
**SABLE OFFSHORE ENERGY PROJECT
2001 ANNUAL REPORT
OFFSHORE ENVIRONMENTAL EFFECTS
MONITORING PROGRAM**

PROJECT NO. NSD12989

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REPORT TO

EXXONMOBIL CANADA LIMITED

ON

SABLE OFFSHORE ENERGY PROJECT

**2001 ANNUAL REPORT
OFFSHORE ENVIRONMENTAL EFFECTS MONITORING PROGRAM**

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EXECUTIVE SUMMARY

This document presents the results of Exxon Mobil's Sable Offshore Energy Project (SOEP) Tier I EEM Program which focuses on the activities at the Venture, Thebaud and North Triumph Gas Fields between June 1998 to June/July 2001. The discharge of drilling cuttings containing the synthetic-base mud NovaPlus ceased as of December 31, 1999. EEM surveys undertaken in 2001 continued to evaluate recovery of the benthos from the discharge of drill waste as well as the effects of the release of produced water into the marine environment.

The environmental attributes chosen for the Offshore EEM Program were based on valued ecosystem components (VEC's) identified during the EIS process and attributes identified by Sable Offshore Environmental Effects Monitoring Advisory Group (SEEMAG) and the EEM study team. The study attributes include produced water quality, sediment chemistry, sediment toxicity, benthic habitat and communities, taint in shellfish, marine mammal behaviour, and seabird distribution.

The 2001 offshore monitoring program was modified from previous years EEM programs:

- The EEM program has been reduced from a bi-annual survey to an annual survey.
- Sampling locations in the near-field region (250 and 500 m) were reduced to the original number of stations as the resolution of drill wastes was not improved with an increase of stations added in the 2000 surveys.
- Toxicity testing focused on the assessment of amphipods, this test was the only bioassay that correlated with sediment chemistry results.
- Benthic boundary layer water sampling will be conducted based on drilling activity, but has ceased for production.
- Mussels were collected from the platform legs at Venture and Thebaud to focus on tainting from produced water within less than 100 m from each producing platform.
- Analytical parameters for sediment chemistry were reduced to petroleum hydrocarbons and barium as there is no statistical significant changes in other trace metal or organic elements from the project.

The extent of contamination by drill cuttings decreased to background concentrations at 250 m and beyond at the Venture field. Elevated petroleum hydrocarbons and barium were still present in sediments at distances of 250 m and 500 m in the direction of prevailing currents from the North Triumph and Thebaud platforms, but at concentrations significantly lower than immediately following drilling and approaching background levels. Sediment toxicity on amphipods correlated with these findings.

No significant effect on epifaunal or infaunal communities was observed at any of the survey stations within the Venture, Thebaud or North Triumph fields. No drill cutting pile was apparent at North Triumph from drilling of the single well. Video surveys around the platforms show an abundance of mussels, sea stars, sea cucumbers and crabs.

Petrogenic hydrocarbons attributable to the operations at Venture were occasionally detected in moored mussels within 500 m of the platform; however no taint attributable to drilling or production was evident. No taint from petrogenic hydrocarbons sources was evident at the moored mussels at Thebaud and North Triumph.

The whales, dolphins and seal species observed from the platforms are those species which typically frequent the area. It is reasonable to assume that the marine mammals observed from Thebaud are within the acoustic range of the sound spectra radiating from the drilling and production activities.

Low incidence of dead birds and the high frequency of the surveys indicate that there are no large scale bird fatalities in the vicinity of the platforms. None of the oiled seabird carcasses found on Sable Island contained hydrocarbons traceable to the SOEP Tier 1 operations.

There is no evidence of natural gas and condensate production emissions causing measurable impacts on Sable Island.

1.0 INTRODUCTION

Under the Development Plan Approval, Environmental Effects Monitoring (EEM) is necessary to test the predictions made in the Environmental Impact Statement (EIS) (SOEP 1996, MacLaren Plansearch 1997 a,b), to assess the impact of various discharges, and to collect data that will be useful for environmental management decisions.

This document presents the results of ExxonMobil Canada Properties Limited (ExxonMobil) Sable Offshore Energy Project (SOEP) EEM work to date as of July 2001 and includes baseline and multiple EEM sampling events during and post-drilling, depending upon the stage of development at each field. At the Venture field, one baseline, three drilling and three post-drilling surveys were conducted. At Thebaud, one baseline, two drilling and three post-drilling surveys were conducted, and at North Triumph two baseline, one drilling and three post-drilling surveys were conducted. As of December 31, 1999, ExxonMobil transported all synthetic-based cuttings to shore for treatment. Drilling at Venture (Well V2) occurred between February 7 and May 11, 2001. Water-based mud was used in the intermediate section of the hole (the upper hole section was drilled in the previous batch drilling program in 1998-1999) and discharged overboard. Synthetic-based mud was used below this hole section but the waste mud was skipped and shipped to shore.

The EEM surveys for this year's studies examined the continued recovery phase of the marine benthos. Each field is fully under production; Venture and Thebaud platforms released produced water. Produced water from North Triumph is transported to the Thebaud production platform via the 18 inch pipeline.

1.1 Environmental Management Plan

The offshore EEM program is an integral component of ExxonMobil's Environmental Management Plan (EMP) (SOEI 1999). The objectives of the EMP are to:

- ensure that operational activities are undertaken in an appropriate manner and that any impacts on the environment associated with operations activities are minimised and monitored; and
- anticipate and minimize the risk of potential effects from unexpected incidents, such as hydrocarbons or other chemical spills, and ensure that appropriate contingency plans are in place in the event of such incidents.

The EMP outlines the study design of the drilling phase EEM program. The Sable Offshore Energy Project Environmental Effects Monitoring Advisory Group (SEEMAG), as a part of the EMP, serves an important role in setting standards and providing review for the EEM program. The group continues to evaluate progress of the EEM and to provide feedback on the design and relevance of individual monitoring activities.



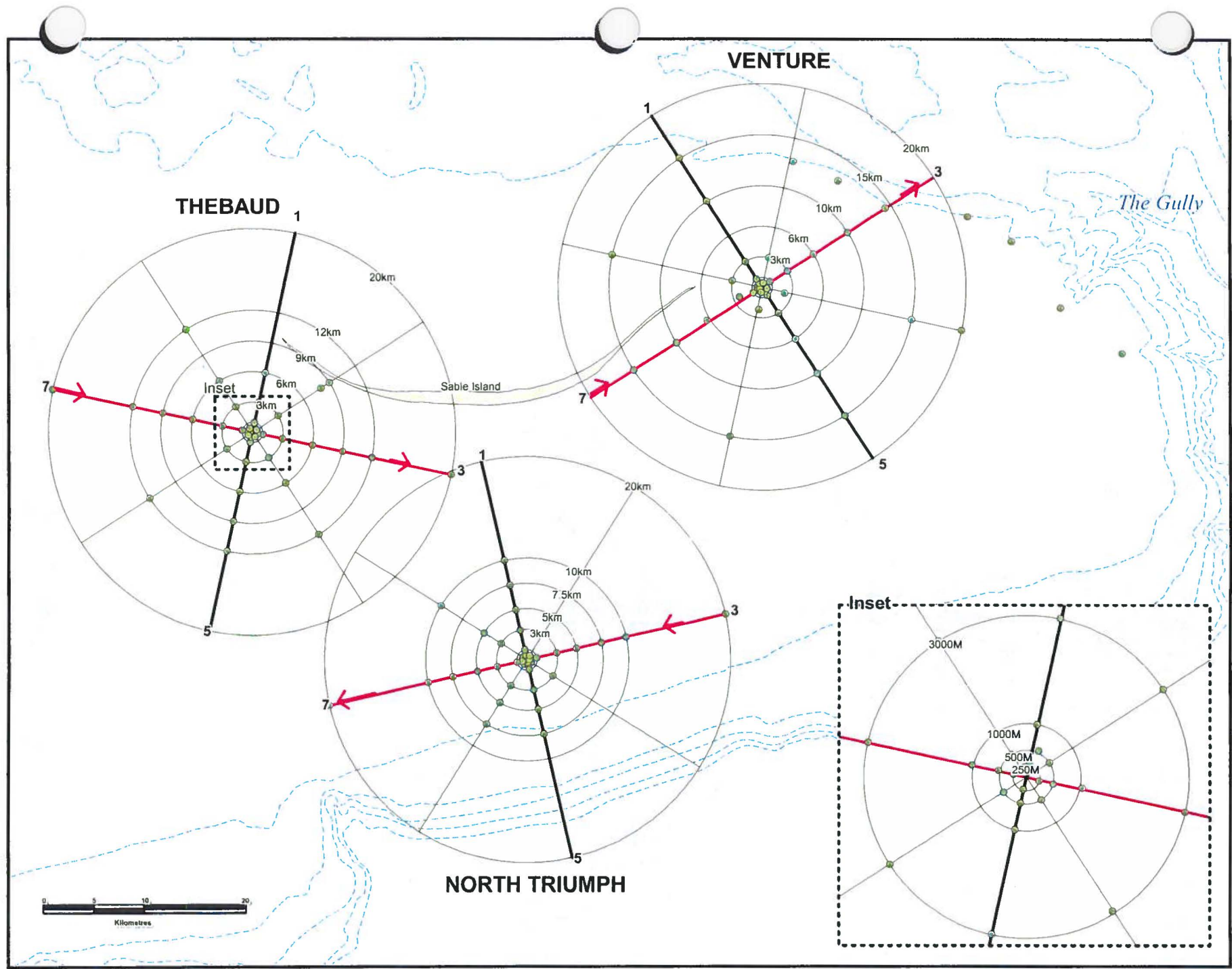
The EEM program also embodies the SOEP Safety, Health and Environmental Policy in the philosophy of continuous improvements, and the conduct of employees during the offshore surveys. With respect to Sable Island, SOEP supports environmental studies including bird surveys and air quality monitoring.

1.2 EEM Design

The objective of the EEM program is to test whether the effects of discharging drill wastes and produced water into the marine environment occur within the zones of influence predicted by the EIS. The goal of the EEM program is to assist decision-making by providing feedback to ExxonMobil, Canada - Nova Scotia Offshore Petroleum Board (CNSOPB), stakeholders, and the public.

Environmental measurements are concentrated within the area of the platforms where meaningful changes are expected to occur and where the point source discharge is located. Selected attributes evaluated in the 2001 EEM program included produced water quality, sediment quality, benthic habitat and biota, shellfish taint and body burden, marine mammals, and seabirds.

The basic strategy of this monitoring design is to take environmental measurements at sufficient spatial coverage over the course of the drilling and production phases to determine drilling material deposition, movement, and fate/impact of discharged waste. The sampling program is based on a gradient to background grid design commonly used to monitor effects from offshore oil and gas developments. This sampling grid consists of major and minor axes with sampling conducted at specific points on these axes. The major axes align with the mean current and most probable storm path directions of drilling and production waste discharges, as predicted by modelling (MacLaren Plansearch Limited 1997 a,b). The monitoring program for the drilling areas was based on a radial design (Figure 1.1), with samples located at regular distances along axes extending away from the drill site, like spokes in a wheel. Major Axes 3 and 7 were aligned with the expected prevailing current direction. Major Axes 1 and 5 were placed at right angles to that direction. Minor Axes 2, 4, 6, 8 are oriented equidistant to the major axes.



p:\envs\ch112\ch112\2000\graphics\maps\spring2000\EEM Overview Map wor

Figure 1.1
Environmental Effects Monitoring Sample Locations

- EEM Sample Site
- ➔ Direction of Prevailing Current

1.3 Objectives

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

- to verify whether the effects of discharging drill and production wastes into the marine environment occur within the zones of influence predicted by the EIS;
- to evaluate the effectiveness of mitigation and identify the need for improved or altered mitigation;
- to provide an early warning of undesirable change in the environment; and
- to provide results to the CNSOPB, other regulatory authorities, stakeholders and public so that there can be informed decision making.

