densities were higher and Northern Fulmar densities were lower in 2010/2011
    - During summer periods fulmar and storm-petrel densities were lower and tern densities were higher in 2010
    - During autumn periods, Great Shearwater densities were lower in 2010, but this likely reflects the timing of the survey which occurred after the peak fall migration period.

- Overall seabird densities were equal between 2010/2011 and 2006-2009 periods (4.03 birds/km2)

Beached Bird Surveys (Section 5)

- During 2010, the corpses of 354 beached gannets, tubenoses, gulls, and alcids were collected on Sable Island. Tubenoses (primarily shearwaters) accounted for 42.9% of total seabird corpses recovered, and alcids comprised 27.7%.
- For all species combined, the oiling rate for birds coded for oil (i.e. with >75% of body intact) was 0.9%. The highest rate for a seabird group, 5.3%, was observed in alcids.
- Four samples of oil were collected in 2010, and likely represented four separate discharge events.
- None of the four samples contained light or mid-range distillate fuels, or condensates that would be typical of oils produced on offshore gas facilities such as the SOEP processing platforms off Sable Island.

Mussel Body Burden (Section 6)

- Nine years of monitoring the uptake of hydrocarbons in mussels has shown that the presence of aliphatic hydrocarbons is attributable primarily to biogenic hydrocarbons generated by phytoplankton.
- Higher concentration of biogenic hydrocarbons in filter feeding mussels indicates that the platforms promote phytoplankton growth.
- Polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and PCBs were below detectable levels (0.05 mg/kg, 15 mg/kg, and 0.05 μg/g respectively) in both the control and Thebaud mussels.
- With the exception of a slight increase in strontium, and lower levels of some other metals (aluminum, arsenic, copper, iron, manganese, selenium, and zinc), total metal concentrations in mussels from the Thebaud platform were similar to those measured in mussels from a reference location.
- BTEX in mussels is not expected to be a significant concern. BTEX removal from the water column is rapid via evaporation, adsorption to particles and sedimentation, biodegradation, and photolysis.
- Sensory evaluations conducted up until 2001 showed that any odour and taste difference was attributable to the condition of the Control mussel samples.

1. INTRODUCTION

Thebaud Platform

North Triumph Platform

Alma Platform

Venture/South Venture Platforms

1.1 OVERVIEW

This report is a compilation of studies for the 2010 Sable Offshore Energy Project (SOEP) Environmental Effects Monitoring (EEM) program. Figure 1-1 in the Appendix shows the location of the platforms and pipelines. Data were provided by various EMC staff, government and laboratories funded or contracted to carry out specific assignments:

- Seabird monitoring data was collected by contracted bird observers nominated by Environment Canada (EC) ;
- Beached bird survey data was collected by Zoe Lucas under contract to EMC;
- Chemical analysis of mussel samples was conducted by Canadian Institute of Fisheries Technology/Maxxam Analytics subcontracted by EMC;
- Produced water toxicity analyses provided by Harris Industrial Testing/Aquatox provided under contract to EMC;
- Produced water chemical analyses provided by SGS Laboratories under contract to EMC;
- Flare monitoring data was collected daily by EMC staff; and
- Air emissions monitoring data from the Sable Island Air Quality Monitoring Station was collected by EC with support from Nova Scotia Environment.

The initial SOEP offshore EEM program focused on the effects of drilling and production activities at Tier 1 sites (i.e., Venture, Thebaud, and North Triumph) beginning in 1997. With the majority of the development drilling completed and the start-up of operations at Tier 1 sites by 2000, EEM surveys undertaken from 2001 to 2003 focused on the effects on sediments and bottom fauna of exposure to intermittent discharges of muds/cuttings during drilling and continuous produced water discharges during operations. Until 2002, the assessment of produced water was delayed until the produced water volume was of sufficient quantity to study.

The 2005 program addressed start-up activities at Tier 2 sites (Alma in 2003 and South Venture in 2004) whilst considering lessons learned from the Tier I EEM Program and the recommendations from the 2003 Offshore Environmental Effects Monitoring Workshop held at the Bedford Institute of Oceanography.

Based on the results observed and the adaptive basis of the EEM program, the scope for the 2006 program was modified. Sediment chemistry and toxicity, scallop taint and body burden, and fish health components were discontinued in the 2006 program.

The 2006 - 2010 offshore EEM programs were built on the previous years' EEM programs, and were developed from recommendations made by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) EEM Review Committee which includes representatives of Fisheries and Oceans Canada, Environment Canada (EC), and the Canadian Environmental Assessment Agency (CEAA).

A summary of the history of the SOEP EEM program is provided in Table 1-4 in the Appendix.

1.2 BACKGROUND

The purpose of the EEM program is to test whether the effects of facility presence and production emissions into the marine and atmospheric environments occur within the zones of influence predicted by the Environmental Impact Statement (EIS) (Table 1-1). Environmental measurements are concentrated where meaningful changes are expected to occur and where the point source discharge is located. The 2010 offshore EEM program was designed to address relevant predictions made during the SOE environmental assessment process.

Table 1-1: EA Predictions Relevant To 2010 EEM Program

EIS Prediction [1]	Valued Ecosystem Component [2]	2010 EEM Component
"Impacts of effluent discharges (e.g. produced water) were considered to have no significant impacts on the marine environment."	• Fish • Shellfish	• Produced Water Chemistry and Toxicity • Mussel Health/Body Burden
"Air emissions were considered to have no significant impacts on the marine environment."	• Sable Island	• Flare Monitoring
"Lights [from work lights and gas flares] may attract migrant bird species, especially in fog and/or low cloud and rain."[3]	• Seabirds	• Seabird Monitoring
"Because of the importance of Sable Island and the Gully, special attention will be paid to these areas in the development of monitoring."[4]	• Seabirds • Sable Island	• Air Quality • Beached Seabird Surveys

[1]Unless otherwise noted, the predictions apply only to routine construction and operations activities (i.e., not accidental events) as stated in the Executive Summary of the SOEP–EIS Vol. 3.
[2] Only offshore-related VECs assessed under the marine environment were considered
[3] As stated in Section 5.2.1.9 of the SOEP – EIS Vol. 3.
[4] As stated in Section 7.4 of the SOEP – EIS Vol. 3.

The EEM components were based on valued ecosystem components (VECs) identified during the EA process and components identified by Sable Offshore Environmental Effects Monitoring Advisory Group (SEEMAG) and the EEM study team. The SOEP offshore EEM is intended to be adaptive, efficient and meaningful. Therefore, the monitoring plan is adjusted annually by dropping or adding monitoring components or sampling sites with the prior approval of the CNSOPB EEM Review Committee based on the latest monitoring results and scientific information, or to address new Project activities.

1.3 EMISSIONS AND DISCHARGES

The five platforms generate atmospheric, liquid, and solid wastes. Table 1-2 lists various emissions from the Thebaud, Venture, South Venture, North Triumph, and Alma platforms with the exception of solid wastes. Domestic waste and hazardous waste materials generated on the platforms are shipped to shore via supply vessel to approved and licensed waste receivers in Nova Scotia and Canada. This EEM program evaluates produced water and air emissions. No drilling or major construction activities took place in 2010 that would cause any changes in steady state emissions from the SOEP facilities.

Table 1-2 provides a summary of the main sources of emissions on each platform.

Table 1-2: Summary of Emissions Sources on all Platforms

PLATFORM	OPERATION STATUS	POTENTIAL EMISSION SOURCES
THEBAUD {LAT: 43.53 LONG: -60.12}	STEADY-STATE PRODUCTION OPERATIONS THROUGH 2010	FLARE (~9.5E3M3/DAY)
		PRODUCED WATER (15.9 MG/L AVG. 2010)
		DRAINS WATER DISCHARGES (VARIES BY WEATHER)
		NATURAL GAS TURBINES
		EMERGENCY DIESEL GENERATORS
VENTURE {LAT: 43.59 LONG: -59.37}	STEADY-STATE PRODUCTION OPERATIONS THROUGH 2010	VENTING (~0.3E3M3/DAY)
		PRODUCED WATER (15.2 MG/L AVG. 2010)
		DRAINS WATER DISCHARGES (PROCESSED AND DISCHARGED @ THEBAUD)
		DIESEL GENERATORS
NORTH TRIUMPH {LAT: 43.35 LONG: -59.51}	STEADY-STATE PRODUCTION OPERATIONS THROUGH 2010	VENTING (~0.08E3M3/DAY)
		PRODUCED WATER ROUTED TO THEBAUD PLATFORM
		DRAINS WATER DISCHARGES (PROCESSED AND DISCHARGED @ THEBAUD)
		DIESEL GENERATORS
ALMA {LAT: 43.35, LONG: -60.12}	STEADY-STATE PRODUCTION OPERATIONS THROUGH 2010	VENTING (~0.6E3M3/DAY)
		PRODUCED WATER (9.2 MG/L AVG. 2010)
		DRAINS WATER DISCHARGES (VARIES BY WEATHER)
		DIESEL GENERATORS
SOUTH VENTURE {LAT: 43.59 LONG: -59.37}	STEADY-STATE PRODUCTION OPERATIONS THROUGH 2010	VENTING (~0.5E3M3/DAY)
		PRODUCED WATER (8.0 MG/L AVG. 2010)
		DRAINS WATER DISCHARGES (VARIES BY WEATHER)
		DIESEL GENERATORS

1.4 PROJECT ACTIVITIES

Aside from routine production activities, no additional activities (construction or drilling) occurred in the SOEP natural gas production field in 2010.

1.5 GOALS AND OBJECTIVES

This EEM program involves the collection of repeated measurements of environmental variables to detect changes directly or indirectly attributable to production discharges. The EEM program is undertaken with the following primary objectives:

- to verify whether the effects of discharging production wastes into the marine environment occur within the zones of influence predicted by the EA report;
- to evaluate the effectiveness of mitigation and identify the need for improved or altered mitigation; and
- to provide an early warning of undesirable change in the environment.

1.6 SCOPE

This report focuses on the EEM program of the Tier I and Tier II development and includes the natural gas well fields at Venture, South Venture, Thebaud, Alma, and North Triumph. (As the North Triumph platform does not discharge produced water, no sampling occurs at this platform). Potential effects of Project activities evaluated in the 2010 EEM program included produced water, air emissions (flaring), water quality, seabirds, and mussels. (Table 1-3).

Table 1-3: 2010 Sable Offshore EEM Program

Location	Environmental Component	Type of Monitoring/Analysis	2010 Program
Thebaud	Shellfish	Body burden for mussels (jacket scraping) {Reference samples for each species to be sourced from commercial seafood outlets}	– Analyze body burden consistent with previous programs, plus BTEX & Mercury.
	Seabirds	Observations recorded on supply vessel transects from shorebase to platform & between platforms. (Ideally on a seasonal basis)	– Systematic observations using CWS protocol on supply vessel transect surveys.

Location	Environmental Component	Type of Monitoring/Analysis	2010 Program
	Air Quality	Visual observations of the Flare Plume from platform. Flare plume observations will be provided to EC for analysis with Sable Island Air Quality Monitoring data.	– Record flare plume characteristics twice daily (using EC supplied smoke chart) along with concurrent weather conditions on the platform
Sable Island	Seabirds	Monthly Beached Bird Surveys	– Surveys to be carried out and report to be prepared by Zoe Lucas, resident biologist on Sable Island. Relate to historical time series data.
Thebaud, Venture, South Venture and Alma	Produced Water	Toxicity analysis as per OWTG (2002)	– Relate to OWTG expectation – Continue use of same bioassay species
Thebaud, Venture, South Venture and Alma	Produced Water	Chemistry analysis as per OWTG (2002)	– Relate to OWTG expectation

The surveys undertaken in 2010 continued to investigate or support data collection to later analyze potential effects of the development on:

- water quality of the receiving environment with respect to toxicity and chemical characterization;
- air quality from flaring at Thebaud on Sable Island; and
- the presence of the platforms on seabird populations at sea and on Sable Island.

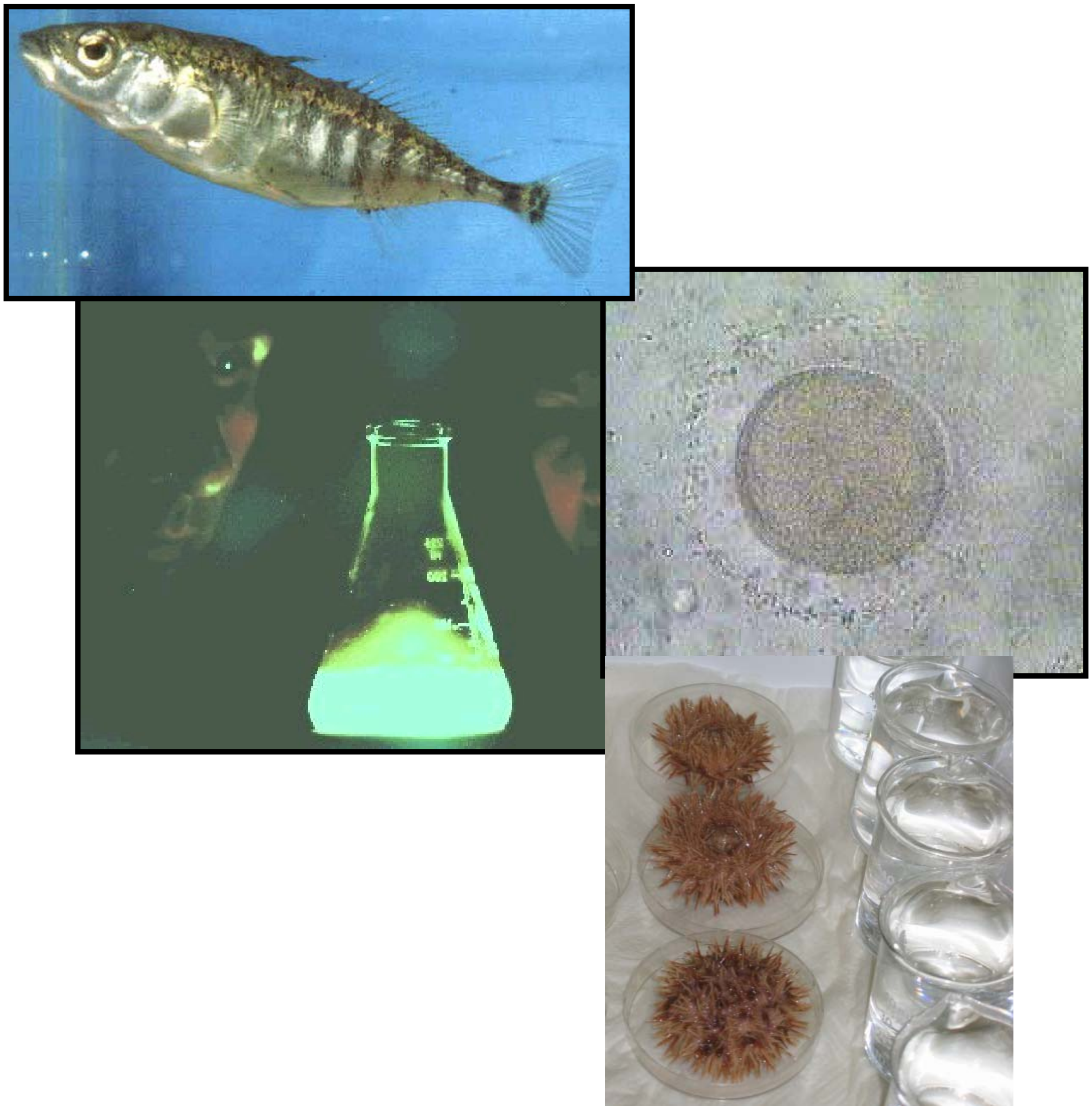
1.7 REPORT ORGANIZATION

This report consists of an assemblage of component study reports relating to specific EEM requirements. Each component study report was prepared using a concise format agreed to by the C-NSOPB Review Committee to facilitate information summarization and readability. To the extent possible, references were provided for detailed methodological and analytical procedures.