1.4 Scope

This report focuses on the EEM program of the Tier I development and includes the natural gas well fields at Venture, Thebaud and North Triumph. Drilling at Venture commenced on June 20, 1998, followed by development drilling at Thebaud on November 22, 1998. Drilling at the North Triumph gas field started in November 1999 to complete one well before the CNSOPB December 31, 1999 deadline for the discharge of LTMO cuttings. The surveys undertaken in 2001 continued to investigate two main effects of the Tier I development:

- 1) the recovery of the marine benthos from the discharge of drilling wastes, and
- 2) effects from the release of produced water.

2.0 METHODOLOGIES

The majority of the EEM sampling design focuses upon the seabed because sediments are the ultimate destination or sink for persistent chemicals in the marine environment from the release of drill fluids and cuttings. Particulates from drill wastes and produced water in the benthic boundary layer are also considered in the program.

2.1 Sampling Design

The sampling design and methodologies for the JWEL sampling program are described in detail in the baseline and drilling design report (JWEL 1998). The flaring emissions study is under a separate contractor and not included in this section.

Water Column Quality

A series of three toxicity tests were performed on produced water in close proximity to the caisson at Thebaud. Samples were obtained with assistance from Seatech Ltd. who were undertaking compliance monitoring of produced water for ExxonMobil. Chemical analyses also were performed on the water samples.

Benthic Boundary Layer

Water from the benthic boundary layer (BBL) (the bottom one metre layer) was not sampled in 2001 due to the lack of a persistent presence of drill mud. Background levels of naturally occurring SPM often exceed limits expected to exert chronic detrimental effects on sea scallops (*Placopecten magellanicus*).

Sediment Quality

Sediment was collected by a grab sampler and analysed for barium, hydrocarbons and toxicity. Sediment samples were collected annually at all stations for each platform.

Benthic Habitat

Benthic habitat and epifaunal species were recorded at each sampling site using an underwater still camera to provide qualitative and quantitative assessments of changes to this environmental component.

Benthic infauna were not collected in the vicinity of the North Triumph platform in 2001 as no statistically significant changes were detectable after drilling in previous survey years.

Taint and Body Burden of Fish and Shellfish

Taint and hydrocarbon shellfish analyses were assessed from mussels attached to the platform legs at Thebaud and Venture. The low volume, intermittent discharge and high dilution of the produced water in the receiving environment necessitated focussing tainting effort close to the platforms.

Marine Mammals and Seabirds

Offshore observers provided by the Oil and Gas Observer Program (OGOP) and organized through the Seafood Producers Association of Nova Scotia (SPANS) are contracted by ExxonMobil to conduct platform-based daily monitoring of marine mammals and seabirds that are within visual range. Dead and exhausted seabird surveys are also conducted around the platform structure.

An independent oiled bird survey is conducted on Sable Island beaches on a monthly basis. Collected specimens are sampled for oil identification. These data are provided for inclusion into the annual report.

2.2 Data Analysis

Details on the statistical approach and analysis for the various EEM components are provided in Appendix A.

3.0 MONITORING RESULTS

This section presents the results of the EEM surveys undertaken from November 1998 through to June 2001 and compares the findings with the baseline surveys.

3.1 Produced Water Quality

3.1.1 Toxicity Analysis

Five samples of produced water were collected from Thebaud platform in July 2001 to coincide with the release of produced water. The first sample was collected by fast rescue craft (FRC) at the outer perimeter of the platform legs. Safety considerations prevented the sampling crew from approaching the produced water caisson under the platform. A 5 L Niskin bottle was deployed to 10 m depth approximately 5 m from the caisson. This sample was contained in a clean 10L pail and submitted to Harris Industrial Testing within two days. The remaining four samples (Sequence 1-4) were collected using a 5 L Niskin bottle lowered from the platform at a point closest to the produced water caisson located in the centre of the platform structure. The samples were contained in 20 L plastic jerry cans and transported by supply vessel back to port. The transpired time between sample collection and receipt of the samples onshore was seven days. The toxicity of these samples was assessed using two test organisms: threespine stickleback (*Gasterosteus aculeatus*) and sea urchin (*Lytechinus pictus*). Each test was undertaken using standard and approved EPS protocols. The measured lethal toxicity test for threespine stickleback is survival. For the sea urchin reproduction sublethal toxicity test, the measured effect is fertilization success.

Table 3.1 provides the toxicity testing results of the receiving water exposed to discharged produced water. Full lab reports are provided in Appendix B. The 96 hour LC₅₀ value for the fish test is the concentration estimated to be lethal to 50% of the exposed organisms. The No Observed Effect Concentration (NOEC) is the highest concentration of final produced water at which no adverse effects are observed. The Lowest Observed Effect Concentration (LOEC) is the lowest produced water effluent concentration at which organisms exhibit statistically significant adverse effects. Inhibition concentration (IC) values are an alternative method for measuring effluent toxicity and in general are more appropriate for temporal and inter-species comparisons. The IC values represent the concentration at which the produced water sample was estimated to cause a specified level of reduction of growth.

Table 3.1 Toxicity Results of Produced Water From Thebaud						
Test Date	Sample	Threespine Stickleback Survival	Sea Urchin Fertilization			
		LC ₅₀	NOEC	LOEC	IC ₂₅	IC ₅₀
July 9/10	Sample 1	>100%	100%	>100%	>100%	>100%
July 17/18	Sequence 1+2	>100%	100%	>100%	>100%	>100%
July 17/18	Sequence 3+4	>100%	100%	>100%	>100%	>100%

Results of the toxicity testing on threespine stickleback and sea urchin show that the receiving waters immediate to the Thebaud discharge caisson is not acutely or chronically toxic. The result of >100% means that the produced water effluent would need to be at a concentration >100% to elicit a response.

In addition to toxicity testing, receiving water samples were collected from Sequence 1-4 samples and submitted for analysis of hydrocarbon, ammonia, fatty acids and total organic carbon. In conjunction with the sampling of these receiving waters, Seatech Ltd. sampled and analysed produced water prior to discharge for hydrocarbons. The concentration of total oil fraction and dissolved oil fraction ranged between 32 and 47 mg/L. The results of the overboard discharges are provided in Appendix C. Table 3.2 presents data on total organic carbon, ammonia and volatile fatty acid content of receiving water adjacent to the produced water caisson. The concentration of dispersed oil (total oil fraction minus dissolved oil fraction) of each of these water samples was less than the detectable limit of 1 mg/L.

Table 3.2 Water Quality of Receiving Water Samples Near the Produced Water Caisson								
Sample	TOC mg/L	Ammonia mg/L	C2 ug/ml	C3 ug/ml	C4 ug/ml	C5 ug/ml	C6 ug/ml	C7 ug/ml
Sequence 1	8.0	<0.05	<5	<1	<1	<1	<1	<1
Sequence 2	9.0	<0.05	<5	<1	<1	<1	<1	<1
Sequence 3	6.0	0.05	<5	<1	<1	<1	<1	<1
Sequence 4	6.0	<0.05	<5	<1	<1	<1	<1	<1

C2= acetic acid

C3=propanoic acid

C4=butanoic acid

C5=pentanoic acid

C6=hexanoic acid

C7=heptanoic acid

Dilution of discharged produced water into the receiving environment was estimated to be 1:1000 within 50 m and 1:3000 within 100 m of the discharge point (MacLaren Plansearch 1977c).

3.2 Sediment Chemistry

Appendix D provides all the sediment chemistry data from 1998 to 2001. Overall, the analysis of sediments collected between 1998 and 2000 has shown non-detectable results for all or virtually all samples submitted for the PAH (polycyclic aromatic hydrocarbon) and BTEX (benzene, toluene, ethyl benzene and xylenes) compounds. Likewise, concentrations of the low molecular weight (C₆-C₁₁) in the total petroleum hydrocarbon (TPH) compounds also have been uniformly non-detectable. Therefore, a limited analytical suite was employed during 2001. Organic analyses included benzene, toluene, ethylbenzene, xylenes, as well as the fractionated TPH compounds (Appendix D). Of these, only the heavier (C₁₁-C₂₀ and C₂₁-C₃₂) hydrocarbons were detected. For statistical purposes, hydrocarbons were expressed as TPH (the sum of C₆ to C₃₂ hydrocarbons).

Among the inorganic analytes, concentrations of antimony, arsenic, beryllium, boron, cadmium, cobalt, copper, lithium, molybdenum, mercury, nickel, selenium and tin were typically less than or at the analytical detection limits in virtually all samples submitted between 1988 and 2000. Of the remaining analytes (total inorganic carbon (TIC), total organic carbon (TOC), aluminum, barium, chromium, iron, lead, manganese, strontium, thallium, uranium, vanadium and zinc) barium was considered to be a key element for monitoring purposes because it is a constituent of barite, a clay-like mineral used in drilling muds and has shown change in concentration relative to drilling activities.

As part of the overall quality assurance and quality control plan for the monitoring program, field duplicate samples were collected at selected sampling stations. In addition, laboratory duplicate samples were also processed. The field duplicate samples incorporate at least three sources of variation (field variation between samples; sub-sampling variation in the laboratory, and analytical uncertainty), whereas the laboratory duplicate samples incorporate sub-sampling variation and analytical uncertainty. Inspection of the quality assurance results indicated that there was little variation attributable to laboratory analysis. Variability in field duplicates was somewhat higher, indicating that there is local scale patchiness in TPH, and to a lesser extent barium concentrations. Overall, however, the laboratory and field duplicates indicated that the data were of high quality and reliable.

3.2.1 Sediment Chemistry at the Gully

The data set for the Gully consists of five sampling stations that have been sampled on each of the seven consecutive surveys (Appendix D). As a result, it is possible to test for differences over Time (with the five sampling stations as replicates). It would also be possible to test for differences between stations at the Gully. However, as there were no drilling activities at the Gully, and these samples were collected to provide assurance that activities near Sable Island were not affecting this area, detecting differences between stations at the Gully is of considerably less interest than detecting differences over Time. Appendix A provides the results of the statistical analyses.

An analysis of variance (ANOVA) was conducted only for sediment barium and TPH concentrations:

- For barium, no significant differences were detected at Gully stations, over Time.
- For TPH, higher levels of TPH were detected at Gully stations in June 1999 than at any other time; TPH concentrations were between 2.65 and 5.45 mg/kg sediment. In June 2001, TPH ranged from 0.47 to 0.57 mg/kg in sediments from the Gully.

These higher TPH concentrations are consistent with background TPH concentrations measured at far-field stations around the drilling platforms in June 1999.

3.2.2 Sediment Chemistry at Venture

3.2.2.1 Near-Field vs. Far-Field

Differences between barium and TPH concentrations at the near-field and the far-field areas were evaluated for the seven survey dates, using ANOVA (testing for effects due to Field, Time, and Field×Time). Data were log-transformed, as appropriate, to improve the homogeneity of the variance (Appendix A).

For barium, there was no statistically significant evidence of differences between near-field and far-field, nor was there any evidence of change over time. For TPH, there were similarly no significant differences between near-field and far-field, however, TPH was higher overall during the June 1999 survey than at other times. During June 2001, only traces of TPH were detected at two stations 250 m (Axes 5 and 7) from the platform, and one station 500 m (Axis 7) from the platform.