1.8 END OF FIELD LIFE MONITORING

After the offshore Sable platforms and associated equipment have been decommissioned, plans will be developed to conduct field monitoring that will compare the original baseline data. The end-of-life monitoring approach will be discussed with the CNSOPB as field decommissioning timing becomes clearer.

2. PRODUCED WATER CHEMISTRY AND TOXICITY



2.1 RATIONALE & BACKGROUND

Produced water (PW) includes formation water, injection water and process water that is extracted along with oil and gas during petroleum production. At offshore production installations, this water is separated from the petroleum process stream and, after treatment, is discharged to the marine environment.

Based on the concentrations of toxic chemicals in most PW and predicted dispersion rates, there is limited potential for acute toxicity beyond the immediate vicinity (within 500 m of discharge point) of platform sites (Lee and Neff, 2009, in press). Harmful biological effects in water column biological communities near open-ocean PW discharges have been shown to be minimal and localized, because of the rapid dilution and dispersion rates of most produced water discharges to the ocean. The environmental impact of cumulative effects from the discharge of produced water from various installations within the region is also considered a low risk due to the number and distance between operational facilities.

To illustrate at SOEP, a DFO COOGER research study (DFO COOGER, 2010) showed that potential contaminants in the relatively small PW discharges[1] from the SOEP central processing platform (Thebaud) and Venture satellite platform were diluted rapidly[2] to no-effects concentration levels within a few metres[3] of the mouth of the discharge caisson located several metres below the sea surface[4]. The resulting narrow plume of PW shifts primarily under the influence of the ebb and flow of tidal currents. The overall conclusion of the study was that "…*the toxicity of produced water from the Venture/Thebaud platforms is not considered an environmentally relevant factor of concern*". Based on these findings and previous SOEP EEM results, further EEM research and monitoring were not carried out in 2010.

However, SOEP PW environmental compliance monitoring (ECM)[5] samples were collected in 2010 and analyzed for chemical composition and potential toxicity as per specific requirements outlined in the Offshore Waste Treatment

[1]The discharge rates of PW at SOEP platforms are one or two orders of magnitude less than at other East Coast offshore facilities. For example, the average daily discharge rates for SOEP platforms in 2010 are as follows: Venture (532.9m^3/day), Thebaud (129.4m^3/day), S. Venture (19.5m^3/day) and Alma (15.8m^3/day). Rates for other former, current and proposed East Coast projects respectively are as follows: COPAN (18,140, m^3/day); current Hibernia (19,000 m^3/day) and Deep Panuke (6,050 m^3/day).

[2] Organic constituents of SOEP produced water have also been shown to be highly volatile and therefore readily vaporize prior to discharge

[3] Predicted using the DREAM (Dose-related Risk and Effect Assessment Model)

[4] typically after first passing through a diffuser to aid dispersion

[5] ECM results are included in this report since the results of produced water testing and EEM marine water quality monitoring should be considered together when assessing the potential impact of contaminants discharged to the marine environment.

Guidelines (OWTG, 2002)[6] . As such, the composition of produced water from each production installation was analyzed twice yearly for the following parameters: aluminum, ammonium, antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, magnesium, mercury, molybdenum, nickel, phosphorus, selenium, silver, strontium, sulphur, thorium, tin, uranium, vanadium, and zinc and total petroleum hydrocarbons (TPH). As specified in the guidelines, the toxicity of produced water was evaluated once in 2010, using the sea urchin fertilization test method and at least two other bioassay tests (e.g., early life stage of fish, bacteria, algal species, etc.) satisfactory to the Chief Conservation Officer and each toxicity test was conducted contemporaneously with one of the twice-yearly chemical characterization tests described above and the results submitted to the CNSOPB Chief Conservation Officer.

The OWTG (2002) do not specify threshold limits for any of the inorganic chemical parameters required to be tested. The criteria with respect to TPH are a 30-day weighted average of oil in discharged produced water that does not exceed 30 mg/L and a 24-hour arithmetic average of oil in produced water that does not exceed 60 mg/L. There is no pass/fail stipulation for any of the toxicology bioassay tests.

PW environmental compliance (ECM) samples were collected at all SOEP production platforms that is, the Thebaud central production platform and the satellite platforms: Alma, South Venture and Venture. [Note: PW from the North Triumph platform is routed to the Thebaud production platform for treatment and discharge]. Toxicology bioassay analyses were the Microtox[7], the Sea Urchin Fertilization[8], and the Threespine Stickleback[9] tests as per the recommendation of Dr. Ken Doe of the Environment Canada Toxicology Laboratory in Moncton, NB.

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[6] The OWTG (2002) has recently been replaced by an updated version (15 December, 2010) which the offshore petroleum boards (NEB, CNSOPB, CNLOPB) will use to regulate future PW treatment and monitoring on offshore platforms beginning in 2011.

[7] The basic technology of the Microtox Test System is based upon the use of luminescent bacteria, specifically the strain *Vibrio fisheri* NRRL B-11177, to measure toxicity from environmental samples. Luminescent bacteria produce light as a byproduct of cellular respiration. Cell respiration is fundamental to cellular metabolism and all associated life processes. Bacterial bioluminescence is tied directly to cell respiration, and any inhibition of cellular activity (toxicity) results in a decreased rate of respiration and a corresponding decrease in the rate of luminescence. The more toxic the sample, the greater the percent light loss from the test suspension of luminescent bacteria. Bacterial bioluminescence has proved to be a convenient measure of cellular metabolism and consequently, a reliable sensor for measuring the presence of toxic chemicals in aquatic samples. Strain 11177 was originally chosen for the acute and chronic tests because it displayed a high sensitivity to a broad range of chemicals.

[8] The Sea Urchin Fertilization test is a common marine bioassay used for routine environmental monitoring, investigative evaluations, and/or regulatory testing of effluents and sediment pore waters.

[9] The acute lethality test with seawater-acclimated Threespine Stickleback *(Gastreostreus acculeatus)* (TSS) has been used by Environment Canada and several Canadian laboratories concerned with evaluating the potential toxic effects of effluents discharged into estuarine or marine environments.

2.2 GOALS

- Achieve the CNSOPB PW environmental compliance monitoring requirements for 2010 as specified in the OWTG (2002)
- Review historical PW ECM results at SOEP with respect to chemistry and toxicity
- Recommend a PW monitoring strategy for 2011 in light of ECM results and research findings with respect to the chemical and biologically relevant characteristics of PW

2.3 OBJECTIVES

- Determine the chemical composition and potential toxicity of PW water samples as per the OWTG (2002)
- Compare 2010 results with historical PW ECM data

2.4 2010 SAMPLING

Note: Produced water samples were collected and analyzed following procedures outlined in tables below and in attached "*Produced Water Sampling Procedures*" provided by SGS (Appendix for Section 2).

Table 2-1 2010 Produced Water Sampling Program

Collection Date(s):	Thebaud: Jan. 22 - Chemistry samples Aug. 9 - Chemistry & Toxicity samples	Venture: Jan. 28 - Chemistry samples July 5 - Chemistry & Toxicity samples	S. Venture: May 19 - Chemistry samples Nov. 4 - Chemistry and Toxicity samples	Alma: Oct 23 - Chemistry & Toxicity samples Dec. 11 - Chemistry samples
Platforms:	Thebaud, Venture, South Venture, Alma			
Type of Sample::	Produced water			
Test Sample Locations:	Taken directly from the discharge caisson on the platform (prior to overboard discharge to the marine environment).			

Reference Sample Locations:	N/A
Sample Preparation[10]:	Sample Bottles were provided by SGS as follows (see Attachment 2-1): • BTEX/TPH – 2 x 40ml amber vials (filled to top; no head space) and 1X1L glass bottle (filled approximately 90%) • Metals (dilute and shoot) – 1X250ml plastic (filled approximately 80%) • Mercury – 100 ml amber glass • Ammonia and TKN – 60ml amber glass (filled approximately 80%) • Toxicity sample - HDPE container
Sampling QA/QC[11]:	• Each bottle (supplied by the SGS laboratory to ensure the integrity of the samples and kept cool until shipping to the lab (not frozen). • PW samples were stored in sealed cooler with a frozen gel pack to keep samples cool. They were shipped to shore by helicopter following sample collection. The samples were then picked up by SGS for chemical testing for toxicity testing, • For toxicity testing, PW was collected in a HDPE container on each platform. The container was shipped to shore by helicopter following sample collection. The samples were collected by from the heliport by Harris Industrial Testing Service (HITS). Subsamples were extracted from each, and then shipped to appropriate subcontractors (see Section 2.5) for specific toxicity testing.

2.5 ANALYSES

Contractors:

1. Harris Industrial Testing Service Ltd. (Threespine Stickleback toxicology)
2. AquaTox Testing & Consulting Inc. (Microtox and Sea Urchin Fertilization toxicology)
3. SGS (Chemical Analysis)

[10] Canadian Helicopter Corporation (CHC) does not allow any preservatives on flights offshore. Preservatives are added upon receipt at the laboratory, if necessary

[11] The QA/QC procedures for the each laboratory involved with the various testing included the use of duplicates, method blanks, surrogates, spikes, chain of custody, and certified reference materials where applicable.

Parameters Analyzed:

Parameters	Analysis Method
Cellular metabolism	Microtox Test[12]
Egg fertilization	Sea Urchin Fertilization Test [13]
Acute fish toxicity	Threespine Stickleback (TSS) [14]
BTEX/TPH[15]	VPH (Volatile petroleum hydrocarbons) by Combi-Pal and TEH (total extractable hydrocarbons) by Gas chromatography - flame ionization detector (GC-FID)
Chemical Characterization	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
Sulphur and Magnesium	Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)
Mercury	Cold Vapour Atomic Absorption
Ammonia-N	Colorimetric Test
Phosphorous	Colorimetric Test
Nitrogen	Total Kjeldahl Nitrogen Test

[12] Environment Canada, 1992/97
[13] Environment Canada, 1992
[14] Environment Canada, 1990
[15] BTEX =Benzene, toluene, ethyl benzene, xylenes ; TPH = total petroleum hydrocarbons

2.6 RESULTS

2.6.1 PW Chemistry[16]

Sampling Date		28 Jan. 2010	5 July 2010	22 Jan. 2010	09 Aug. 2010
Chemical Parameters as per OWTG (2002)	**Units**	**VENTURE**	**VENTURE**	**THEBAUD**	**THEBAUD**
Thorium	mg/L	<0.00004	<0.00004	0.00015	0.00007
Mercury	mg/L	<0.0001	<0.0001	0.0003	<0.0001
Aluminum	mg/L	0.09	0.11	0.33	<0.01
Antimony	mg/L	0.07	0.05	<0.01	0.002
Arsenic	mg/L	0.052	0.057	0.0070	0.0230
Barium	mg/L	**1050**	**1140**	**48.2**	**243.0**
Boron	mg/L	**16.4**	**45.3**	**0.968**	**3.82**
Cadmium	mg/L	0.00367	0.00389	0.00006	0.00004
Chromium	mg/L	0.012	0.011	0.0199	0.033
Cobalt	mg/L	0.0261	0.0222	0.00112	0.00501
Copper	mg/L	0.212	0.127	0.0082	0.031
Iron	mg/L	**31.1**	**90**	**7.32**	**23.9**
Manganese	mg/L	31.6	27.9	1.03	5.26
Lead	mg/L	**0.0510**	**0.0452**	**0.00543**	**0.0040**
Molybdenum	mg/L	<0.0001	0.0100	0.00065	0.0017
Nickel	mg/L	0.314	0.141	0.0174	0.052
Selenium	mg/L	<0.01	0.34	<0.01	0.04
Strontium	mg/L	**4.79**	**2280**	**59.9**	**355**
Sulphur	mg/L	1.15	148	42.6	0.71
Tin	mg/L	0.0002	0.0009	<0.0001	<0.0001
Uranium	mg/L	0.00008	0.00031	<0.000012	<0.00001
Vanadium	mg/L	<0.0003	0.0012	0.00415	0.0063
Zinc	mg/L	**5.73**	**5.06**	**0.139**	**0.7**
TPH	mg/L	**18.26**	**26.47**	33	**57**
Ammonia	mg/L	**234**	**21**	**12.9**	**57.2**
TK Nitrogen	mg/L	200	135	18.1	62.5
Phosphorus	mg/L	**0.30**	**0.915**	**0.11**	**0.034**

[16] Bolded values for selected chemical parameters were plotted below (see Section 3.6.1) to facilitate comparisons between platforms in recent years of sampling.

Sampling Date		23 Oct. 2010	11 Dec 2010	19 May 2010	04 Nov. 2010
Chemical Parameters as per OWTG (2002)	**Units**	**ALMA**	**ALMA**	**S. VENTURE**	**S. VENTURE**
Thorium	mg/L	<0.001	<0.001	0.00050	<0.001
Mercury	mg/L	<0.000026	<0.000026	<0.0001	<0.000026
Aluminum	mg/L	<0.005	<0.005	0.04	0.190
Antimony	mg/L	<0.002	<0.002	0.01	0.007
Arsenic	mg/L	0.01	0.008	0.023	<0.002
Barium	mg/L	**14.1**	**12.3**	**1080**	**942**
Boron	mg/L	**5.09**	**4.69**	**10.3**	**0.122**
Cadmium	mg/L	<0.000017	<0.000017	0.00008	0.000072
Chromium	mg/L	0.001	0.001	0.009	0.004
Cobalt	mg/L	0.002	0.002	0.00820	0.016
Copper	mg/L	0.004	0.002	0.07	0.058
Iron	mg/L	**16.9**	**16.3**	**60.1**	**82.0**
Manganese	mg/L	**0.202**	**0.193**	**6.33**	**6.94**
Lead	mg/L	**0.0016**	**<0.0005**	**0.0063**	**0.0074**
Molybdenum	mg/L	<0.002	<0.002	0.00820	0.013
Nickel	mg/L	**0.014**	**0.014**	**0.0640**	**0.666**
Selenium	mg/L	<0.001	<0.001	0.07	<0.001
Strontium	mg/L	**45.4**	**38.7**	**1190**	**1330**
Sulphur	mg/L	**4.29**	**0.690**	**154**	**11.8**
Tin	mg/L	<0.002	<0.002	<0.001	<0.002
Uranium	mg/L	<0.0001	<0.0001	0.00007	<0.0001
Vanadium	mg/L	<0.002	<0.002	<0.0003	<0.002
Zinc	mg/L	**<0.005**	**<0.005**	**0.54**	**0.093**
TPH	mg/L	**36.208**	**33.180**	**21.747**	**3.2282**
Ammonia	mg/L	**20.5**	**21.0**	**110.0**	**124**
Nitrogen	mg/L	**22.3**	**20.1**	**92.9**	**131**
Phosphorus	mg/L	**--**	**--**	**0.23**	**--**

2.6.2 PW Toxicity

Toxicity Test	96 Hour LC50/IC50[17] Values for TSS & Microtox and IC25 Values for Sea Urchin Fertilization (95% confidence limits in brackets)			
	Thebaud	**Venture**	**S. Venture**	**Alma**
Threespine Stickleback Fish Toxicity (TSS)	Aug.9[18]: **8.85% (6.25-12.3%)**	July 5: **5% (4.1-6.3%)**	Nov 4: **8.84% (6.25-12.5%)**	Oct 23: **35.4% (25-50%)**
Microtox	**1.7% (1.50-1.93%)**	**14.2% (13.1-15.3%)**	**11.6% (10.1-13.3%)**	**2.44% (2.34-2.54%)**
Sea Urchin Fertilization	**0.83% (0.13-1.38%)**	**0.06% (0.02-0.13%)**	**0.64% (0.37-1.06%)**	**48.4% (42.3-52.9%)**
Salinity (ppt)	**55**	**185**	**130**	**9**
Oil-in-Water (Mg/L)	**57**	**26**	**3**	**36**

2.7 DISCUSSION

As mentioned above, the OWTG (2002) do not have a pass/fail criterion, however most effluent discharge regulations stipulate that if an effluent has greater than 50% mortality at 100% concentration, it fails. Based on this criterion, PW discharges from all four SOEP platforms (for the period 2005-2010 incl.) would be considered ‘toxic’ (Gary Harris, HITS Ltd., pers. comm. - see attached summary reports from HITS in Appendix, Section 2.9; figures below)[19]. Of the four platforms, PW discharges from the Venture platform have historically been the most toxic and from Alma the least toxic based on a weight-of-evidence approach.

[17] LC50 is the medial lethal concentration, i.e., the concentration of material in the water that is estimated to be lethal to 50% of the test organisms

[18] PW samples for ECM toxicity analysis were collected on same day as one of two ECM water chemistry samples at each platform location as stipulated under OWTG (2002)

[19] Even using less rigid criteria (Sprague (1973); Environment Canada (1984) for assessment of 2010 samples, PW would be considered as ‘toxic’ at all platform locations except Alma since the IC25 values for echinoid fertilization (generally considered the most sensitive test) were less than 1% (see Section 2.62).

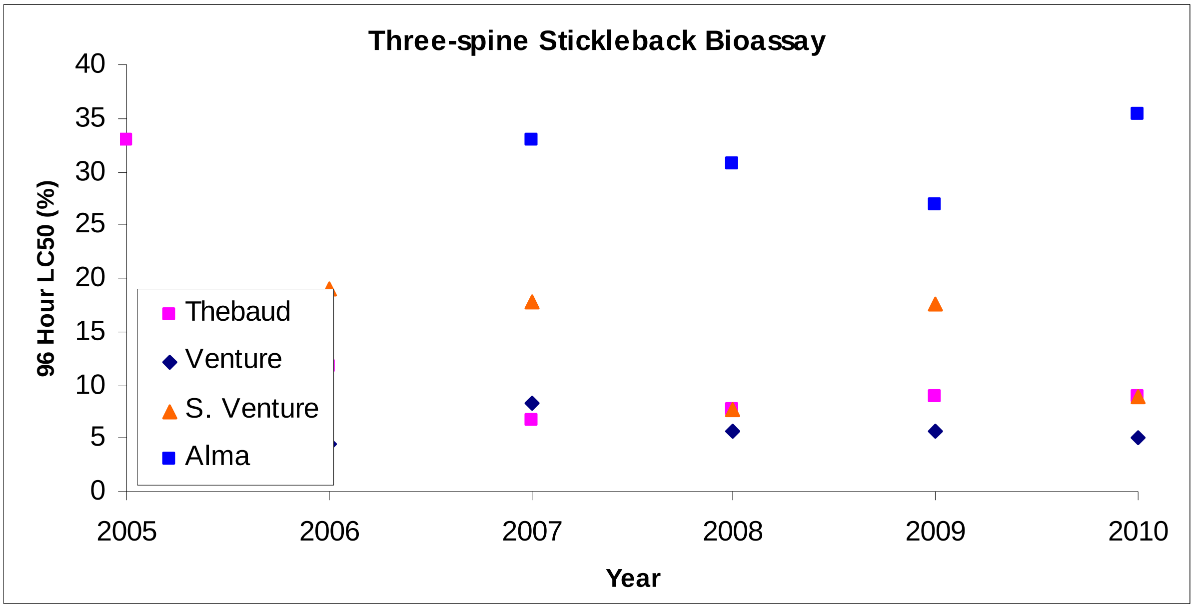

Figure 2.1 Three-spine Stickleback Bioassay

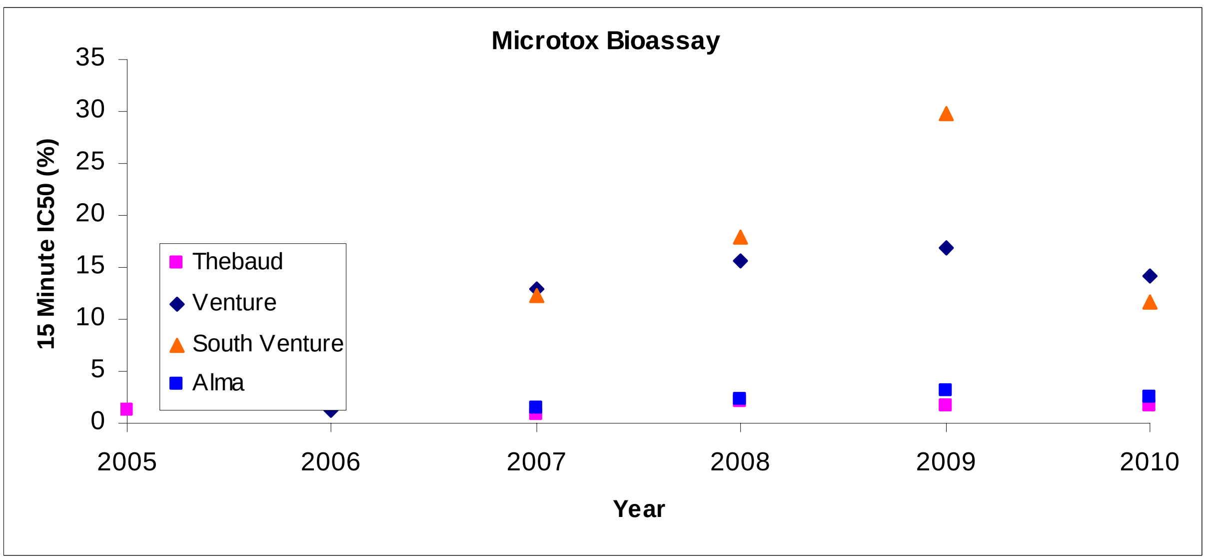

Figure 2.2 Microtox Bioassay

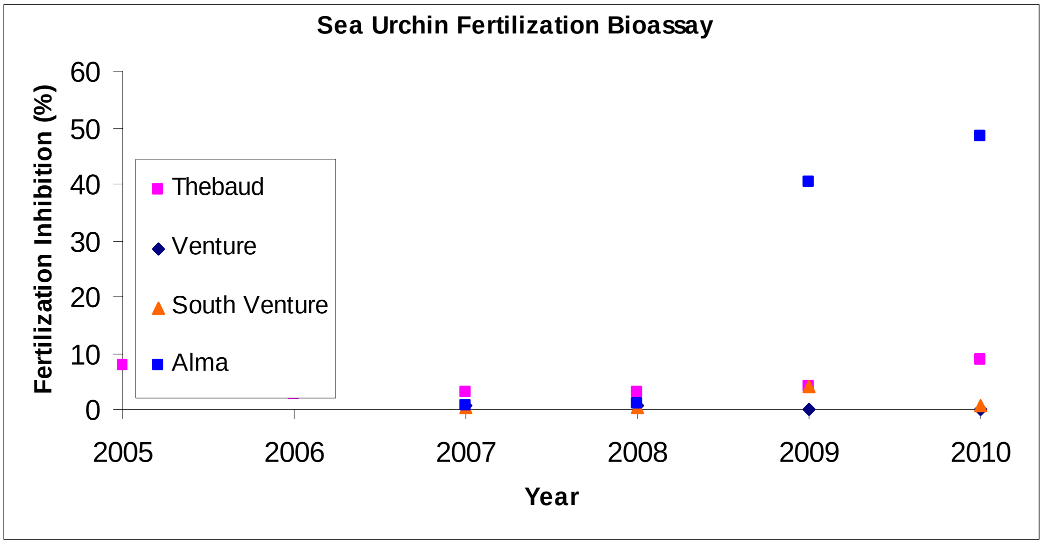

Figure 2.3 Sea Urchin Fertilization Bioassay

2.8 CONCLUSIONS

Normal seawater salinity values range from 28-32 ppt. Salinity values for all PW toxicity samples in 2010 (with the exception of the Alma sample) were much higher than normal values (see Section 2.6.2). In all three types of toxicity tests at the four SOEP platforms in 2010, toxicity continued to occur in concentrations diluted to normal salinity values, which would suggest that petroleum hydrocarbons or other chemical parameter(s) were the likely cause of toxicity. Nevertheless, salinity has been shown to contribute significantly to the toxicity response observed for microbial processes (DFO COOGER, 2010).

TPH values for all ECM PW samples taken at the four platforms in 2010 (Section 2.6.1) were below the threshold limit of 60 mg/L (24-hour arithmetic average) for TPH specified in the OWTG (2002)[20]. The two highest average values of TPH recorded in ECM PW samples for chemical analysis since 2005 were for the Thebaud and Alma[21] platform samples in 2010 (see below).

[20] There were no exceedances of the OWTG (2002) guideline for TPH in PW on any of the SOEP platforms over the entire 2010 year period.

[21] The Thebaud value appears to be an anomaly since other OIW measurements made on August 9 were consistently much lower (i.e., 12.2, 14.3, 16.1, and 15.3 mg/L). Likely explanation at Alma was delays in changing out 'Crudesorb' filters due to severe weather.

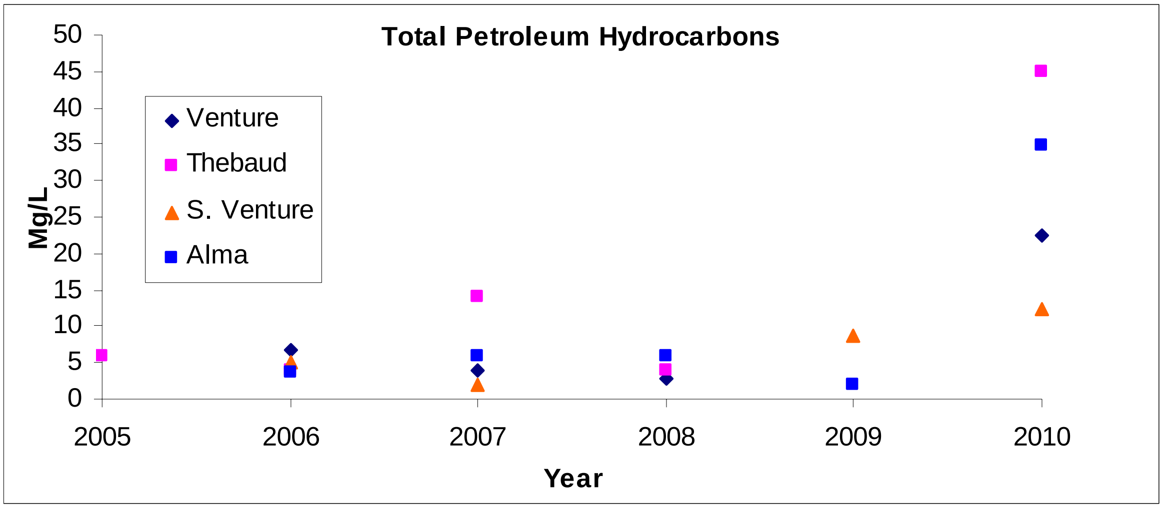

Figure 2.4 Total Petroleum Hydrocarbons in Produced Water

While petroleum hydrocarbon compounds such as PAHs and phenols and heavy metals such as lead are known to be toxic, they are likely to have contributed little to the overall toxicity of PW due to their low concentrations. Concentrations of other key non-organic PW constituents (i.e., barium, boron, iron, lead, zinc, strontium, and ammonia) have been relatively low in recent years (see figures below). Two potentially toxic constituents, iron and ammonia, (see Section 2.6.1 and figures below) would more likely have contributed to the high toxicity observed (DFO COOGER, 2010).