As there were no large-scale differences between the near-field and far-field that were indicative of an effect of drilling that affected the entire near-field area, it was considered appropriate to examine possible effects within the near-field area (250 to 3,000 m).

3.2.2.2 Within the Near-Field Area

Concentrations of TPH in sediment were higher overall at the 250 m distance than at 500 m, 1,000 m or 3,000 m distances. Although this was not accompanied by a significant Distance×Time interaction term, it was interpreted as an effect due to drilling. Taken over all Times, TPH concentrations in sediments at a distance of 250 m from the Venture platform ranged from <0.5 mg/kg to 75.2 mg/kg (in November, 1998) with a median value of 1.45 mg/kg. The highest recorded value at a distance of 500 m from the platform was only 5.8 mg/kg (median value <1 mg/kg). Overall, however, TPH appears to have peaked at a distance of 250 m from the drilling platform at Time 3 (June 1999), and lower values have been recorded since that time.

In 2001, total petroleum hydrocarbon concentrations in near-field stations appear to be relatively stable and are within background concentrations (<0.25 to 10 mg/kg). The highest concentration of 16.9 mg/kg was found at Station 250-7, in the southwesterly direction where elevated TPH concentrations were previously found. Historical ranges in TPH concentrations at the 250 m and 500 m distances at Venture are shown below in Table 3.3.

Table 3.3 Ranges in Total Petroleum Hydrocarbons Concentrations at Venture Near-Field Stations

Time	Survey Period	250 m Radius	500 m Radius
1	June 1998	<15 mg/kg*	<15 mg/kg
2	November 1998	75.2–<15 mg/kg	<15 mg/kg
3	June 1999	37.4–2.6 mg/kg	5.8–2.7 mg/kg
4	November 1999	15.2–3.3 mg/kg	<0.5 mg/kg
5	June 2000	1.7–<0.5 mg/kg	1.4–<0.5 mg/kg
6	November 2000	2.8–<0.5 mg/kg	1.3–<0.5 mg/kg
7	June 2001	16.9–1.97 mg/kg	3.61–0.93 mg/kg

* limit of detection at that time

For barium, there were significant differences due to Time, as well as Distance. A slightly elevated barium concentration of 350 mg/kg on Axis 5 at 250 m in November 1999 is evident. Barium concentrations were higher overall in June 2001 (Time 7) than at Times 1, 2, or 6. In addition, barium concentrations were lower overall at the 3,000 m distance from the platform, than at the 250 and 1,000 m distances. Barium concentrations in sediment were within background levels through all survey periods. Ranges in barium concentrations on the 250 m and 500 m radii are shown below in Table 3.4.

Table 3.4 Ranges in Barium Concentrations at Venture Near-Field Stations

Time	Survey Period	250 m Radius	500 m Radius
1	June 1998	170–140 mg/kg	210–180 mg/kg
2	November 1998	280–190 mg/kg	220–140 mg/kg
3	June 1999	240–170 mg/kg	240–170 mg/kg
4	November 1999	350–160 mg/kg	220–190 mg/kg
5	June 2000	240–160 mg/kg	240–170 mg/kg
6	November 2000	240–150 mg/kg	180–120 mg/kg
7	June 2001	330–230 mg/kg	260–140 mg/kg

3.2.2.3 Summary of Observed Effects at Venture

There were no large-scale differences between the near-field and far-field that would indicate widespread effects attributable to drilling activities at the Venture platform. Within the near-field, TPH concentrations at some stations 250 m from the platform may have increased over baseline (1998) concentrations after drilling began, although this effect appeared statistically as a Distance effect, and not as the Distance×Time interaction which would have provided definitive statistical evidence. In this regard, a peak TPH concentration of 75.2 mg/kg was detected at the 250 m distance on Axis 7 during the November 1998 survey, and concentrations of 37.4 and 29.3 mg/kg were detected at the same distance on Axes 3 and 7 during the June 1999 survey. By November 1999, the highest concentration was 15.2 mg/kg, recorded at the 250 m distance on Axis 5. A TPH concentration of 16.9 mg/kg was observed at 250 m distance on Axis 7 during June 2001.

3.2.3 Sediment Chemistry at Thebaud

3.2.3.1 Near-Field vs. Far-Field

The results of the statistical testing are summarized in Appendix A and chemistry data are provided in Appendix D. The barium and TPH concentrations were higher overall in the near-field than in the far-field. The TPH concentration was also higher in June 1999 than at other times.

Overall, the differences associated with barium and TPH appear may be indicative of effects attributable to drilling. These effects are explored in more detail below, by examining the significance of variation within the near-field zone. The differences observed for other variables appear to reflect large-scale environmental or temporal variability.

3.2.3.2 Within the Near-Field Area

For TPH, significant differences were identified due to Distance and Time. The Distance effect was attributable to the fact that overall TPH concentrations decreased with distance from the Thebaud platform. The Time effect was due to higher overall TPH concentrations in June 1999 than at other times. Although there was no significant Distance×Time interaction term, these changes were considered to be attributable to drilling activities. In 1999, the observed TPH concentrations ranged from 0 to 1,550 mg/kg at a distance of 250 m from the drilling platform (median value 5.0 mg/kg), but concentrations dropped rapidly with increasing distance. The observed concentrations at the 500 m distance ranged from 0 to 564 mg/kg (median value 1.4 mg/kg), and at 1,000 m distance, the range of values was 0 to 35.5 mg/kg (median value 0.1 mg/kg). In June 2001, TPH concentrations of 360 mg/L and 564 mg/L were detected at distances of 250 m and 500 m, respectively, on Axis 3. The TPH concentration at 250–3 in 2001 is the highest observed to date but within the order of magnitude found in June of previous years. There is no apparent decrease/recovery of sediment contamination within 500 m along Axis 3 since drilling ceased. All other TPH results for the area around the Thebaud platform were <3 mg/kg.

The highest TPH concentrations were found along the 250 m radius on Axis 3 and 7, the predicted prevailing easterly and westerly current directions. TPH levels decrease substantially along Axis 7 with Time, but is persistent along Axis 3 which indicates the residual current and transport direction of drill cuttings. Ranges in TPH concentrations over five survey periods are shown below in Table 3.5.

Table 3.5 Ranges in Total Petroleum Hydrocarbons Concentrations at Thebaud Near-Field Stations				
Time	Survey Period	250 m Radius	500 m Radius	1000 m Radius
1	June 1998	<15 mg/kg	<15 mg/kg	<15 mg/kg
2	June 1999	1550–24.7 mg/kg	324–5.3 mg/kg	35.5–3.3 mg/kg
3	November 1999	23.4–4.5 mg/kg	23.4–<0.5 mg/kg	<0.5 mg/kg
4	June 2000	486.8–4.2 mg/kg	283–1.4 mg/kg	2.7–<0.5 mg/kg
5	November 2000	449.3–<0.5 mg/kg	36.8–<0.5 mg/kg	0.4–<0.5 mg/kg
6	June 2001	360–0.8 mg/kg	564–0.5 mg/kg	0.5–0.4 mg/kg

For barium, there were no Time effects indicating that barium concentration overall have not changed over the period of monitoring. There were, however, significant Distance effects, indicating that barium concentrations 250 m distant from the platform are higher than concentrations at 500 m, 1,000 m and 3,000 m; and that concentrations at 500 m are greater than at 1,000 m. The trend in barium concentrations follows that of TPH. In June 1999, barium levels were highest and similar in value at 250 m radius on Axes 3 and 7. Barium decreased to background levels during the November periods and was elevated in the June periods, except on Axis 3 which remains elevated in 2000. The 2001 results show that the concentration of barium did not decrease within 500 m along Axis 3. Barium was not elevated at the 1000 m radius at anytime. Ranges in barium concentration are shown below in Table 3.6.

Table 3.6 Ranges in Barium Concentrations at Thebaud Near-Field Stations				
Time	Survey Period	250 m Radius	500 m Radius	1000 m Radius
1	June 1998	270–200 mg/kg	230–89 mg/kg	200–95 mg/kg
2	June 1999	760–300 mg/kg	650–120 mg/kg	180–80 mg/kg
3	November 1999	280–170 mg/kg	230–120 mg/kg	150–120 mg/kg
4	June 2000	1200–230 mg/kg	900–150 mg/kg	210–110 mg/kg
5	November 2000	890–190 mg/kg	670–120 mg/kg	210–130 mg/kg
6	June 2001	790–210 mg/kg	1200–150 mg/kg	200–120 mg/kg

3.2.3.3 Summary of Effects at Thebaud

Overall, this analysis shows that there were few significant differences between the near-field and far-field at Thebaud, and that these are mainly attributable to natural variation. However, higher overall concentrations of barium and TPH were detected within the near-field. When effects within the near-field area are examined in detail, there appears to be significant natural variation at the 1,000 m distance, where slightly coarser sediments display lower concentrations of many elements than were observed at other distances.

Concentrations of TPH were significantly higher near the Thebaud platform during the June 1999 survey than at other times, and were higher overall at the 250 m distance than at other distances. Since June 1999, however, TPH concentrations in the vicinity of the Thebaud drilling platform have declined substantially, and maximum observed concentrations are less than 600 mg/kg (median values are less than 3 mg/kg).

Barium concentrations of up to 760 mg/kg (two to three times the background concentration) were detected at the 250 m distance near Thebaud in June 1999. Also in June 1999, a barium concentration of 650 mg/kg was detected at the 500 m distance on Axis 3. However, the barium concentrations returned to the background range (100 to 300 mg/kg) by November 1999, likely through sediment transport, and remained in this range during 2000. During 2001, most values were in the background range, although a high value of 1,200 mg/kg was noted at the 500 m distance, again on Axis 3.

3.2.4 Sediment Chemistry at North Triumph

3.2.4.1 Near-Field vs. Far-Field

For TPH, a significant difference was detected between near-field and far-field areas, again indicating that TPH concentrations in the near-field have been higher overall than those in the far-field. However, for TPH there was also a significant difference due to Time, and a significant Field×Date interaction. The Time effect indicated that TPH was higher in November 1999 than in November 1998 or November 2000, and that the TPH concentrations measured in June 2001 were lower overall than at any other time. The interaction term indicated that TPH concentrations were higher in the near-field than in the far-field in November 1999 and June 2000. Significant differences between near-field and far-field at other times were not found.

For barium, a significant difference was detected between near-field and far-field areas, indicating that barium concentrations in the near-field have been higher, overall, than those in the far-field. No significant effects due to Time or the interaction term were detected.

3.2.4.2 Within the Near-Field Area

For TPH, the significant Distance effect indicated that TPH concentrations at the 250 m distance are higher overall than at 500, 1,000 or 3,000 m. Significant Time effects indicate that the TPH concentration was higher in November 1999 than in November 1998, November 2000, or June 2001. Further, the TPH concentrations measured in June 2001 were lower overall than at any other time. The significant interaction term showed that although there were no significant differences due to Distance in November 1998 or June 1999 (baseline), or in June 2001, TPH concentrations were elevated close to the drilling platform in November 1999, June 2000, and November 2000, declining to near baseline levels at 3,000 m distance. Ranges of TPH concentration at North Triumph are shown below in Table 3.7. Since

2000, there is apparently a considerable decrease in sediment TPHs within the 250 and 500 m distances compared to background levels.