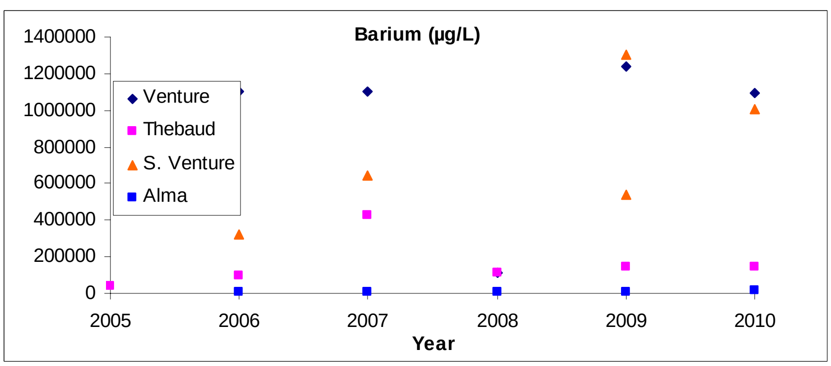

Figure 2.5 Barium in Produced Water

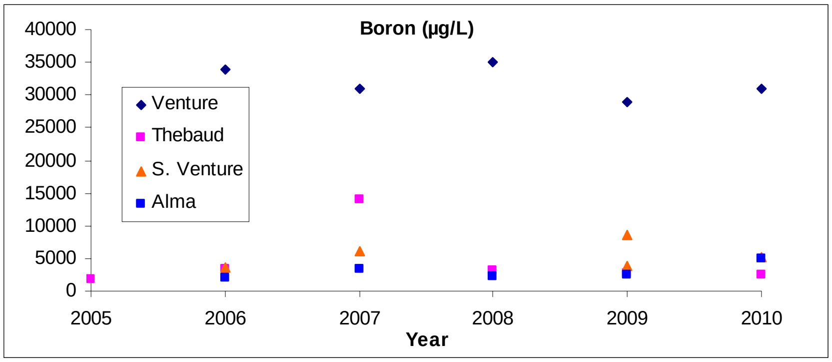

Figure 2.6 Boron in Produced Water

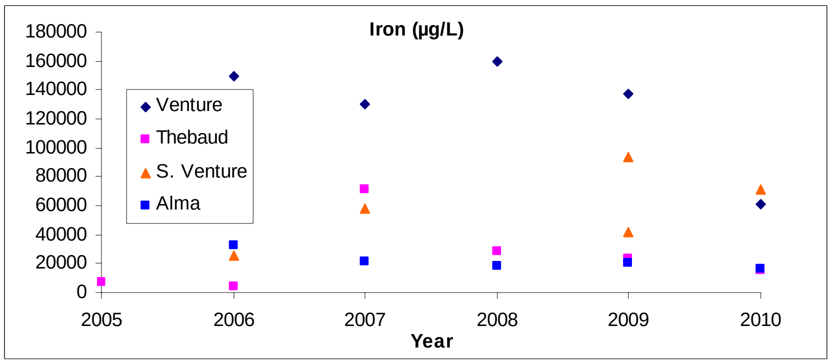

Figure 2.7 Iron in Produced Water

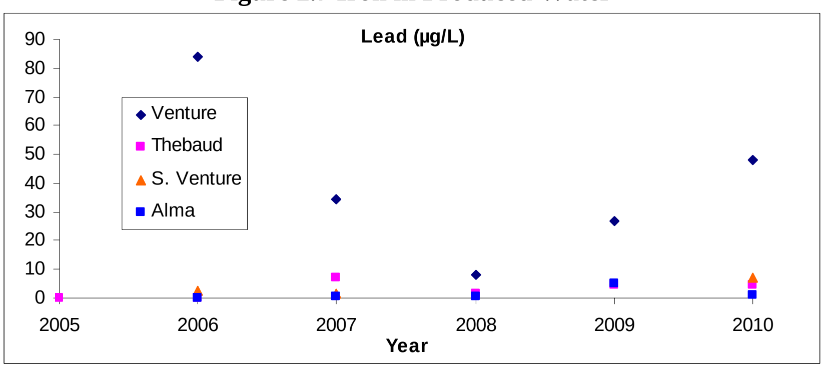

Figure 2.7 Lead in Produced Water

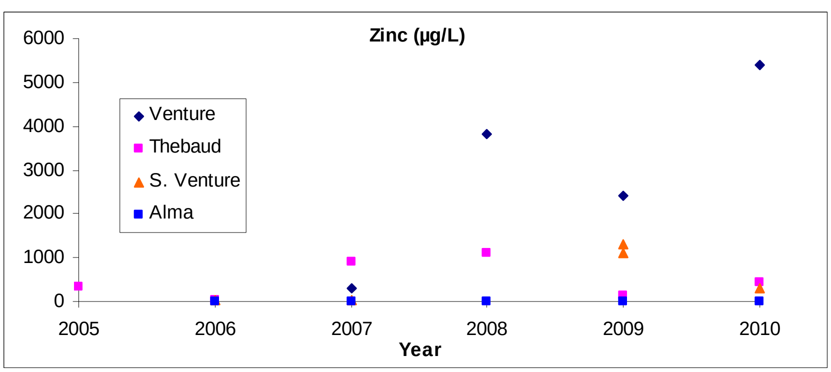

Figure 2.8 Zinc in Produced Water

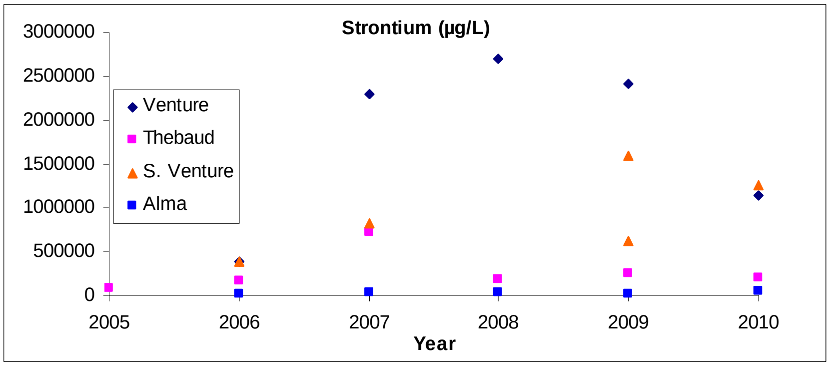

Figure 2.9 Strontium in Produced Water

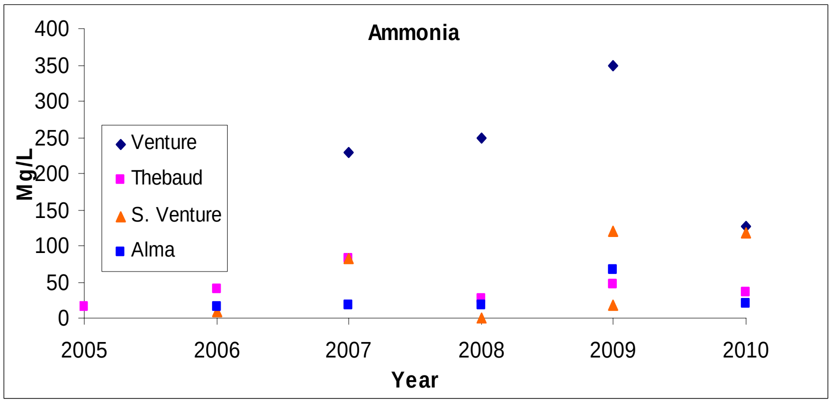

Figure 2.10 Ammonia in Produced Water

Given the low potential for environmental effects, (see Section 2.1), further EMC-sponsored research related to PW discharges from SOEP platforms is not planned in 2011. However, EMC will continue to discuss possible synergies regarding produced water studies with Dr. Ken Lee of DFO COOGER.

EMC will strive to achieve performance targets for the treatment of PW discharges outlined in the latest version of the OWTG (15 December, 2010). In addition, EMC will report 2011 chemistry and toxicity results for produced water discharges from SOEP platforms in the 2011 EEM Report.

2.9 REFERENCES

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Sprague, J.B., 1973, The ABC's of Pollutant Bioassay Using Fish, Biological Methods for the Assessment of Water Quality, ASTM STP 528, American Society for Testing and Materials, pp 6 – 30

3. AIR QUALITY

Photo courtesy of ExxonMobil Canada

Courtesy of Green Horse Society

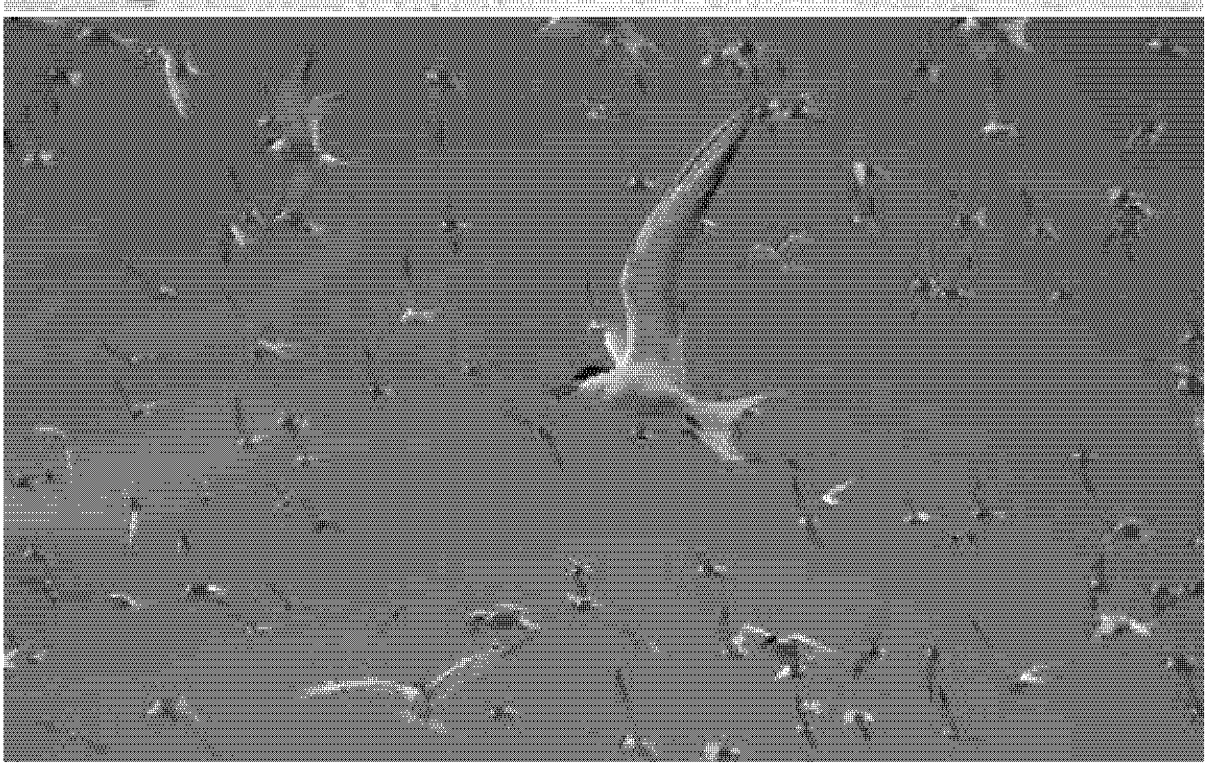
TO BE COMPLETED WHEN AVAILABLE FROM ENVIRONMENT CANADA

- Environment Canada is currently awaiting audited air quality data from Nova Scotia Department of Environment. Once they have received the final data set for the recent years they will be able to proceed with and report on the data results from the Sable monitoring equipment. This Environment Canada report will be included in a future annual report. Only <u>flaring data</u> for the Thebaud platform is included in the appendix for reference.

- ExxonMobil is participating in an ESRF - funded study led by Environment Canada and Dalhousie University entitled "Data Display and Source Apportionment of Volatile Organic Compounds and Particulate Matter on Sable Island". This project will provide regulators, industry and researchers with necessary data to evaluate the impacts attributable to contaminant emissions to ambient air from petroleum-related activities.

- Flaring data for the Thebaud platform is included in the appendix for reference. (see Appendix for section 3).

4. SEABIRD MONITORING



4.1 RATIONALE

Seabird monitoring observations were conducted on a relatively continuous basis at the Thebaud production (gas) platform from 1999 until 2004 by independent observers supplied by Offshore Oil and Gas Observer Group Ltd. (OGOP). The OGOP received periodic training in seabird identification from various experts including Canadian Wildlife Service (CWS) biologists. While CWS believes that these observations provided a general appreciation of seabird/platform interactions, the observations were unable to fully assess the relative distribution of seabirds around the platform since they were restricted to a single location and limited field of view (Wilhelm and Boyne 2006). As an alternative to earlier observations at a single location (i.e., platform) by OGOP observers, a vessel-based approach using transect surveys was adopted in 2005 involving systematic observations of seabirds by CWS-trained biologists along supply vessel transits to and from offshore platforms. The transect approach offered the possibility of detecting changes in density of seabirds in relation to distance from SOEP offshore manned and unmanned gas platforms off Nova Scotia. This vessel-based approach was continued in 2007, 2008 and 2010 (no surveys from supply vessels were conducted in 2009). Analysis of these data are supplemented by the availability of vessel-based transects conducted in other areas of the Scotian Shelf (i.e., not along regular supply vessel tracks to and from SOEP platforms) by CWS observers aboard 'vessels-of-opportunity' as part of a multi-year monitoring program to document the distribution and abundance of seabirds in offshore areas of Atlantic Canada.

The 2009 EEM report (Section 5 Seabird Monitoring – updated report Nov 2010) provided the first analysis of these combined datasets to examine seasonal and spatial variability in seabird densities around SOEP platforms and other areas of the Scotian Shelf. This report concluded that 1) survey effort was uneven across seasons, 2) some species of birds occurred at higher densities while other occurred at lower densities within 10 km of the platforms, and 3) assessment of attraction or repulsion was inconclusive. This chapter of the 2010 EEM report provides an assessment of seabird densities recorded from five surveys aboard SOEP supply vessels between January 2010 and January 2011.

4.2 GOALS

The goal of the seabird monitoring is to evaluate if seabird abundance and activity is affected by the presence of the platforms and flaring operations.

4.3 OBJECTIVES

The objective of the seabird monitoring component of the EEM program is to compare seabird observational data along platform and 'reference' transects on the Scotian Shelf including Sable Island Bank. This is undertaken in order to:

1) document the distribution and density of seabirds around the SOEP production area, and
2) determine the extent of attraction of seabirds to SOEP manned and unmanned offshore platforms.

Objective 2 should partly be addressed by the radar and VHF radio-tracking studies planned by Encana/Acadia/CWS in 2011/2012 and with some EMCP support (VHF radio-tracking on Sable Project supply vessels) and objective 1 will be addressed in this report in light of additional surveys conducted in 2010/2011.

4.4 METHODS

Between 2006 and January 2011, vessel-based observations were made by Canadian Wildlife Service (CWS) seabird biologists and seabird observers contracted by CWS and Exxon Mobil, following a standardized protocol (Environment Canada 2008). Surveys are conducted while looking forward from the bridge, scanning ahead to a 90° angle from either the port or starboard side, limiting the observations to a transect band 300 m wide from the side of the moving platform. While the platform is in motion, a series of 10-minute (2006 - Oct 2007) and 5-minute (after Nov. 2007) observation surveys (hereafter "watches") are conducted, regardless if birds are present or not, with an attempt to ensure consistent coverage throughout the day. Observations are not conducted when visibility is poor (i.e., when the entire width of the 300 m transect is not visible due to rain or fog).

Transects are scanned continuously by eye, to count and identify birds present in the air or on water. Binoculars are used to confirm species identification, and other details, such as age, sex, moult and behaviour. Observed birds on the sea surface are continuously recorded throughout the watch period, and their distance from the platform is estimated. Flying birds are not recorded continuously throughout the 5- and 10-minute watch periods, as this would over estimate abundance. Instead, flying birds are recorded using instantaneous counts, or "snapshots", at regular intervals throughout the observation period (Tasker et al. 1984). The number of snapshots conducted depends on the speed of the vessel.

All data are stored in the Eastern Canada Seabirds At Sea (ECSAS) database. For the purposes of this analysis, all records from the Scotian Shelf (area defined in Fig. 4-1) were extracted from the database. With data pooled from CWS 'reference' transects and supply vessels traveling to and from SOEP platforms, this included a total 9940 watches (5- and 10-minute combined) recorded between

12 March 2006 and 17 January 2011. Bird densities (birds/km^2) were calculated for each watch based on a 300 m wide band and the distance traveled, which varied with ship speed.

A Geographic Information System (GIS; ArcGIS 9.3) was used to classify watches based on distance from platforms The maximum distance between platforms is approximately 50 km, thus, a 25 km buffer around the platforms creates an area that encompasses all waters between the platform areas, and defines the "Platform Area" (Fig. 5-2). All watches within 25 km of platforms were compared between SOEP data from 2010/2011 and previous years' data from 2006-2009.

To account for seasonal changes in bird abundance due to breeding and migratory periods, all data were categorized by season and analyzed separately. Seasons were defined by general migratory (spring March-April; autumn September-October), breeding (summer: May-August), and non-breeding (winter: November-February) periods typical of seabirds the Northwest Atlantic.

4.5 ANALYSIS

All data for the Scotian Shelf are included in initial descriptive results but comparisons between periods were restricted to watches within 25 km of SOEP platforms. Analyses compared 2010/2011 SOEP transect data to 2006-2009 CWS and SOEP transects. Independent samples t-tests compared differences in seabird densities between periods. Separate analyses were conducted for each season. Statistical significance of differences in densities was determined by critical values of $p \leq 0.05$.

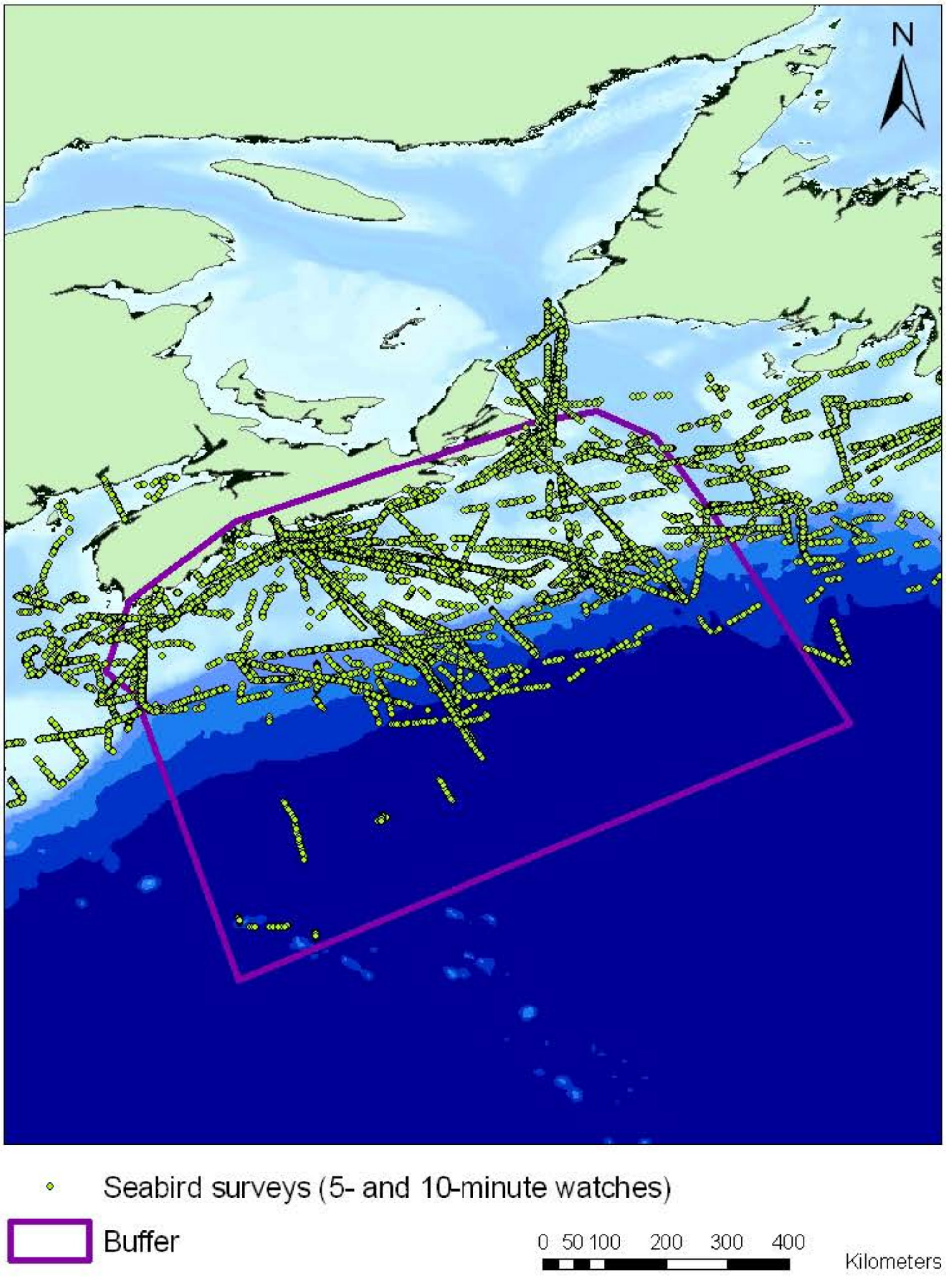


FIG. 4-1 SEABIRD SURVEY DATA.

Distribution of 5- and 10-minute watches available from the Eastern Canada Seabirds At Sea database. Buffer indicates the extent of the Scotian Shelf and adjacent pelagic waters. This buffer delineates the subset of data used in the analysis for this chapter.

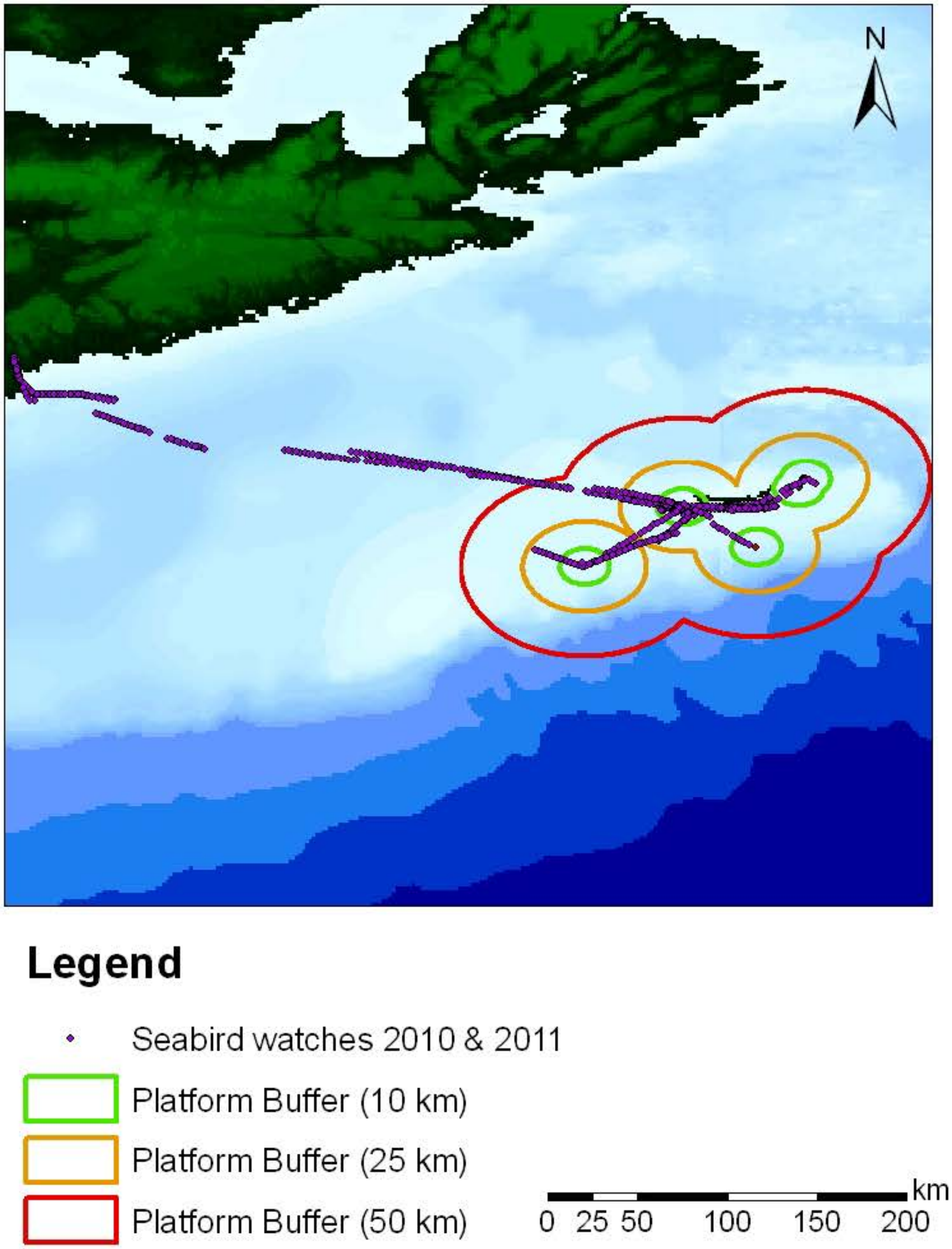


FIGURE 4-2. DISTRIBUTION OF ALL WATCHES FROM SOEP SUPPLY VESSELS BETWEEN JANUARY 2010 AND JANUARY 2011.

Buffers represent distance classes surrounding SOEP gas platforms.

4.6 RESULTS

In 2010 and early 2011, surveys were conducted during 5 trips from Halifax to the SOEP production field, resulting in 28 days of surveys and 604 5-minute watches (Table 4-1). Most surveys were conducted during summer breeding periods (May and July) or during winter non-breeding periods (January); no surveys were conducted during spring migratory periods and few were conducted during autumn migration. This survey effort improves substantially on winter surveys in comparison to previous years. Spatial distribution of surveys included 26%, 32%, 6%, and 36% of surveys within 0-10 km, 10-25 km, 25-50 km, and >50 km from SOEP platforms, respectively. 1038 birds were observed during surveys and bird densities were highest during both winter surveys and nearly double that of densities during all other periods (Table 4-1).

Table 4-1 Summary Of Surveys Conducted From SOEP Supply Vessels In 2010/2011

Survey period	Season	# of survey days	# watches	# of birds	Mean (SD) bird density (birds/km2)
23-26 Jan 2010	winter	4	123	352	6.27 (17.7)
19-26 May 2010	summer	8	158	207	2.89 (4.29)
15-20 Jul 2010	summer	4	105	195	3.74 (10.92)
14-18 Oct 2010	autumn	5	63	23	1.49 (4.71)
20-27 Jan 2011	winter	7	155	261	4.66 (11.42)
Totals		28	604	1038	4.03 (11.25)

Watches Refer To 5-Min. Observation Periods from the Eastern Canada Seabirds at Sea Database.

Table 4-2 summarizes the frequency of occurrence and densities of all species encountered during 2010/2011 surveys from SOEP supply vessels. Dovekies were encountered most frequently during watches (9.6% of watches), accounted for 39% of all bird sightings, and had the highest average densities of 1.58 birds per km^2. Likewise, Dovekies were the most abundant bird from all Scotian Shelf surveys (see Table 4-2 from 2009 EEM report). The overall density of all birds combined across all seasons was identical (4.03 birds per km^2) during the 2010/2011 SOEP surveys and the Scotian Shelf wide surveys 2006-2010 (see Table 4-2 from 2009 EEM report).

Table 4-2 Summary Of Seabird Numbers And Densities Recorded During SOEP Supply Vessel Surveys, January 2010 To January 2011.

Family	Species	# of birds	% of birds	% of watches encountered	Avg. density (birds/km2)	SD
Shearwaters & Fulmars						
	Great Shearwater	110	10.6	5.0	0.39	3.42
	Sooty Shearwater	40	3.9	2.6	0.15	1.18
	Northern Fulmar	8	0.8	1.3	0.03	0.29
Storm-petrels						
	Leach's Storm-petrel	14	1.3	1.5	0.05	0.43
	Wilson's Storm-petrels	5	0.5	0.7	0.02	0.23
	unidentified Storm-petrels	37	3.6	4.5	0.13	0.68
Cromorants and Gannets						
	Double-crested Cormorant	10	1.0	0.3	0.04	0.80
	Northern Gannet	12	1.2	1.7	0.04	0.31
Gulls						
	Glaucous Gull	2	0.2	0.3	0.01	0.13
	Iceland Gull	1	0.1	0.2	0.00	0.09
	Ring-billed Gull	1	0.1	0.2	0.01	0.16
	Great Black-backed Gull	36	3.5	4.1	0.21	1.70
	Herring Gull	65	6.3	4.8	0.28	1.82
	Black-legged Kittiwake	117	11.3	5.1	0.47	5.93
	unidentified Gull	8	0.8	1.0	0.03	0.28
Terns						
	Common Tern	10	1.0	1.0	0.04	0.40
	Artic Tern	2	0.2	0.2	0.01	0.15
	unidentified Tern	42	4.0	4.0	0.17	1.01
Alcids						
	Dovekie	408	39.3	9.6	1.58	7.35
	Black Guillemot	2	0.2	0.2	0.01	0.20
	Razorbill	11	1.1	0.7	0.05	0.66
	Atlantic Puffin	12	1.2	1.8	0.05	0.35
	Common Murre	1	0.1	0.2	0.00	0.09
	Thick-billed Murre	9	0.9	1.0	0.03	0.37
	unidentified Murres	30	2.9	1.8	0.11	1.20
	unidentified Murre/Razorbill	14	1.3	0.7	0.06	0.76
	unidentified Alcids	1	0.1	0.2	0.00	0.09
Misc.						
	Red Phalarope	16	1.5	0.3	0.05	1.12
	Pomarine Jaeger	1	0.1	0.2	0.00	0.09
	Common eider	9	0.9	0.5	0.03	0.49
	unidentified birds	3	0.3	0.5	0.01	0.18
Total		**1038**	**100.0**		**4.03**	**11.25**

Shaded Cells Indicate The Top 10 Highest Values For Each Column (Boxed Cell Indicates The Highest).

Within each season, t-tests were used to compare seabird densities between 2010/2011 SOEP data and 2006-2009 data for areas within 25 km of SOEP platforms. During winter periods (Nov-Feb; Table 4-3), Northern Fulmar densities were significantly lower and Dovekie densities were significantly higher during the most recent surveys (2010/2011) in comparison with previous years. During summer periods (May-Aug; Table 4-4) the 2010/2011 surveys documented an increase in terns but a decrease in Northern Fulmar and storm-petrels. In autumn periods (Sep-Oct; Table 4-5) only Great Shearwaters showed significant declines, which resulted in a nearly significant ($p = 0.06$) overall decline in total bird densities. No surveys were conducted in spring (Mar-Apr) migratory periods. See section 4.6 for discussion of these changes in bird densities.

Table 4-3 Winter (Nov-Feb) comparison of seabird densities between 2010-2011 and 2006-2009 periods.

Winter			Bird density per km^2		Results of t-test			
Species/Group	Years	N	Mean	SD	t	df	P	Change
Great Shearwater	2006-2009	64	0.00	0.00	n/a			
	2010-2011	184	0.00	0.00				
Sooty Shearwater	2006-2009	64	0.00	0.00	n/a			
	2010-2011	184	0.00	0.00				
Northern Fulmar	2006-2009	64	0.28	1.34	2.279	246	**0.024**	decrease
	2010-2011	184	0.03	0.34				
Storm-petrel spp.	2006-2009	64	0.00	0.00	n/a			
	2010-2011	184	0.00	0.00				
Northern Gannet	2006-2009	64	0.00	0.00	-0.589	246	0.556	
	2010-2011	184	0.02	0.27				
Great Black-backed Gull	2006-2009	64	0.10	0.46	-1.058	246	0.291	
	2010-2011	184	0.49	2.94				
Herring Gull	2006-2009	64	0.04	0.30	-0.595	246	0.552	
	2010-2011	184	0.12	1.10				
Black-legged Kittiwake	2006-2009	64	2.45	17.66	0.652	246	0.515	
	2010-2011	184	1.24	10.63				
Tern spp.	2006-2009	64	0.00	0.00	n/a			
	2010-2011	184	0.00	0.00				
Dovekie	2006-2009	64	0.03	0.25	-2.208	246	**0.028**	increase
	2010-2011	184	2.39	8.54				
Atlantic Puffin	2006-2009	64	0.00	0.00	-1.020	246	0.309	
	2010-2011	184	0.04	0.33				
Murres & Razorbills	2006-2009	64	1.05	3.67	0.813	246	0.417	
	2010-2011	184	0.70	2.79				
All Birds	2006-2009	64	3.98	18.15	-0.465	246	0.642	
	2010-2011	184	5.04	14.80				

ALL DENSITIES ARE WITHIN 25 KM OF SOEP PLATFORMS. N = # OF WATCHES. P < 0.05 INDICATES STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN PERIODS. N/A = NOT APPLICABLE WHEN T-TEST COULD NOT BE PERFORMED.