Table 3.7 Ranges in Total Petroleum Hydrocarbons Concentrations at North Triumph Near-Field Stations

Time	Survey Period	250 m Radius	500 m Radius	1000 m Radius
1	November 1998	4.1–<2.5 mg/kg	5.6–<2.5 mg/kg	4.8–<2.5 mg/kg
2	November 1999	2440–7.9 mg/kg	613–14.1 mg/kg	52.7–5.8 mg/kg
3	June 2000	3108–9.6 mg/kg	12.1–4.5 mg/kg	2.6–0.5 mg/kg
4	November 2000	73.8–0.4 mg/kg	26.7–<0.5 mg/kg	0.3–<0.5 mg/kg
5	June 2001	3.5–0.5 mg/kg	3.5–0.4 mg/kg	0.8–0.5 mg/kg

For barium, the significant Distance effect indicated that concentrations were higher at the 250 m distance than at the 500 or 3,000 m distances. Significant Time effects indicated that the barium concentrations in November 1999 were higher overall than in November 1998 or June 1999. Barium concentrations since November 1999 have been declining, but not significantly. There is a continued decrease in barium levels in sediments within 250 m of the platform since 1999. Barium concentration beyond 250 m is stable and within background levels. Ranges in barium levels at North Triumph are shown below in Table 3.8.

Table 3.8 Ranges in Barium Concentrations at North Triumph Near-Field Stations

Time	Survey Period	250 m Radius	500 m Radius	1000 m Radius
1	November 1998	200–140 mg/kg	200–170 mg/kg	180–140 mg/kg
2	November 1999	1900–220 mg/kg	580–180 mg/kg	260–190 mg/kg
3	June 2000	1200–120 mg/kg	260–120 mg/kg	340–120 mg/kg
4	November 2000	550–140 mg/kg	270–150 mg/kg	270–160 mg/kg
5	June 2001	390–180 mg/kg	220–170 mg/kg	230–170 mg/kg

3.2.4.3 Summary of Effects at North Triumph

The above results show that there were clearly increases in the barium and TPH concentrations near the North Triumph drilling platform after drilling activities began in 1999 (*i.e.*, within the 250 m and 500 m monitoring distances, but declining to near background levels at 3000 m). Sediment chemistry at 250 m and beyond has recovered to background levels.

3.3 Sediment Toxicity

Two toxicity bioassays, including one microbial assay and one assay with a sensitive invertebrate organism, were used in standardised testing of marine sediments prior to 2001. The microbial (Microtox) test looks at potential inhibition of photoluminescence in a strain of marine bacteria (*Vibrio fischeri*). The invertebrate test looks at the survival of a marine amphipod (*Rhepoxinius abronius*). A third test (echinoderm fertilization) was previously used in this program, but was discontinued due to the large number of false-positive responses observed.

During 2001, only the amphipod test was continued, as the Microtox™ test rarely indicated sediment toxicity, and appears to be relatively insensitive in this program.

3.3.1 Amphipod Survival

Amphipod survival tests have been carried out semi-annually at four stations 250 m from the drilling platform, four stations 500 m from the platform, four stations at a distance of either 1000 m or 3000 m, as were selected stations at greater distances. During 2001, only stations at distances of 250 m, 500 m and 1000 m from the Venture, Thebaud and North Triumph platforms were tested. Prior to 2001, five stations at the Gully were also tested during each semi-annual survey. Gully stations, and all stations located 3000 m or further from a drilling platform were considered a potential reference stations, which provide a good basis for evaluating baseline toxicity over the study period.

Therefore, three classes of stations (the 3000 m stations, >3000 m stations, and Gully stations) were identified, and an ANOVA was performed to evaluate whether there were statistically significant difference between these groups. No significant differences were observed, and in no case did the amphipod mortality in toxicity tests exceed 30% mortality level. Since Environment Canada's interpretation guidelines (Aquatic Toxicology Section) use the 30% mortality level to identify potentially toxic responses, it was concluded that no toxicity was evident in baseline samples, and that these data could be pooled statistically to provide a single large sample against which potential changes close to the drilling platforms could be evaluated.

As a further check on the suitability of the reference data, the Gully stations were tested, using ANOVA, to determine whether there was any evidence for changes in baseline toxicity over Time. No significant differences were found, further validating the decision to pool the reference toxicity data.

To screen the results from the individual drilling platforms, box plots were drawn to display the range of observed toxicity results for stations located 250 m, 500 m, 1000 m from each drilling platform, along with the pooled reference toxicity data (Figure 3.1). These plots showed that there were no substantial differences between the 500 m, 1000 m and reference groups, although a few outlying values indicative of toxic responses were observed at the 250 m distance for North Triumph and Thebaud. No indication of toxic response was evident at any time near the Venture platform (Figure 3.1).

The toxic responses (amphipod mortality 30% or greater) that were observed were confined to the 250 m distances from the drilling platforms. (Table 3.9) (Appendix E). At Thebaud, toxicity was observed on Axis 3, with decreasing toxicity after it was initially observed in June 1999. However, toxicity increased at 500 m and remains at 250 m on Axis 3 (Figure 3.2) This result coincides with elevated TPH. High toxicity (95% mortality) was also observed at 250 m distance on Axis 7 in June 1999, but this observation was not repeated during 2000 or 2001. At North Triumph, moderate toxicity was observed at 250 m distance on axes 1, 5 and 7 in June 1999, but no further toxicity was observed in 2000 or 2001.

Table 3.9 Amphipod Mortality Observed at North Triumph and Thebaud

Station	Time	Axis	Mortality	TPH (mg/kg)
T-250-3	3 (June 1999)	3	81%	1,550
T-250-7	3 (June 1999)	7	95%	586
T-250-3	5 (June 2000)	3	64%	487
T-250-3	6 (Nov 2000)	3	43%	449
T-250-3	7 (June 2001)	3	46%	360
T-500 -3	7 (June 2001)	3	30%	564
NT-250-1	3 (June 1999)	1	56%	2.4
NT-250-5	3 (June 1999)	5	30%	5.0
NT-250-7	3 (June 1999)	7	36%	4.5

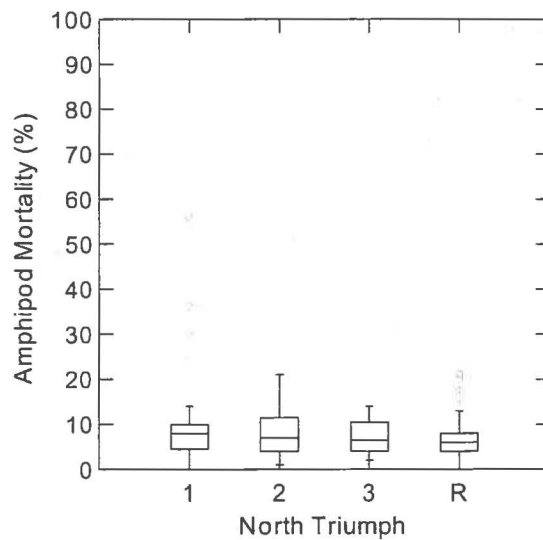
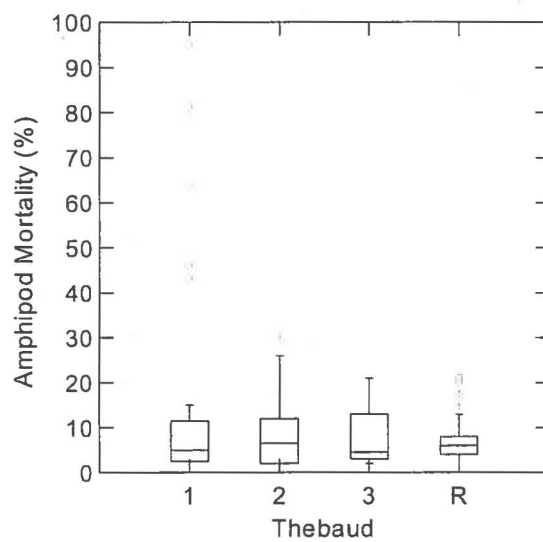
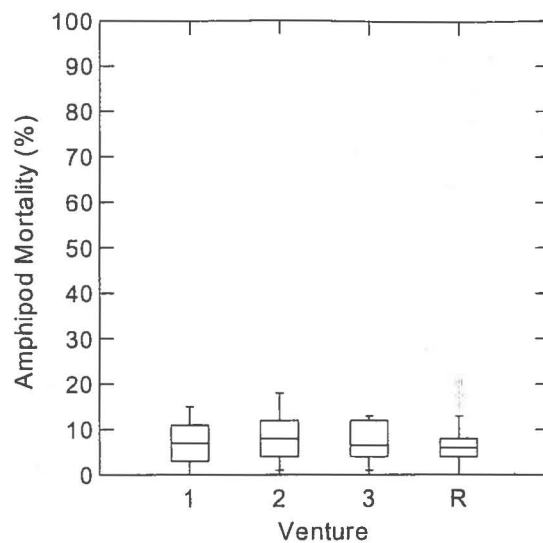
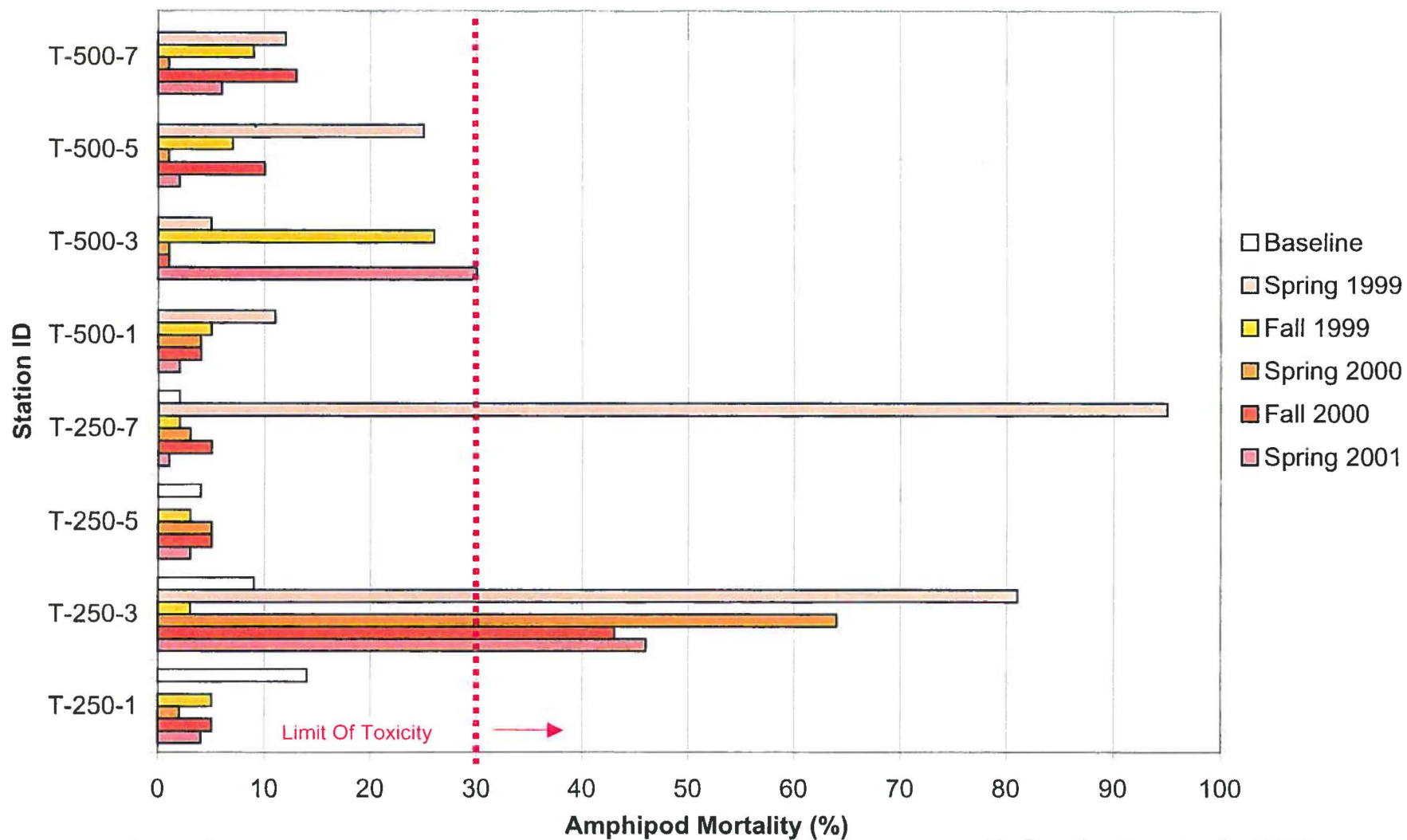


Figure 3.1 Toxicity Results for Amphipods at (a) Venture, (b) Thebaud and (c) North Triumph. The codes 1, 2, 3 and R denote 250 m, 500 m, 1000 m and reference samples, respectively.