Table 4-4 Summer (May-Aug) comparison of seabird densities between 2010-2011 and 2006-2009 periods.

Summer			Bird density per km^2		Results of t-test			
Species/Group	Years	N	Mean	SD	t	df	P	Change
Great Shearwater	2006-2009	27	0.68	1.33	-0.451	142	0.653	
	2010-2011	117	1.33	7.46				
Sooty Shearwater	2006-2009	27	0.00	0.00	-1.230	142	0.221	
	2010-2011	117	0.25	1.07				
Northern Fulmar	2006-2009	27	0.03	0.16	2.107	142	**0.037**	decrease
	2010-2011	117	0.00	0.00				
Storm-petrel spp.	2006-2009	27	2.21	2.20	6.230	142	**0.000**	decrease
	2010-2011	117	0.29	1.21				
Northern Gannet	2006-2009	27	0.00	0.00	n/a			
	2010-2011	117	0.00	0.00				
Great Black-backed Gull	2006-2009	27	0.07	0.36	0.333	142	0.740	
	2010-2011	117	0.04	0.35				
Herring Gull	2006-2009	27	0.07	0.34	-0.657	142	0.512	
	2010-2011	117	0.17	0.78				
Black-legged Kittiwake	2006-2009	27	0.00	0.00	n/a			
	2010-2011	117	0.00	0.00				
Tern spp.	2006-2009	27	0.03	0.17	-2.176	142	**0.031**	increase
	2010-2011	117	1.02	2.34				
Dovekie	2006-2009	27	0.00	0.00	-0.479	142	0.633	
	2010-2011	117	0.02	0.20				
Atlantic Puffin	2006-2009	27	0.00	0.00	n/a			
	2010-2011	117	0.00	0.00				
Murres & Razorbills	2006-2009	27	0.00	0.00	n/a			
	2010-2011	117	0.00	0.00				
All Birds	2006-2009	27	3.12	2.59	-0.168	142	0.867	
	2010-2011	117	3.45	10.33				

All densities are within 25 km of SOEP platforms. N = # of watches. $p < 0.05$ indicates statistically significant differences between periods. n/a = not applicable when t-test could not be performed.

Table 4-5 Autumn (Sept-Oct) comparison of seabird densities between 2010-2011 and 2006-2009 periods.

Autumn			Bird density per km^2		Results of t-test			
Species/Group	Years	N	Mean	SD	t	df	P	Change
Great Shearwater	2006-2009	204	2.97	8.65	2.077	252	**0.039**	decrease
	2010-2011	50	0.41	1.78				
Sooty Shearwater	2006-2009	204	0.03	0.19	0.953	252	0.342	
	2010-2011	50	0.00	0.00				
Northern Fulmar	2006-2009	204	0.10	0.50	1.481	252	0.140	
	2010-2011	50	0.00	0.00				
Storm-petrel spp.	2006-2009	204	0.11	0.89	0.895	252	0.372	
	2010-2011	50	0.00	0.00				
Northern Gannet	2006-2009	204	0.87	3.73	1.576	252	0.116	
	2010-2011	50	0.03	0.23				
Great Black-backed Gull	2006-2009	204	0.13	0.78	1.221	252	0.223	
	2010-2011	50	0.00	0.00				
Herring Gull	2006-2009	204	0.20	0.73	-1.790	252	0.075	
	2010-2011	50	0.73	4.03				
Black-legged Kittiwake	2006-2009	204	0.27	1.34	-0.448	252	0.654	
	2010-2011	50	0.39	2.28				
Tern spp.	2006-2009	204	0.01	0.08	0.494	252	0.622	
	2010-2011	50	0.00	0.00				
Dovekie	2006-2009	204	0.00	0.00	n/a			
	2010-2011	50	0.00	0.00				
Atlantic Puffin	2006-2009	204	0.02	0.17	0.667	252	0.505	
	2010-2011	50	0.00	0.00				
Murres & Razorbills	2006-2009	204	0.00	0.07	0.494	252	0.622	
	2010-2011	50	0.00	0.00				
All Birds	2006-2009	204	4.79	11.52	1.888	252	**0.060**	decrease
	2010-2011	50	1.64	5.16				

All densities are within 25 km of SOEP platforms. N = # of watches. p < 0.05 indicates statistically significant differences between periods. n/a = not applicable when t-test could not be performed.

Table 4-6 Comparison of seabird densities between 2010-2011 and 2006-2009 periods using all available data from the Scotian Shelf

			Bird density per km^2		Results of t-test			
Species/Group	Years	N	Mean	SD	t	df	P	Change
Winter								
Northern Fulmar	2006-2009	788	0.73	3.67	3.232	1064	0.001	decrease
	2010-2011	278	0.02	0.28				
Dovekie	2006-2009	788	2.06	7.34	-2.035	1064	0.042	increase
	2010-2011	278	3.24	10.55				
Summer								
Northern Fulmar	2006-2009	2213	0.20	1.40	1.707	2474	0.088	decrease
	2010-2011	263	0.05	0.33				
Storm-petrels spp.	2006-2009	2213	1.07	3.63	2.808	2474	0.005	decrease
	2010-2011	263	0.44	1.33				
Tern spp.	2006-2009	2213	0.03	0.39	-10.481	2474	0.000	increase
	2010-2011	263	0.48	1.68				
Autumn								
Great Shearwater	2006-2009	3060	1.25	9.10	0.808	3121	0.419	not sig.
	2010-2011	63	0.32	1.59				

Note, 2010-2011 data includes only data from surveys to the SOEP platforms, and, thus, are limited in spatial and temporal coverage in comparison to 2006-2009 data. N = # of watches.

4.7 CONCLUSIONS

This analysis provides a comparison of most recently collected data (2010-11) from SOEP supply vessels, to similar data collected between 2006 and 2009. During 2010/2011, there was an improvement in seasonal coverage with more emphasis on winter surveys (46% of watches), in contrast to previous years where nearly 50% of available data near platforms (within 25 km) was collected during Autumn periods. Bird densities in this area appear to be highest during winter periods (Tables 4-1, 4-3) suggesting that this area is important foraging habitat for non-breeding seabirds, such as the abundant Dovekie.

Within seasons, there were some significant increases and declines in density of certain species during the 2010/2011 surveys (Tables 4-3, 4-4, 4-5). Notably, Northern Fulmars have become nearly absent in both winter and summer, and storm-petrel summer densities decreased from 2.2/km^2 in 2006-2009 to 0.3/km^2 in 2010. Conversely winter dovekie populations have increased substantially in recent years from 0.03/km^2 in 2006-2009 to 2.39/km^2 in 2010. Because surveys sample sizes are quite limited around platforms (n = 64 and 27 during 2006-2009 winter and summer data, respectively), speculation about true population declines or increases should be treated with caution at this point. Some changes in density may be related to the narrow timing of vessel surveys; for example, the decrease in Great Shearwater densities during autumn 2010 (Table 5-5) most likely reflects the timing of autumn surveys which occurred between 14-18 Oct (Table 4-1, after the typical migration exodus of this species (early to mid September). This resulted in very low overall bird abundance in autumn 2010 (1.6/km^2) since Great Shearwaters are typically the most abundant seabird at this time.

Objective 1 (Section 4.3) aimed to determine distribution and densities of seabirds around the platforms of the SOEP production area. This analysis identifies Dovekies, Black-legged Kittiwakes, storm-petrels, and Great Shearwaters as the most abundant species within 25 km of SOEP platforms, depending on time of year. Densities were generally highest during winter months compared to other periods of the year. Within seasons, the data also suggest considerable inter-annual variability in density for some species around platforms (e.g. Dovekie, Northern Fulmar, and storm-petrels). Together these results provide baseline information on the marine bird community of this area, against which future surveys may be compared.

Tables 4-3 to 4-5 identify some species which have shown recent increases in density within the 25 km buffer around platforms. To investigate the generality and biological significance of this, data for these species were compared from 2010-2011 surveys to all previous data collected (2006-2009) from the Scotian Shelf (note 2010 data for other parts of the Scotian Shelf were not provided at the time of analysis). The temporal patterns of change in abundance were the same for all species (Table 4-6) suggesting some generality in these patterns outside of the 25 km buffer zone. However, this interpretation should be treated with caution since 2010 data were only available from the SOEP survey routes, and, thus, are very limited in spatial and temporal coverage in comparison to the entire Scotian Shelf database. Some of these observed differences are likely due to the limited area in which SOEP surveys are conducted. For example, the high tern densities in 2010-2011 are most likely due to the proximity of SOEP surveys in the vicinity of Sable Island where terns are nesting during the summer. Overall, the high annual, seasonal, and species-specific variability in seabird densities make trend analysis difficult with this dataset.

In summary, the following conclusions may be drawn based on the current analysis:

- Survey effort was increased during winter periods in 2010/2011.
- Overall seabird densities were equal between 2010/2011 and 2006-2009 periods (4.03 birds/km^2)
- For areas within 25 km of platforms and comparison between 2010/2011 and 2006-2009 periods:
    - Overall bird density showed no significant changes within seasons
    - During winter periods Dovekie densities were higher and Northern Fulmar densities were lower in 2010/2011
    - During summer periods fulmar and storm-petrel densities were lower and tern densities were higher in 2010
    - During autumn periods, Great Shearwater densities were lower in 2010, but this likely reflects the timing of the survey which occurred after the peak fall migration period.

4.8 FUTURE MONITORING

EMC is considering a potential opportunity to participate in the implementation and testing of new monitoring techniques around offshore platforms. Dr. Phil Taylor, Acadia University, will be initiating studies with Encana's Deep Panuke project on the use of instrument-based automated monitoring tools to enhance the monitoring and study of bird activities and bird attraction to offshore platforms. This includes studies using radar, thermal imagery and tracking of individual birds. The primary advantages of such instrument-based approaches include the monitoring of bird activities 24 hrs per day, year round, at multiple locations and during most weather conditions. This overcomes some of the spatial and temporal limitations inherent in observer-based monitoring from supply vessels.

4.9 REFERENCES

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5. BEACHED SEABIRD SURVEYS

Photos: Sable Island Green Horse Society

5.1 RATIONALE

Since 1996, regular surveys for beached oiled birds have been conducted on Sable Island to monitor trends in numbers and rates of oiling in beached seabirds, and to collect specimens of contamination for gas chromatographic analysis to generically identify oil types. Results of analysis of oil samples collected during 1996-2005 have been reported in [1]. Results of beached surveys conducted during 1993-2009 [2] is in preparation for submission to a peer reviewed scientific journal in March 2011.

5.2 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 offshore operations.

5.3 OBJECTIVES

There are two main objectives of the beached bird surveys:
- To monitor trends in oiling rate in beached seabird corpses; and
- To generically identify oil types found on seabird feathers and in pelagic tar.

5.4 METHODOLOGY

Zoe Lucas, biologist and long time resident of Sable Island, conducted the beach bird surveys on Sable Island. Table 5-1 provides the methodology for the beached seabird survey.

Table 5-1: Beached Seabird Field Survey Methods

Parameter	Sampling Methodology
Survey date:	Between January 1 and December 31, 2010, eleven surveys for beached oil and oiled seabirds were conducted on Sable Island. No survey was conducted for November.
Number of Surveys	11
Type of Sample:	Species identification, corpse condition and extent of oiling were recorded for seabird specimens. When possible, the time since death was estimated based on freshness of tissues and degree of scavenging. The oiling rate is the fraction of oiled birds of the total number of birds coded for oil (i.e. with >75% of body intact) during 2010. Samples of oiled feathers (representing contamination on various seabird species) and beached oil, were collected.
Sample Preparation	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 samples found on the beach and bird corpses on Sable Island were identified as representing separate discharge events on the basis of date, bird corpse condition, and oil characteristics.
Number of Samples	4
Equipment:	Collected by hand using glass or metal foil containers

5.5 ANALYSIS

Maxxam Analytics Inc. conducted the analyses of four oil samples collected from the feathers of beached seabird corpses in March and April 2010.

Table 5-2: Analytical Method for Oiled Seabirds

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

Oil specimens were solid samples (pelagic tar or oiled seabird feathers) and were dissolved directly in dichloromethane. This extract, filtered to remove solids, was injected on a glass capillary column (SPB-1) in an HP 5890 Gas Chromatograph with Flame Ionization Detector (GC/FID). Outputs from the GC were retrieved on HPChem station, and chromatograms were produced and assessed manually.

Concurrently standard oils such as Bunker C, Scotian shelf crude and condensate, marine diesel, and hydrocarbon n-alkane marker standards (C6-C16 and C18-C32) were run under the same conditions. This permitted identification of the n-alkane peaks in the chromatograms. N-alkane peaks were not quantified: only relative concentration calculations based on peak height were undertaken.

Laboratory QA/QC
Maxxam Analytics is a CAEL facility (Canadian Association of Environmental Laboratories).

5.6 RESULTS

During 2010, the corpses of 354 beached gannets, tubenoses, gulls, and alcids were collected on Sable Island. Tubenoses (primarily shearwaters) accounted for 42.9% of total seabird corpses recovered. Alcids comprised 27.7% of total birds recovered (Table 5-3).

The overall density of complete clean corpses was 0.239/km, and for the four bird groups was 0.126/km for tubenoses, 0.049/km for gulls, and 0.039/km for alcids, and 0.025/km for Northern Gannets. All 2010 values are within the range of annual densities recorded during 1993 to 2009 [2]. For example, the linear density of complete clean alcid corpses was below 0.050/km in 7 of the 17-year study period (i.e., 1996, 1997, 1998, 2002, 2003, 2005, and 2007). (Table 5-3)

Table 5-3: Beached Seabird Corpses Collected on Sable Island During 2010

Species	J	F	M	A	M	J	J	A	S	O	D	Total Birds found	Number per km	Total complete corpses	Oiling rate %
Gannet			1		14	1		1	3	9		29	0.032	23	0
Tubenoses	2	1		1	10	53	61	8	3	11	2	152	0.166	115	0
Gulls	5	7	14	11	13	10	1	1	4	4	5	75	0.082	45	0
Alcids	10	14	12	18	6	2	1				35	98	0.107	38	5.3
Total	17	22	27	30	43	66	63	10	10	24	42	354	0.387	221	0.9

Note: Monthly totals, and annual oiling rate based on complete corpses (i.e. with >75% of body intact).

For all species combined, the oiling rate for birds coded for oil (i.e. with >75% of body intact) was 0.9%. The highest rate for a seabird group, 5.3%, was observed in alcids (Table 5-3). Although the 2010 oiling rate for alcids was 2.7 percentage points higher than the 2009 oiling rate for this bird group, it is consistent with the relatively low levels of oiling recorded during the three previous years.