Figure 3.2

Thebaud Amphipod Mortality



* Toxic Effect is considered to be a mortality >30% (30% difference from control)

No Baseline Samples for T-500

3.4 Benthic Habitat and Community

3.4.1 Epibenthic Community

Epibenthic macroinvertebrate species were surveyed at each sampling site using still photography in an underwater frame and housing. The predominant organisms observed during the baseline surveys included sand dollars and brittle stars, although small numbers of snow crabs, sea stars, sea anemones, and moon snail egg cases were also observed.

The abundance of sand dollars and brittle stars was scored at Venture during the baseline (June 1998) survey, and in six subsequent surveys (November 1998, June and November 1999, June and November 2000, and June 2001). Summary statistics for the abundance of these organisms at each distance from the Venture field are provided in Table 3.10. The abundance of sand dollars at Venture was highly (Photos 1 and 2) variable (ranging from 0 to 140/m²), however, the median abundance was generally low (0 to 3.9/m²).

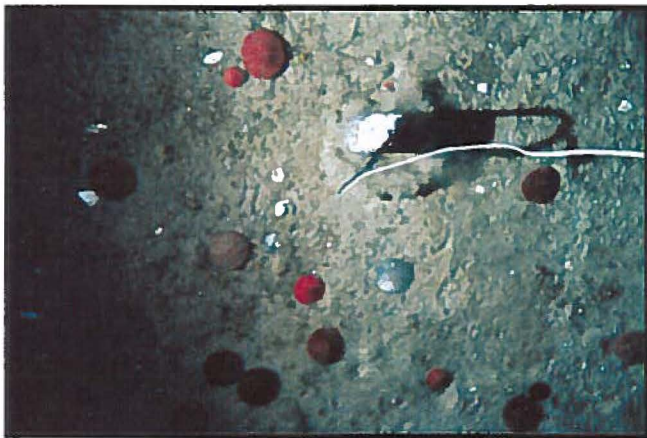


Photo 1 Benthos at V1000-1, note moderate biodiversity

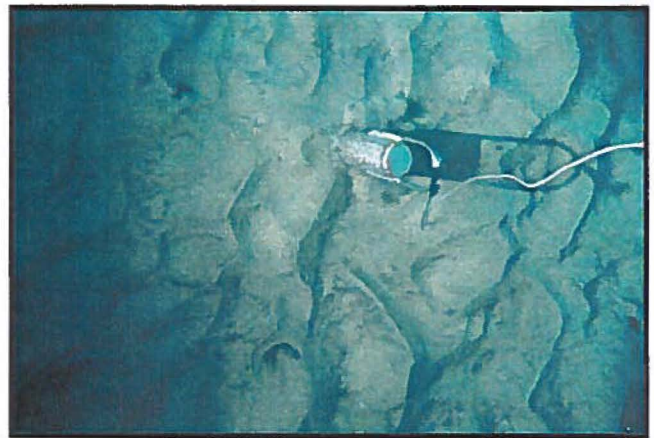


Photo 2 Benthos at V1000-5, note lack of epibenthos

Similar examination of the abundance of sand dollars and brittle stars at North Triumph and Thebaud (Table 3.10) shows no evidence that these organisms have been affected by drilling activities. A high abundance of brittle stars at North Triumph during June 2000 was followed by low abundance in November 2000, however, the November abundance was little different from the abundance observed at this site earlier in the monitoring period, and was not unusual when compared with the abundance of brittle stars at other monitoring sites. Results for 2001 are also consistent with earlier results.

Table 3.10 Abundance of Sand Dollar and Brittle Star at Venture, North Triumph, and Thebaud.

Drill Platform and Survey Period	Sand Dollar (#/m ²)		Brittle Star (#/m ²)	
	Range	Median	Range	Median
Venture				
June 1998 (baseline)	0 – 46	2.6	0	0
November 1998	0 – 48	0		
June 1999	0 – 140	2.5		
November 1999	0 – 43	1.8		
June 2000	0 – 16	3.9		
November 2000	0 – 11	3.9		
June 2001	0 – 26	0		
North Triumph				
November 1998 (baseline)	0 – 33	7.1	0 – 128	9.5
June 1999 (baseline)	0 – 83	10.6	0 – 59	0.9
November 1999	0 – 38	0	0 – 66	0
June 2000	0 – 19	6.4	6 – 107	20
November 2000	3 – 41	9.4	0	0
June 2001	0 – 27	5.1	0 – 73	0
Thebaud				
June 1998 (baseline)	0 – 163	3.6	0	0
June 1999	0 – 57	0.26		
November 1999	0 – 107	2.5		
June 2000	0 – 92	4.4		
November 2000	0 – 49	18.9		
June 2001	0 – 94	0.42		

3.4.2 Drill Cutting Pile and Jacket Leg Surveys

3.4.2.1 Operational Storm Scour Surveys

As part of the post-storm scour survey around the drill rigs and jacket legs using a remotely-operated vehicle (ROV), a quantitative assessment of cuttings pile was possible at Venture, Thebaud and North Triumph.

Venture

ExxonMobil's Subsea Coordinator provided cuttings pile dimensions at Venture from six ROV surveys. The survey dates were September 20, October 17, October 20 and December 6, 1999, July 27, 2000 and 3rd quarter 2001.

The highest point of the pile appears to be centred around the east drive rack on the starboard leg of the RG II. This pile formed below the drill cuttings discharge pipe. The edge of the drilling returns around the starboard leg were measured by sonar and visual estimations using the ROV. Table 3.11 provides the dimensions of the drill waste pile over each of the six surveys.

Table 3.11 Dimensions of the Drill Waste Pile at Venture

Date	Pile Height (m)	West (m)	South (m)	East (m)	North (m)
Sept. 20, 1999	3	22	25	70	n/d
Oct. 17, 1999	3	22	26	66	60 (NE)
Oct. 20, 1999	3	22	25	66	58 (NE)
Dec. 6, 1999	3	23	22	57.3	60 (NE)
July 27, 2000	2.5	nd	nd	50	60
3 rd quarter, 2001	1	nd	nd	40	40

NE refers to Northeast direction from discharge point. nd = no data provided

The method of data collection and recording changed in 2000 compared with previous years, and no direction of cuttings pile spread was provided. However, it appears that the cuttings pile height and areal extent continues to decrease gradually.

Thebaud

Six post-storm scour surveys were conducted at the Thebaud field on November 5 and 25, 1999, September 1, 2000, November 26, 2000, 3rd and 4th quarters of 2001. Following drilling on the first of two holes, the entire Thebaud wellhead appears to be encompassed by the cuttings from information provided by the operator of the ROV. Table 3.12 provides the dimensions of the drill waste pile over the four surveys.

Table 3.12 Dimensions of the Drill Waste Pile at Thebaud

Date	Pile Height (m)	West (m)	South (m)	East (m)	North (m)
Nov. 5, 1999	1	43	29	32	22
Nov. 25, 1999	1	34	29	46	15
Sept 1, 2000	1.2	35	n/d	50	n/d
Nov 26, 2000	1.5	n/d	n/d	n/d	n/d
3 rd quarter 2001	1	30	n/d	30	n/d
4 th quarter 2001	1	42.3	n/d	40	n/d

nd = no data provided

At leg A2 of the wellhead platform, in 1999 the cuttings pile appears to be one metre in height. Directionality of the cuttings pile was not provided in 2000, the lengths and width provided are inserted into the table where most appropriate. Considering the pile height is estimated visually using the ROV, the apparent increase in height is likely an estimation error. Most important are the horizontal dimensions. There is no significant change in pile dimensions since November 1999.

3.4.2.2 Biological Survey

A remotely-operated vehicle (ROV) inspection of the drill cuttings and marine growth on the jacket legs were conducted at Thebaud and North Triumph. At the time of the survey, the current was too strong for the ROV to pass through the water column at Venture. A biological inspection will eventually be completed at that platform. Information on the cuttings pile is obtained from the quarterly operational inspections undertaken by ExxonMobil's Diving Contractor to evaluate scouring around the jacket legs. However, biological information relative to habitat required a separate survey conducted by JWEL marine biologists with the assistance of Pro-Dive Marine Services. The purpose of the surveys at Thebaud and Venture was to collect information on the persistence of the cuttings pile. At North Triumph, there is no residual cutting pile to investigate. Large numbers of snow crab were observed at the base on the North Triumph jacket legs in the 2000 EEM survey which warranted further study. The ROV survey was undertaken to investigate how extensive the snow crabs were relative to the jacket legs. Opportunistic observations on marine growth were also made to determine reef development.

At Thebaud, the jackets legs are completely covered in marine growth. Zonation of flora and fauna was not apparent as the various species occurred continuously from the surface to the bottom. Dense coverage of blue mussels (*Mytilus edulis*) and pelagic goose barnacles (*Lepas* spp.) dominate the epifaunal community. Other taxa present included stalked sea anemones, asteroiid sea stars, encrusting sponges, hydroids and bryozoans. Macrophytes were sparse; the competition for available space is limited by the coverage of sessile invertebrates.

The cuttings pile at Thebaud resembles caked material because of its consolidated nature (Photo 3). The mound is low (one metre) and the edge is well defined. Small chunks around the edge have broken off from the main pile (Photo 4). There is no gradual attenuation as depicted in the predictive modelling (MacLaren Plansearch 1997) since this material is not granular. The size of the pile could not be determined as there are no reference points underwater and the ROV was not equipped with a sonar system. Samples of the material were

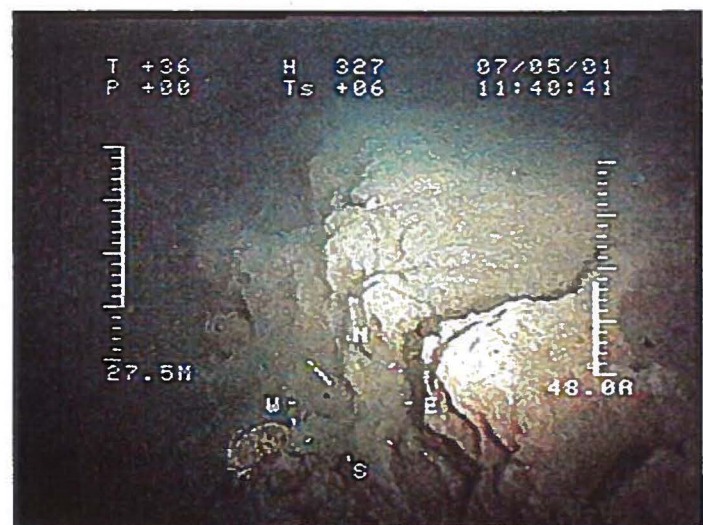


Photo 3 Edge of cutting pile at Thebaud, note Jonah crab at bottom of photo

obtained by attaching stainless steel Shelby tubes to the ROV which extracted cores from the side of the pile. Tactile manipulation of the material was possible as it had the consistency of putty. Geotechnical investigation of samples revealed the cutting material to consist 30.9% sand and 69.1% silt and clay. The colour of the cuttings pile is light grey.