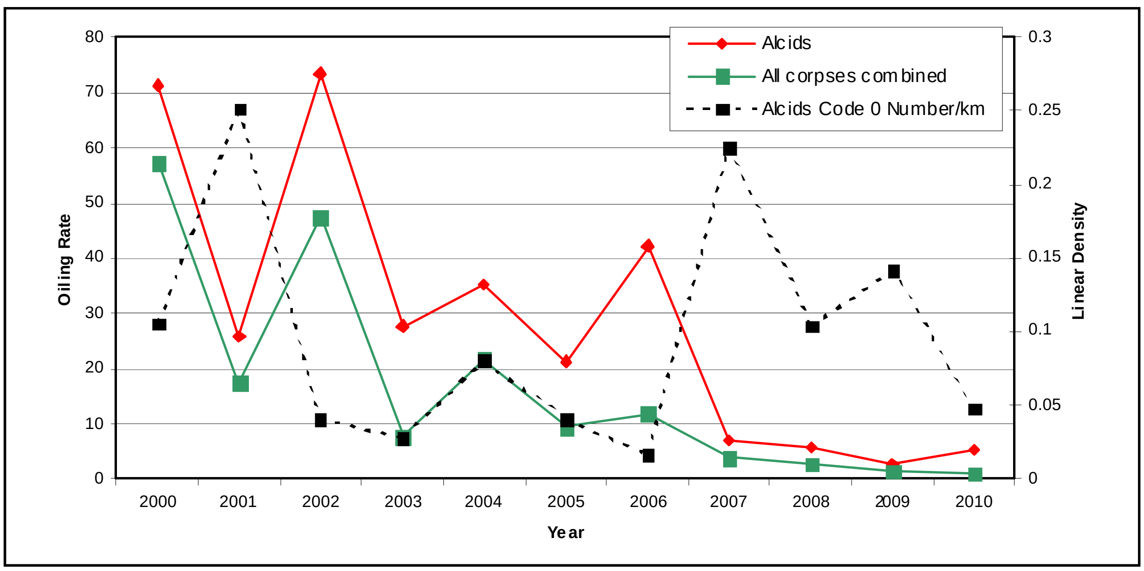

Figure 5-1: Oiling Rate for Complete Seabird Corpses & Alcids

Based on laboratory analysis, the four samples of oil collected from bird feathers in 2010 were determined to most likely represent four separate discharge events (Tables 5-4).

Table 5-4: Discharge Events Identified on Sable Island During 2010

Date	Number of Samples	Matrix	Generic Identification of Oil
Mar 18	1	Beach	crude oil, slight weathering
Mar 18	1	Alcid	lube oil with heavy fuel oil
Mar 18	1	Alcid	Bunker C type fuel oil, possibly a bilge mixture
Apr 23	1	Alcid	crude oil, moderate weathering

Table 5-5 Discharge Events Identified by Generic Oil Source of Samples Collected on Sable Island during 2000-2010

Year	Crude oil	Fuel oil	Bilge	Total
2000	6	1	1	8
2001	12	2	2	16
2002	5	3	2	10
2003	6	2		8
2004	6			6
2005	9			9
2006	5	1		6
2007	2	1		3
2008	3	1	4	8
2009	2	3		5
2010	2		2*	4
Total	58	14	11	83

* 1 specimen possibly bilge or fuel oil

5.7 CONCLUSIONS

Alcids experienced the highest percent oiling rate in 2010; and appear to be the family of birds most impacted by oil discharge. In fact, two alcid species, Thick-billed Murre (Uria lomvia) and Dovekie (Alle alle) have been reported to experience the highest rates of oiling in eastern Canada [3]. Nonetheless, the relatively steady decrease in percent oiling rate of seabird species (overall) from 2000 to 2010 suggests measures to reduce illegal oil discharges from vessels has resulted in a reduction in the seabird oiling events in the Sable Island area.

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

The overall density of complete clean corpses values observed in 2010 are within the range of annual densities recorded during 1993 to 2009 [2]. For example, the linear density of complete clean alcid corpses was below 0.050/km in 7 of the 17-year study period (i.e., 1996, 1997, 1998, 2002, 2003, 2005, and 2007).

5.8 REFERENCES

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6. MUSSEL HEALTH AND BODY BURDEN

6.1 RATIONALE

As part of the on-going EEM program, shellfish have been collected from the SOEP Tier 1 sites and analyzed to determine the degree of hydrocarbon uptake (body burden and/or taint) as a result of production activities in each area.

Thebaud, the main processing platform, has been in operation since December 1999. Mussel collection has been undertaken at Thebaud at least once per year in each of 1999, 2000, 2001, 2002, 2005, 2007, 2009, and 2010.

Throughout 2000 and 2001, caged mussels were moored at 250m, 500m, 1000m, 2000m, 4000m, 10km, and 15km from the platform. The original intent was to set and collect caged samples on a quarterly basis. The mooring program was discontinued after damage and loss of moorings due to supply vessel interaction. Additionally, mussels collected near the seafloor were adversely affected by sand accumulation. Thereafter, mussels were collected by utilizing an Fast Rescue Craft (FRC) in fine weather to scrape samples from the jacket legs near the waterline. Presence of mussels, prevailing weather and safety of field personnel are determining factors in selecting which jacket leg to sample.

The requirement to be ‘downstream’ of the platform is relevant only as related to far-field monitoring sites. Ocean currents near Sable Island are relatively strong, with most of the current energy (about 70% at Thebaud, about 90% at Venture) has been shown to be due to elliptical tidal flows. The envelope defined by average tidal excursion is about 2-3 times the prevailing current. Thus, each jacket leg will be exposed to the PW discharge plume for several hours twice daily. In this average sense, all jacket legs are ‘exposed’ to the produced water (PW) and for sampling purposes, all jacket legs are considered to be within the zone of initial PW plume dilution.

In 2003, no mussel colonies suitable for sampling were found on the jacket legs. This condition was attributed to natural sloughing from the jacket legs observed to occur when mussels and associated biofouling community reach maximum size or density. This process is presumably due to storm wave action. Mussels were not collected in 2008 due to logistical and weather/sea state conditions.

6.2 GOAL

This program component is intended to establish levels of tissue chemical contaminants on blue mussels and if produced water discharge from the platform results in demonstrable deleterious effects to marketability of fishery resources.

6.3 OBJECTIVES

The objectives of the mussel health and body burden component of the EEM report are to:

- characterize hydrocarbon profiles of mussels from Thebaud relative to previously analyzed reference condensate samples and to ‘control’ mussels;
- determine flesh moisture, flesh total lipid content and lipid class composition of mussels from Thebaud and ‘control’ mussels;
- determine total metal, petroleum hydrocarbon, and PAHs concentrations in mussels from Thebaud and ‘control’ mussels;
- compare total metal, petroleum hydrocarbon and PAH levels in Thebaud mussels with levels in mussels collected in previous years.

6.4 HISTORICAL REVIEW

Table 6.1 shows the body burden concentration of hydrocarbons in mussels growing on the Thebaud Production Platform jacket legs from 2001 to 2009. The intent during the 1999 to 2000 EEM program was to assess mussel body burden and tainting on a quarterly basis. That goal was not achieved due to operational limitations however several analyses were undertaken within each year.

Table 6.1: Aliphatic Hydrocarbon Concentrations (C10-C24) (ppm, dry weight) in Blue Mussel Tissues from Thebaud and Control Samples

Location	Nov 99-Feb 00	Feb 00-May 00	June 00-Nov 00	July 2001	July 2002	Oct 2005	Sept 2007	July 2009
Platform				31.65	44.54	20.04	14.28	14.73
Wellhead				20.09				
250 m			32.39					
500 m			32.39					
1000 m t		27.99						
1000 m b		34.22						
2000 m t	17.62	24.15						
2000 m b		14.87						
4000 m t	6.63	16.78						
4000 m b		33.24						
Control t	12.59	17.53						
Control b	13.94	14.62						
Fish Market				11.40		6.61	3.35	33.27

t = top mooring
b = bottom mooring

Table 6.2: Data Interpretation Of Mussel Body Burden And Sensory Evaluation

Sample Dates	Data Interpretation
November 1999-February 2000 (multiple collections)	• Survival of mussel moorings close to the Thebaud platform was low. • Aliphatic hydrocarbon concentration at 2000 m is similar to the Control, yet at 4000 m it is lower than the Control. • No tainting from hydrocarbons
February 2000 – May 2000 (multiple collections)	• Aliphatic hydrocarbons in mussels at 1000 to 4000m • Controls were objectionable on odour and taste • No tainting from hydrocarbons
June 2000 – November 2000	• Aliphatic hydrocarbons in mussels from platform • No tainting from hydrocarbons
July 2001	• Aliphatic hydrocarbons in mussels from platform • No tainting from hydrocarbons
July 2002	• Aliphatic hydrocarbons in mussels from platform
July 2003	• No mussels at surface of platform legs
October 2005	• Aliphatic hydrocarbons in mussels from platform • Source is primarily biogenic (phytoplankton)
September 2007	• Aliphatic hydrocarbons in mussels from platform • Source is primarily biogenic (phytoplankton)
July 2009	• Aliphatic hydrocarbons in mussels from platform • Source is primarily biogenic (phytoplankton)

Pristane is a constituent in most petroleum deposits; however, it is suspected that the pristane in mussel tissues results from the ingestion of phytoplankton (Zhou et al. 1996). The C-21:6 represents an unsaturated hydrocarbon found in red, green, and brown algae, as well as diatoms and phytoplankton.

Table 6.3: Aliphatic Hydrocarbons of Importance (ppm, dry tissue basis) in Mussels

Sample Site Location	Notable Hydrocarbons	
	Pristane (ppm)	21:6[a] (ppm)
May 2000 top cages- avg	0.79	1.41
May 2000 bottom cages – avg	1.40	1.44
June 2000 250-500m avg	0.25	3.18
June 2000 Control	0.12	2.16
July 2001 Platform	1.21	ND
July 2001 Control	0.40	ND
July 2002 duplicate Platform	0.32	ND
July 2002 duplicate	0.24	ND
2005 Platform	0.56	ND

2005 Control	0.48	ND
2007 Platform	0.20	ND
2007 Control	TR	ND
2009 Platform	0.03	ND
2009 Control	0.10	ND

[a] n-heneicosa-3,6,9,12,15,18-hexaene, a hydrocarbon derived from algae.
ND = not detected; TR = present at trace levels

6.5 2010 SAMPLING EVENT

6.5.1 Methods

Live mussels were collected from a Thebaud platform leg on August 17, 2010. Obviously damaged mussels were discarded from the sample and the remainder were packed in ice and stored frozen. Commercial 'control' mussels were purchased at Atlantic Superstore.

6.5.1.1 Analysis of Body Burden

Laboratory analysis of the mussel body burden was conducted by the Canadian Institute of Fisheries Technology (CIFT). The parameters and analysis methods are listed in Table 6.4. Prior to analysis, live test mussels were picked out and scrubbed clean under running tap water and then frozen (~0°C). Metals suite, petroleum hydrocarbons and PAH analyses were conducted by Maxxam Analytics. The control mussels were acquired alive and subsequently cleaned and frozen as were the test samples. Analyses performed are summarized in Table 6.4 below.

Table 6.4: Parameters examined and analysis methods utilized on the mussel sample from the Thebaud platform in August 2010

Laboratory	Parameters	Analysis Method
CIFT	Flesh moisture	A.O.C.S Official Method Ca 2c-25
	Flesh total lipid content	Solvent extraction according to [1]
	Lipid class composition	Iatroscan thin-layer chromatography-FID
	Characterization of hydrocarbon profiles relative to previously analyzed reference condensate samples	Saponification, column chromatography and GC analysis (for details, see QA/QC section)

Maxxam	Metals	(ICP-MS, ashing prior to analysis)
	Petroleum Hydrocarbons	Atlantic PIRI
	PCBs	based on EPA 8082
	Polycyclic aromatic hydrocarbons (PAHs)	based on EPA 8270C

[1] Folch et al.

While the EEM review committee suggested analyzing mussel tissues from the platform for benzene, toluene, ethylene, and xylene compounds (BTEX), it was discovered that testing for these volatile compounds is not yet commercially available locally, and so was not feasible in 2010. Measuring BTEX in tissues is difficult, as the compounds are liberated during the tissue homogenization process.

6.5.1.2 QA/QC

From each of the two samples, test and control, several frozen organisms were randomly chosen. The meats were removed from the shells and homogenized. A subsample of the homogenized meats was prepared from each of the two samples for hydrocarbon, lipid and moisture analyses. A blank consisting of distilled de-ionized water was carried through the hydrocarbon analysis.

Hydrocarbons were isolated by saponification with pentacosane added as internal standard. Recovered hydrocarbons were purified using solid phase extraction cartridges following the method of Ackman et al. (1997). This method isolates both aliphatic and polycyclic aromatic hydrocarbons. Hydrocarbons were then analysed using a Varian 3400 capillary gas chromatograph equipped with a flame ionization detector (FID) and a splitless temperature programmable injection system. The analytes were separated on an SAC-5 column, 30 m x 0.25 mm x 0.25ų phase (Supelco, Oakville, ON). Conditions and temperature were as follows: FID 300 ºC, injector temperature 39 ºC immediately ramped at 150 ºC/min to a final temperature of 250 ºC, initial column temperature of 60 ºC held for 15 minutes, increased at a rate of 13º/min to 280 ºC, held 5 minutes and then increased at a rate of 50 º/min to a final temperature of 300 ºC and held for 10 minutes.

6.5.2 Results

Body Burden

The mussel testing results are summarized in Tables 6.5 to 6.7 below. Hydrocarbon profiles for the control and test mussels are shown in Figure 6-1 and 6-2.

Table 6.5: Moisture and Lipid Contents (% wet weight) of Mussels Collected From Thebaud Platform and Control Mussels in 2010

Sample Site Location	Moisture Contents (%)	Lipid Contents (%)
Thebaud	93.07	0.43
Control	87.55	0.87

Table 6.6: Lipid Classes (Iatrocan area %[a]) in Mussels Collected From Thebaud Platform and Control Mussels in 2010

Sample Site Location	Triacylglycerol	Free Fatty Acid	Sterol	Polar Lipid
Thebaud	4.1	TR	6.6	89.3
Control	11.5	2.6	5.2	80.7

[a] uncorrected for Iatroscan detector response
TR = present at trace levels

Table 6.7: Hydrocarbons of Importance (ppm, dry tissue basis) in Mussels Collected From Thebaud and Control Mussels in 2010

Sample Site Location	Aliphatic Hydrocarbons C_{10} - C_{24}[a] (ppm)	Polycyclic Aromatic Hydrocarbons (ppm)	Notable Hydrocarbons	
			Pristane (ppm)	21:6[b] (ppm)
Thebaud	24.27	ND	0.11	ND
Control	17.65	ND	0.04	ND

[a] The specific alkane pattern suggests a possible biogenic origin for the aliphatic hydrocarbons
[b] n-heneicosa-3,6,9,12,15,18-hexaene, a hydrocarbon derived from algae.
ND = not detected;
.