The presence of the cutting pile appears to attract crabs (Photos 4 & 5). Hermit crabs were the most common occurring in clusters along the edge of the pile. Jonah crabs were also abundant and have burrowed into the pile. The occasional flounder and sculpin were observed swimming over the pile. The cuttings pile does not appear to have been colonised by infaunal organisms.

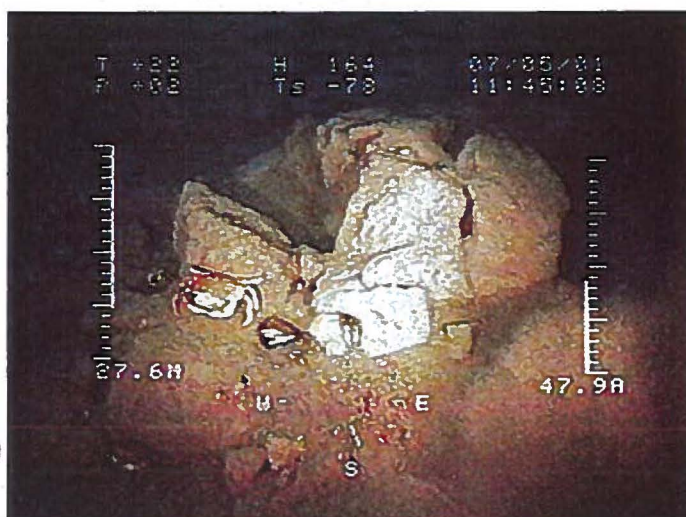


Photo 4 Hermit and Jonah crabs cluster along the edge of the cutting pile



Photo 5 Aggregations of hermit crabs on the cutting pile

At North Triumph, the biological zonation down the jacket legs is better defined than the shallower platforms. At 30 m the encrusting dense growth of mussels and barnacles give way to patches of hydroids which dominate the marine growth to the seafloor at 75 m. From 30 m to 75 m depth, coverage of available leg surface is approximately 50 %.

The seafloor immediately around the platform is littered with blue mussels upon which snow crabs were feeding (Photo 6). Sea cucumbers were observed around the base of the leg as well as perched on supports above the seafloor (*ie.*, they climbed) (Photo 7). Both male and female snow crabs were present in highest numbers around and under the leg supports, but they also were present along a transect 50 m from the leg base (Photo 8). Sculpins, asteriid sea stars, and flounder were also present in association with clumps of mussels on the seafloor.

The mattresses overlying the pipeline does not appear to be covered in marine biofouling growth, however, they do attract large numbers of sea stars, sea cucumbers and snow crabs (Photo 9).



Photo 6 Snow crabs, starfish feeding upon mussels fallen from the North Triumph jacket. Note a solid but friable piece of cuttings in the middle of the photo.

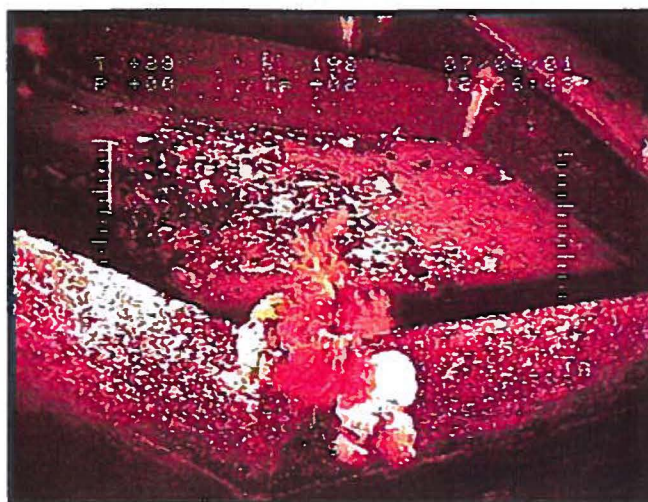


Photo 7 Sea cucumbers are abundant epifauna on the jacket leg supports

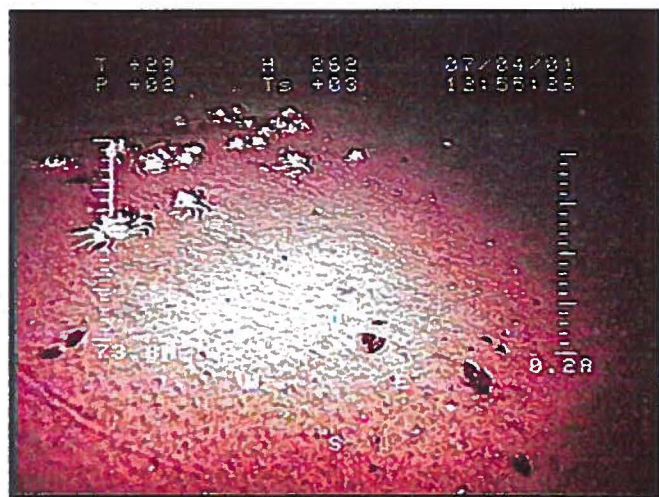


Photo 8 Snow crabs occur in high abundance immediate to and in the vicinity of the North Triumph jacket.



Photo 9 Sea stars, sea cucumbers and snow crabs densely cover the concrete protective mattresses.

3.4.3 Summary of Benthic Epifauna Results

The use of video and still photography to record the abundance of benthic epifauna is a practical tool for monitoring purposes. However, the abundance of these organisms tends to be patchy and may be highly variable both spatially and over time. Hence, although these organisms are readily identified and counted in photographic images, the statistical power to detect change in the environment is inherently low. Sand dollars are common and ubiquitous on Sable Island Bank. Brittle stars were common at North Triumph, but not at Venture or Thebaud. Other organisms were observed too rarely to be considered useful for monitoring purposes.

3.5 Taint and Body Burden

In 2001, a different approach to mussel collection was taken. Because of renewed drilling activity at Venture in 2001, the mussels moorings were required to be removed to avoid destruction by the drill rig and supply vessels. As an alternative, mussels were scraped from a jacket leg at the surface (0-1 m) which provided a sample as close as possible to the produced water caisson (Photo 10 & 11). At Venture, mussels were removed from one jacket leg. At Thebaud, mussels were removed from the production platform jacket leg furthest from the caisson in the direction of prevailing current and from the well head leg in the same direction of current. This platform provides two distances to compare body burden and tainting. No control mooring was set.

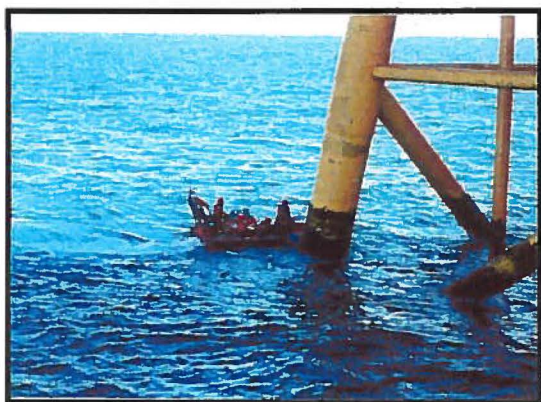


Photo 10 The supply vessel FRC was used to approach the platform legs.



Photo 11 Scraping mussels for the jacket leg at low tide.

Another new addition to this EEM component was the collection and analysis of snow crab at North Triumph. Appropriate sentinel finfish species are not readily available. The ROV scour inspection surveys at North Triumph in 2000 revealed an abundance of snow crab in the immediate vicinity. A crab trap was set at approximately 250 m from the platform and at 20 km distance for a reference. The traps were left to soak for four hours before retrieval (Photo 12). The crabs were submitted for tissue analysis as per the mussels.



Photo 12 Retrieval of snow crab trap off the stern roller of the supply vessel.

3.5.1 Venture

Table 3.13 shows the results of sensory evaluations and body burden of hydrocarbons in mussels moored in the vicinity of the Venture platform.

November 1999 – February 2000

Results from the sensory evaluation showed a significant difference at the 5% level for mussels at the top cage at Venture 1000 m. Taste panelists were contradictory with respect to mussels from top cages at Venture 1000 m. Different panelists referred to either the control or the sample as having a non-petroleum sweet flavour. Hydrocarbon analyses showed a peak for C_{17} and pristane as being much larger at Venture 1000 m compared to the standard and other mussel samples. Examination of lipid composition shows that 10% of the lipid is free fatty acids; a result that is double that of the control. This result suggests considerable metabolic activity in these mussels. This observation is also evident at the 10 km samples from Venture which exhibit the next highest levels of lipid, triacylglycerol and free fatty acids (Appendix F). The mussels at Venture 1000 m were well nourished and apparently healthy.

The concentration of aliphatic hydrocarbon is relatively similar throughout the Venture samples and the North Triumph control samples. Total hydrocarbon values at Venture 4000 m and 10 km are lower in comparison. The oil-base mud region is similar for Venture mussels except at 500 m (Table 3.13). Examination of the chromatographic charts of these samples (Appendix F) shows that the C_{17} /pristane pair (indicative of healthy intake of algae) is less important and the higher concentration of hydrocarbons are non-biogenic.



February 2000 – May 2000

Triangle testing identified significant differences in the sensory characteristics of the Control samples and at the top cage of Venture 2 km. The Control samples were described as “bitter, off and quite obviously different”. The Venture 2 km mussels were significantly different in odour, not taste. The tissue lipid content of the Control mussels was higher than that of the Venture and Thebaud levels. It is unknown if this factor caused the discernable flavour difference. Aliphatic hydrocarbon analyses showed the fraction of oil-based mud is lower than tainting concentrations.

June 2000 – November 2000

Modification to the mooring locations was made considering that drill cuttings and associated mud are no longer discharged from the drill rigs and the dispersion of drill cuttings was apparently not affecting the bottom set of mussels. The number of mussel mooring stations have been changed to include stations at 250 and 500 m from the Venture platform with cages set at mid-depth in an effort to place the mussels in the zone of influence of produced water.



Triangle testing of the mussel samples showed no significant difference between the two Venture locations and the Controls.