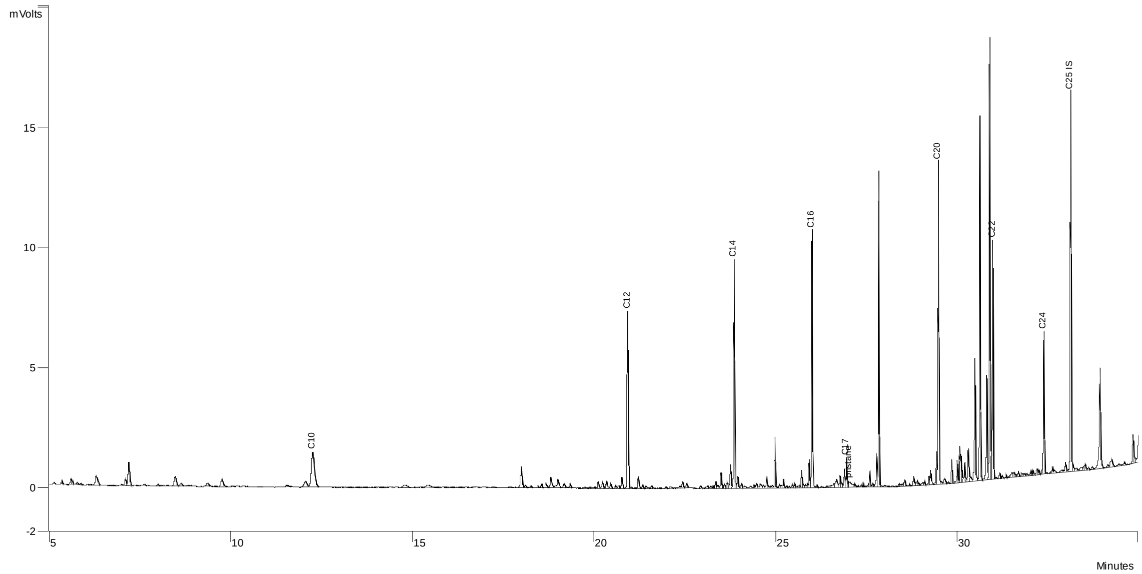

Figure 6-1: Hydrocarbon Profile of Control Mussels in 2010.

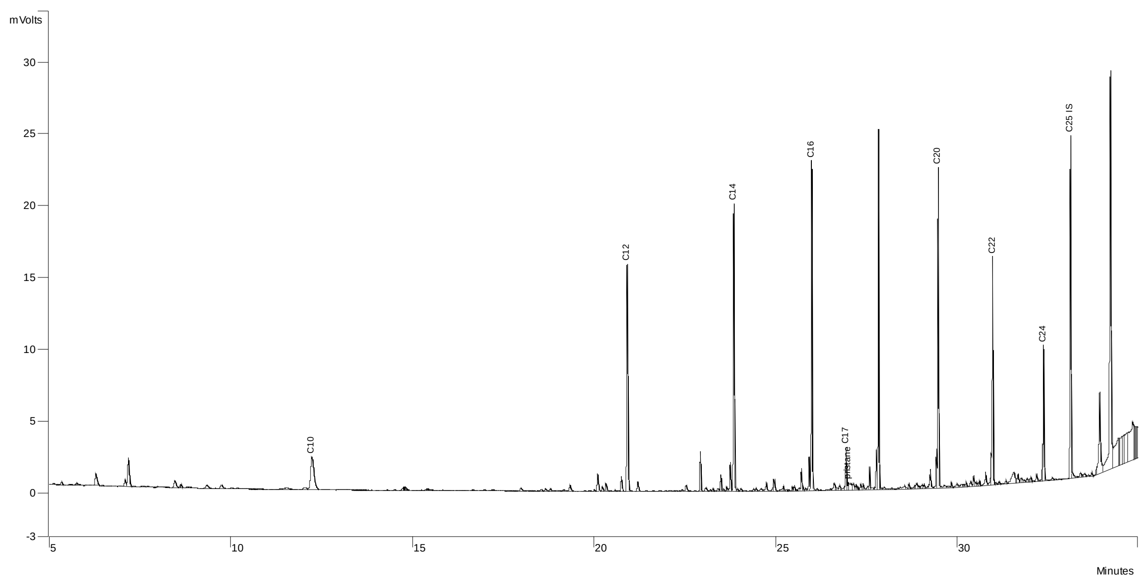

Figure 6-2: Hydrocarbon Profile of Mussels Collected from Thebaud Platform in 2010

Mussels from the Thebaud platform were found to have higher levels of strontium, cadmium and boron than control mussels. (Table 6.8). Levels of several metals, such as aluminum, arsenic, copper, iron, manganese, selenium, and zinc, were lower in the Thebaud mussels than the control mussels. Mercury was detected in the Control mussels, but not in the Thebaud mussels.

Table 6.8: Total Metals in Mussels Collected From Thebaud and Control Mussels in 2010

Metals	Units	RDL	THEBAUD	CONTROL
Aluminum (Al)	mg/kg	2.5	<2.5	8.5
Antimony (Sb)	mg/kg	0.50	<0.50	<0.50
Arsenic (As)	mg/kg	0.50	0.64	1.24
Barium (Ba)	mg/kg	1.5	<1.5	<1.5
Beryllium (Be)	mg/kg	0.50	<0.50	<0.50
Boron (B)	mg/kg	1.5	4.9	4.5
Cadmium (Cd)	mg/kg	0.050	0.581	0.209
Chromium (Cr)	mg/kg	0.50	<0.50	<0.50
Cobalt (Co)	mg/kg	0.20	<0.20	<0.20
Copper (Cu)	mg/kg	0.50	0.64	1.03
Iron (Fe)	mg/kg	15	<15	35
Lead (Pb)	mg/kg	0.18	<0.18	<0.18
Lithium (Li)	mg/kg	0.50	<0.50	<0.50
Manganese (Mn)	mg/kg	0.50	0.76	1.85
Mercury (Hg)	mg/kg	0.01	<0.01	0.01
Molybdenum (Mo)	mg/kg	0.50	<0.50	<0.50
Nickel (Ni)	mg/kg	0.50	<0.50	<0.50
Selenium (Se)	mg/kg	0.50	<0.50	0.56
Silver (Ag)	mg/kg	0.12	<0.12	<0.12
Strontium (Sr)	mg/kg	1.5	9.7	6.0
Thallium (Tl)	mg/kg	0.020	<0.020	<0.020
Tin (Sn)	mg/kg	0.50	<0.50	<0.50
Uranium (U)	mg/kg	0.020	<0.020	<0.020
Vanadium (V)	mg/kg	0.50	<0.50	<0.50
Zinc (Zn)	mg/kg	1.5	9.3	13.2

Note: Result in red font is higher than comparison

Polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and PCBs were below detectable levels (0.05 mg/kg, 15 mg/kg, and 0.05 µg/g respectively) in both the control and Thebaud mussels (Table 6.9).

Table 6.9: Hydrocarbon and PCB Concentrations in Control Mussels and in Mussels from the Thebaud Platform in 2010

	Units	RDL	THEBAUD	REFERENCE
Polyaromatic Hydrocarbons				
1-Methylnaphthalene	mg/kg	0.05	<0.05	<0.05
2-Methylnaphthalene	mg/kg	0.05	<0.05	<0.05
Acenaphthene	mg/kg	0.05	<0.05	<0.05
Acenaphthylene	mg/kg	0.05	<0.05	<0.05
Anthracene	mg/kg	0.05	<0.05	<0.05
Benzo(a)anthracene	mg/kg	0.05	<0.05	<0.05
Benzo(a)pyrene	mg/kg	0.05	<0.05	<0.05
Benzo(b)fluoranthene	mg/kg	0.05	<0.05	<0.05
Benzo(g,h,i)perylene	mg/kg	0.05	<0.05	<0.05
Benzo(j)fluoranthene	mg/kg	0.05	<0.05	<0.05
Benzo(k)fluoranthene	mg/kg	0.05	<0.05	<0.05
Chrysene	mg/kg	0.05	<0.05	<0.05
Dibenz(a,h)anthracene	mg/kg	0.05	<0.05	<0.05
Fluoranthene	mg/kg	0.05	<0.05	<0.05
Fluorene	mg/kg	0.05	<0.05	<0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	<0.05	<0.05
Naphthalene	mg/kg	0.05	<0.05	<0.05
Perylene	mg/kg	0.05	<0.05	<0.05
Phenanthrene	mg/kg	0.05	<0.05	<0.05
Pyrene	mg/kg	0.05	<0.05	<0.05
Petroleum Hydrocarbons				
>C10-C16 Hydrocarbons	mg/kg	15	<15	<15
>C16-C21 Hydrocarbons	mg/kg	15	<15	<15
>C21-<C32 Hydrocarbons	mg/kg	15	<15	<15
PCBs				
Total PCB	ug/g	0.05	<0.05	<0.05

6.5.2 Results cont'd.

In response to a query from EEM Review Committee, a preliminary analysis of Thebaud platform mussel sample age composition was conducted. Note however that the sample was not considered representative of the natural mussel population distribution at Thebaud for several reasons:

- Hand-picking of mussels is not possible, due to the constant sea swells and the safety concerns associated with accessing the platform legs via a small work boat, thus mussels were collected via the usual collection method (raking) from jacket legs at low tide. This process inherently biases the sample towards larger-sized mussels. At the time of sampling, field personnel were unaware of the query regarding mussel colony age (until after mussels had been collected for chemical analysis) so were unprepared to adapt the mussel collection program to capture a representative sample of the jacket leg population.

- While several hundred mussels were collected, the CIFT lab hand-selected a subsample of preferred size-class specimens for tissue analysis, and discarded the remaining sample. For chemical analyses of tissues, mussels of relatively uniform size should always be utilized to minimize the effects of size range variations and the associated metal concentrations variation (Phillips and Segar 1986). Only 60 large specimens suitable for tissue analysis were retained. These mussels averaged 55.6 mm in length, with a standard deviation of 0.55.

  The 60 retained Thebaud mussels were aged by counting the annual growth 'checks' on their shells. They were found to have an average age of 2.85 years (range 1 to 5), with a standard deviation of 1.04. The control mussels were not aged for comparison, as they were cultivated under different environmental conditions which aimed to maximize growth (usually to market after 2 years), presumably came from a single cohort, and were not representative of a natural population.

6.5.3 2010 Summary

The concentration of aliphatic hydrocarbons in the 2010 test sample was higher than both the control and the 2009 sample. However, it was within the range of concentrations observed since the initiation of the aliphatic hydrocarbon analysis in 2000.

Lipid levels were twice as high in the control mussels as the Thebaud mussels (0.87% vs. 0.43%). This may be related to differences in spawning season, as mussels are known to jettison gonadal associated lipids into the water column during spawning, thereby decreasing their overall lipid contents (Shigenaka and Laurenstein 1988). The spawning condition of the Thebaud sample prior to analyses was not known.

The presence of polycyclic aromatic hydrocarbons (PAH) and an unresolved complex matrix in the GC chromatograms would indicate petrogenic hydrocarbon tainting however, there was no evidence in either control or Thebaud sample. Furthermore, the aliphatic hydrocarbon profile reported is typical of that produced by naturally occurring phytoplankton. The hydrocarbon profile of both the test sample and control contained the same biogenic hydrocarbon species in the same relative proportions, only the total amounts differed. There is no difference in the aliphatic hydrocarbon profile in test or control samples (i.e., ratio of even to odd carbon numbered aliphatics is the same in both sample types).

With the exception of a slight increase in strontium, cadmium and boron and lower levels of some other metals (as aluminum, arsenic, copper, iron, manganese, selenium, and zinc,), total metal concentrations in mussels from the Thebaud platform were similar to those measured in mussels from a reference location (control mussels) in 2010. PAHs and PCBs were not detected in either Thebaud or control mussels in 2010.

While analysis of the BTEX concentrations in mussel tissue was not feasible for this study in 2010, BTEX in mussels is not expected to be a significant concern. BTEX removal from the water column is rapid (Kennicutt et al. 1988) via evaporation, adsorption to particles and sedimentation, biodegradation, and photolysis. Under turbulent conditions, with strong vertical mixing, half-lives for BTEX compounds may be as short as a few hours (Brooks et al., 1984). While marine organism have been shown to take up BTEX compounds rapidly, they also release these compounds very quickly (Neff, 2002). In addition, due to specific chemical and physical properties, BTEX compounds have a low potential to bioaccumulate (EPA, 1991), and therefore are not bioaccumulated to high concentrations by marine organisms (Neff, 2002).

BTEX compounds in produced water and seawater therefore pose a minimal risk to marine organisms and humans (Neff, 2002).

6.6 CONCLUSIONS

Nine years of monitoring the potential for uptake of hydrocarbons in mussels has shown that the presence of aliphatic hydrocarbons is attributable primarily to biogenic hydrocarbons generated by phytoplankton.

Higher concentration of biogenic hydrocarbons in filter feeding mussels suggests the production platform may promote phytoplankton growth due to local nutrient enrichment.

Mussels from Thebaud exhibited lower concentrations of several metals relative to control mussels.

6.7 REFERENCES

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7. SUMMARY AND CONCLUSIONS

The summary and conclusions for 2010 EEM Program specific components are as follows:

- Produced Water at all SOEP platform locations was interpreted as being 'toxic' based on 2010 bioassay results of EMC samples and TPH levels in produced water samples for toxicity analyses were below the OWTG (2002) limit (60 mg/L over 24-hrs).

- High salinity levels in some produced water samples (up to 185 ppt) may also have contributed to the toxicity observed in samples although toxicity continued to occur in concentrations diluted to normal salinity values in bioassay tests.

- High toxicity of produced water from SOEP platforms is not considered an environmentally relevant factor of concern based on findings in a 2010 DFO COOGER research study. Potential contaminants in the relatively small PW discharges from SOEP platforms are diluted rapidly to no-effects concentration levels within a few metres of the mouth of the discharge caisson located below the sea surface.

- The air quality monitoring program and past observations of various emission-producing activities on and around the island do not yet allow for confirmation as to whether the effects of offshore oil and gas activities can be measured on the island.

- The most abundant species observed during moving vessel Scotian Shelf bird surveys were the Dovekie (39.3% of 1038), Black-legged Kittiwake (11.3% of 1038), Great Shearwater (10.6% of 1038) and Herring Gull (6.3% of 1038). Dovekies were encountered most frequently during watches (9.6% of watches), accounted for 39% of all bird sightings, and had the highest average densities of 1.58 birds per km2.

- During 2010, the corpses of 354 beached gannets, tubenoses, gulls, and alcids were collected on Sable Island. Tubenoses (primarily shearwaters) accounted for 42.9% of total seabird corpses recovered, and alcids comprised 27.7%. For all species combined, the oiling rate for birds coded for oil (i.e. with >75% of body intact) was 0.9%. The highest rate for a seabird group, 5.3%, was observed in alcids.

- None of the four samples of hydrocarbons found on beached birds in 2010 contained light or mid-range distillate fuels, or condensates that would be typical of oils produced on offshore gas facilities such as the SOEP processing platforms off Sable Island

- Nine years of monitoring the uptake of hydrocarbons in mussels has shown that the presence of aliphatic hydrocarbons is attributable primarily to biogenic hydrocarbons generated by phytoplankton.

- Polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and PCBs were below detectable levels (0.05 mg/kg, 15 mg/kg, and 0.05 μg/g respectively) in both the control and Thebaud mussels.

- BTEX in mussels is not expected to be a significant concern. BTEX removal from the water column is rapid via evaporation, adsorption to particles and sedimentation, biodegradation, and photolysis.