Table 3.13 Aliphatic Hydrocarbon Concentration in Blue Mussel Tissues at Venture Mooring Stations (ppm, dry weight)

Distance	Aug 98–Oct 98		Oct 98 – Apr 99		Nov 99 – Feb 00		Feb 00 – May 00		Aug 00 – Nov 00	
	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM
250 m									21.26	3.74
500 m t	20.5	0.4	37.7	15.2	18.63	14.77	28.44	3.6	28.64	4.43
500 m b	20.5	0.5					25.68	2.69		
1000 m t			26.25	3.55	13.7	1.43	33.50	2.51		
1000 m b							22.45	0.60		
2000 m t			27.45	3.1			19.67	1.42		
2000 m b							31.43	3.52		
4000 m t	12.5	2	27.35	9.9	9.51	2.61	20.84	4.00		
4000 m b	8.5	1.5	17.25	2.1						
10 km t			27.4	6.7	9.94	0.68	20.98	2.09		
10 km b							24.36	1.96		
15 km t			11.1	1.7	17.56	1.92	22.75	1.8		
15 km b			8.55	1.55	11.52	0.82	19.65	1.65		
Control t	11.5	2.5	11.2	1.2	12.59	3.62	17.53	1.84	23.83	6.42
Control b	9.5	2	11.2	2.6	13.94	1.40	14.62	1.41		
Source			11.2	0.6						

***Bold** indicates where significant difference in taste and/or odour were detected



November 2000 –April 2001

Analytical results of test mussels from the 250 m and 500 m Venture moorings provided no definitive indication of tainting originating from petrogenic hydrocarbon sources. Triangle testing identified a significant difference at the 5% level in flavour of mussels between the control and the 500 m site. This difference may be coincidental as the comments ranged considerable. Biochemical markers show that the mussels were in good health.

July 2001

Mussels collected from the Venture jacket leg contained a high level of interfering material resembling a hydrocarbon distillation cut (a light lubricating oil). When diluted this material appeared to be similar to a hydrocarbon profile previously observed at mussel mooring stations at 250 and 500 m. The hydrocarbon profile of produced water condensate samples were compared and found not similar in the signature. The lipid content of the Venture mussels indicate they are in a healthy nutritional state.

3.5.2 Thebaud

Table 3.14 shows the sensory evaluation and body burden concentration of hydrocarbons in moored mussels in the Thebaud field.

November 1999 – February 2000

Survivability of mussel moorings associated with the Thebaud platform was low. The sensory evaluation did not find any significant difference between the 2000 m site and the Control. Aliphatic hydrocarbon concentration is lower than the Control or other stations but similar in the oil-base mud region.

February 2000 – May 2000

Analyses of the Thebaud mussel monitoring sites provide no definitive indication of tainting originating from petrogenic hydrocarbon sources. Triangle testing identified significant differences in the sensory characteristics of the Control samples and mussels from 1000 m (odour) , 2000 m (odour and flavour) and 4 km (odour and flavour) distances from the platform. As with the Venture Control samples discussed above, the Control samples were considered objectionable which formed the basis of their forced choice decision.

June 2000 – November 2000

Triangle testing of the mussel samples showed no significant difference between the samples and Control. Pristane and C₁₇ levels were low in comparison to previous sample lots and the C₂₁ peak representing algal hydrocarbon heneicosahexaene was not present as in previous samples. The mussels were considered in poor condition judging by their high water content. The mussels had not received enough food to replenish body reserves following spawning.

July 2001

In the absence of an offshore control mooring, mussels from a local commercial supplier (Sobeys) were used for the sensory and body burden analysis. Those mussels were considerably different in size, lipid content and water.

Aliphatic hydrocarbons in mussels from the Thebaud production platform were twice the concentration (25.87 ppm) detected in commercially bought mussels (11.40 ppm). Hydrocarbons within the OBM range were higher in the platform mussels compared with the Sobeys control. The triangle tests indicated that taste decisions were biased by appearance because no adverse comments were made on aroma and flavour on Control or Venture and Thebaud mussels.

Petrogenic hydrocarbons were not detected in either crab leg tissues or crab hepatopancreas samples. No significant differences in sensory evaluation were observed in reference or North Triumph crab leg meat samples.

Table 3.14 Aliphatic Hydrocarbon Concentration in Blue Mussel Tissues at Thebaud Mooring Stations (ppm, dry weight)

Distance	Nov 99 – Feb 00		Feb 00 – May 00		Aug 00 – Nov 00		July 01	
	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM	C ₁₀ –C ₂₄	OBM
platform							31.65	5.71
wellhead							20.09	4.76
250 m					32.39	7.99		
500 m t					32.39	7.99		
500 m b								
1000 m t			27.99	2.17				
1000 m b			34.22	3.17				
2000 m t	17.62	1.13	24.15	1.78				
2000 m b			14.87	0.61				
4000 m t	6.63	1.41	16.78	1.16				
4000 m b			33.24	1.76				
10 km t								
10 km b								

15 km t								
15 km b								
Control t	12.59	3.62	17.53	1.84	12.57	1.70		
Control b	13.94	1.40	14.62	1.41				
Sobeys							11.40	0.95

*Bold indicates where significant difference in taste and/or odour were detect

t=top cage; b=bottom cage

3.6 Marine Mammals Monitoring

3.6.1 Thebaud Observations

A total of 245 marine mammal observation surveys were performed at the Thebaud production platform from the start of January 2001 to the end of December 2001. These observations identified three whale and one seal species. Of these 245 surveys, visibility of less than one kilometre (due to weather) was observed in 18 of those surveys. No marine mammals were observed in 79% of all marine mammal surveys at this location. A total of 26 minke whales, 1 pod of pilot whales, 1 fin whale, 13 unidentified whales, 43 unidentified seals, 27 grey seals, and 25 unidentified dolphins were observed over the course of these surveys. Due to the close proximity of Sable Island, herds of seals were often noted along the Island's west bar. Minke whales were observed in association with seals 25% of the time.

The minke whales, fin whales, pilot whales, dolphins and grey seals observed from the platforms are representative of those species which are expected to transit this area, and their presence demonstrates either indifference or attraction. The majority of sightings of marine mammal by observers on platforms were grey seals, clearly the dominant marine mammal species in that vicinity as Sable Island is a major breeding and moulting area.

Since cetaceans were observed from the platforms, it is clear that they were well within the acoustic envelope of onboard platform and support vessel noise generating activities. The species reported, are those most frequently seen by observers on transport and recreational vessels as well. The observed behavior of the species has been to approach stationary and moving vessels, and often follow and appear to demonstrate some curiosity. This is typical behavior of the minke whale for example, well known for its surprise appearances alongside and aft of vessels. This behaviour may reflect non-avoidance of SOEP structures that seem to pose no threat, over a period which now encompasses several generations of marine mammals. Lack of avoidance is a lower level of response than deliberately approaching structures.



3.7 Offshore Seabird Monitoring

3.7.1 Survey Results

Platform-based Surveys –Thebaud Platform

Seabird monitoring observations continued on the Thebaud production platform throughout 2001. In 2001, 252 surveys were conducted over 150 days at Thebaud, an average of 1.68 per day (ranging from 1 to 3 per day), comparable to 1.7 per day in 2000. The number of days that surveys were conducted were slightly higher than in 2000.

More than 3,700 birds were recorded at Thebaud in 2001 during daylight surveys. The five most numerous species encountered were Black-legged Kittiwake, Herring Gull, Greater Shearwater, Northern Gannet, and Great Black-backed Gull (Figure 3.3). No birds were recorded in 21% of the surveys; these results are consistent with the 2000 data. Figure 3.4 shows the number of seabirds per survey from 1998 to 2001. The number of birds observed per unit effort in 2001 was down from that of 2000 at Thebaud (22.6 birds/day+night survey in 2000 vs. 14.7 birds/day+night surveys in 2001). A total of 12 marine bird species and one coastal species (Double-Crested Cormorant) were identified.

All of the common species were observed both far from, and in close proximity to, the platform, and did not generally appear to be avoiding the platform area. More gulls were counted within 300 m of the platform than beyond 300 m, which is in contrast with the previous year's trend. More Greater Shearwaters and Northern Gannets were recorded within 300 m than beyond 300 m.

There was an increase in the number of night-time surveys conducted under the platform lights in 2001. More than 42 surveys were conducted throughout the year. There was a decrease in the average number of birds per survey from 75 birds per survey in 2000, to 19 birds per survey in 2001. Herring and Great Black-backed Gulls dominated the night-time surveys, with the occasional Greater Shearwater and Black-legged Kittiwake. Birds were seen on all but one survey conducted under the platform lights in 2001.

Platform Dead/Exhausted Bird Surveys - Thebaud Platform

In 2001, 482 walkabouts on Thebaud to survey dead/exhausted birds were performed over 322 days (1.5 surveys per day), which is close to 90% of the days in 2001. A total of 28 birds in 20 different surveys were recorded with 10 birds found dead, of which nine were land-based birds (warblers and sparrows), and one of unknown species. Of the known causes of death, one bird died from the flare.

More than 60% of bird mortality was recorded in October and November which corresponds with fall migration of land-based birds. Other species found on the platforms in various conditions, included egret, sparrow, hawk, junco and petrel.

Figure 3.3 Seabird Species Composition for Thebaud Platform

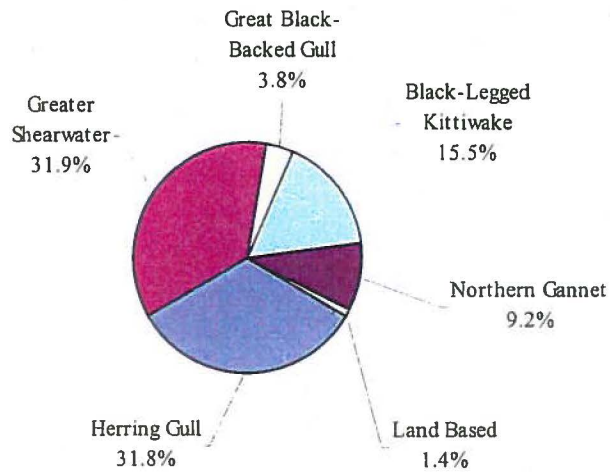
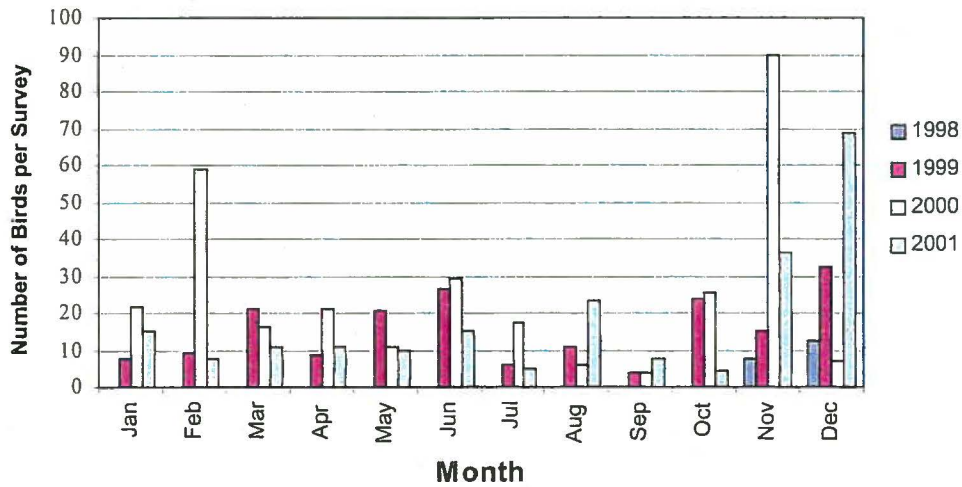


Figure 3.4 Number of Birds per Survey at Thebaud Platform



The relatively low incidence of dead birds (1.7% of the surveys) and the relatively high frequency of the surveys suggest there were likely few large scale fatalities in the vicinity of Thebaud, despite evidence that birds were, on occasion, fatally attracted to the upset flaring.

3.7.2 Population Trends

Procellariidae

In decreasing abundance, Greater Shearwater, Northern Fulmar and Sooty Shearwater occur regularly in the vicinity of Sable Island (Brown 1986). Shearwater abundance is lowest during the winter months after they have migrated to the southern hemisphere. Greater Shearwaters are most abundant during the period from July to September while Sooty Shearwaters are most abundant between April and June (Brown 1986). Northern Fulmars are present in the vicinity of Sable Island throughout the year, but are most abundant between October and December, and are least abundant between January and April.

At Thebaud, shearwaters were also most common in June in 1999, 2000 and 2001, presumably returning from breeding in the southern hemisphere (Figure 3.5). Their distribution loosely mirrors the trend for the Sable Island area (Brown 1986). In 1999, 71 Sooty Shearwaters were recorded over the spring/summer, while only seven and eight individuals were recorded in 2000 and 2001 respectively. Northern Fulmars encounters were infrequent; four were recorded in January 1999, and up to seven birds were recorded over 12 surveys in seven days in October, 1999. Only one Northern Fulmar was recorded in 2000 (July 7) while seven individuals were recorded in April and May at Thebaud in 2001.

The area around Sable Island supports high densities of Greater Shearwaters in comparison to other areas in Atlantic Canadian waters. Densities of Sooty Shearwater and Northern Fulmar in the Sable Island area are moderate in comparison to densities in other areas of Atlantic Canada.

Greater Shearwaters have generally been one of the most abundant and frequent species recorded during the platform-based surveys. Other shearwaters (*i.e.*, Sooty) have been relatively rare, as have Northern Fulmars. Therefore, there is no obvious change in the distribution of procellarids in the vicinity of Sable Island.

Storm-petrels

Two species of Storm-petrel, Leach's Storm-petrel and Wilson's Storm-petrel are regularly reported in Atlantic Canadian waters (Brown 1986). Relatively high numbers of Leach's and Wilson's Storm-petrels are found the waters around Sable Island as compared to other areas of Atlantic Canada. Large numbers of Leach's Storm-petrels arrive in Canadian waters in May. They remain plentiful off Sable Island until early autumn when they migrate south following the end of the breeding season. Wilson's Storm-petrels spend the austral winter in the northern hemisphere. Migrating birds begin to appear in



Figure 3.5 Shearwater Spp. Occurrence at Thebaud

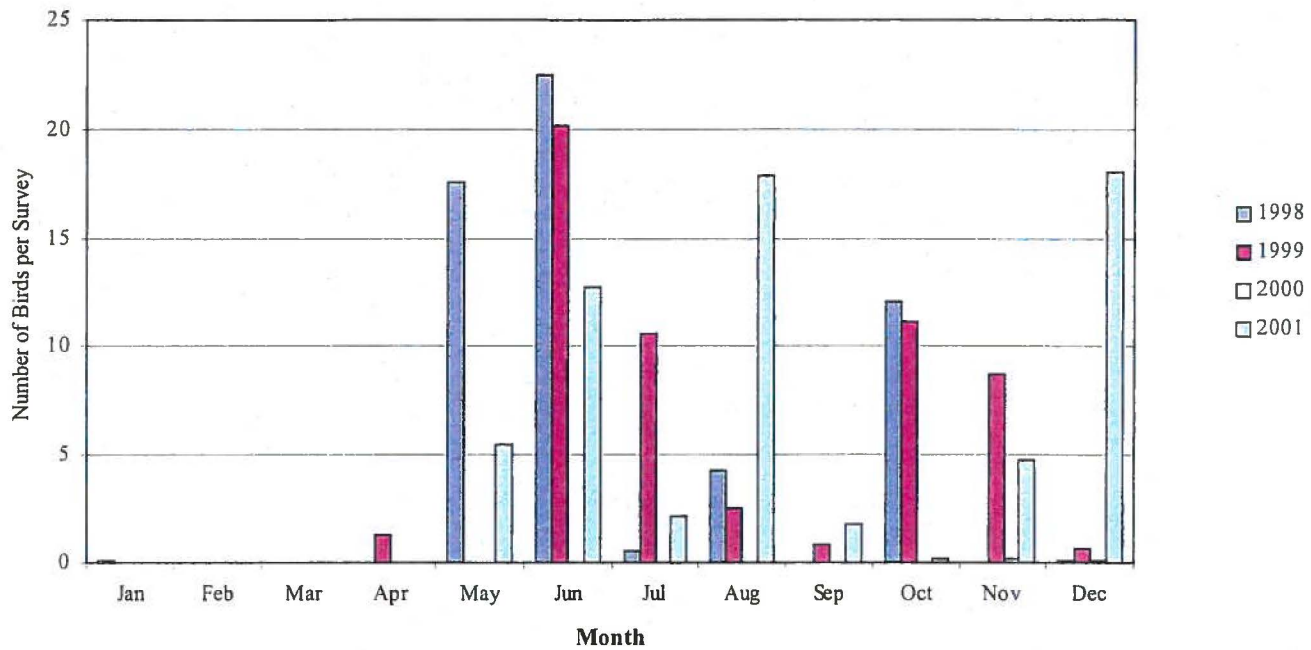
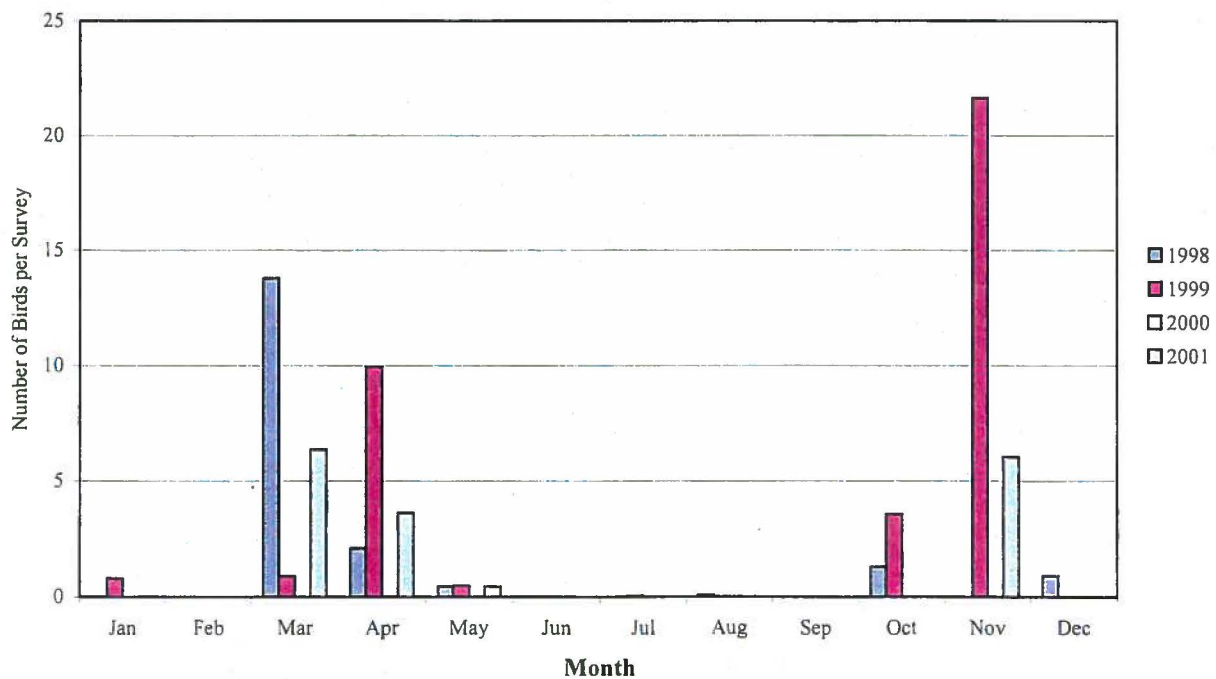


Figure 3.6 Northern Gannet Occurrence at Thebaud



large numbers in the vicinity of Sable Island in May and remain abundant until August when they begin to migrate south. Wilson's Storm-petrel is the most abundant of the two species. Both species have been found resting on the platforms during the daily walkabouts, however, their numbers have been small. Due to their small size, they are likely being missed during platform-based surveys.

Northern Gannets

Northern Gannets are most abundant in the vicinity of Sable Island during the months of June and July. The birds present in the vicinity of Sable Island at this time may be subadults or failed breeders. Northern Gannet numbers are typically very low during the fall and winter months when they migrate to the southeastern coast of the United States and the Gulf of Mexico. The concentrations of Northern Gannets found around Sable Island are similar to those found in most areas of Atlantic Canada except for the vicinity of breeding colonies where concentrations are very high.

At Thebaud, Northern Gannet numbers peaked in March, 1999, likely migrating to breeding colonies in the Gulf of St. Lawrence (Figure 3.6). In 2000, the spring peak was highest in April, while the highest peak for the year was in November, which is more typical of the area. In 2001, over 50% of the Northern Gannets observations were recorded in the months of March, April, and May. Gannets recorded from the platforms were migrating through the area, however there was no evidence of avoidance of the platforms.

Larids

At least 13 species of *laridae* (gulls, terns, jaegers and skuas) have been recorded in the PIROP data for the region (Brown 1986). Herring Gull, Great Black-backed Gull and Black-legged Kittiwake account for most of the larid species observed within the region, and this same trend was found at the Thebaud platform in 1998, 1999 and 2001 (Figures 3.7 to 3.9). All of these species display the same seasonal abundance patterns. The lowest numbers of larids are present during the period from April to June. At this time gulls and kittiwakes are gathered at their coastal breeding colonies and tend to forage in close proximity to the colonies. Both Herring Gull and Great Black-backed Gull breed on Sable Island. Larid numbers increase through the summer and peak during the period between October and December. At this time, adult and juvenile larids have dispersed from their breeding colonies and are foraging at sea. Larid numbers decrease between January and March, probably as a result of a combination of mortality and movement of birds to their colony sites.

The waters around Sable Island support relatively high concentrations of Herring Gulls and Great Black-backed Gulls in comparison to other areas of Atlantic Canada. This may reflect the presence of large colonies of both species on Sable Island. Population densities of Black-legged Kittiwakes are generally lower in the waters around Sable Island than in other areas of Atlantic Canada.

Herring and Black-backed Gulls have generally been two of the most abundant and frequent species recorded during the platform-based surveys, and of the other larids, Black-legged Kittiwake were the most abundant. The data at Thebaud generally supports the trend of peak abundance of all three species in the fall (Figures 3.7 to 3.9). An exception is the high number of Black-legged Kittiwakes recorded in February 2000; this was due to two flocks estimated at 500 birds each during two surveys at Thebaud.

A single Long-tailed Jaeger was recorded at Venture in February, 1999, and Great Skuas were recorded at Venture in October/November over four surveys. No jaegers and a single Great Skua (April 18) were recorded at Venture in 2000. At Thebaud, up to three Great Skuas were recorded over five days in July, August and September, and an estimated 350 were recorded resting within 300 metres of the Thebaud production platform in December, however the latter observation is suspect and has not been confirmed. In 2000 and 2001, no jaegers or skuas were recorded; however, given that the rarity of these species is not unexpected, and surveys were conducted over fewer days in 2001 than 1999, their apparent absence cannot be attributed to the platforms.

Terns are associated with Sable Island. At Thebaud, Common Terns were only recorded in July and August 2001 (Figure 3.10). The recording of few terns at Thebaud in 2001 is not surprising since only one was recorded in 2000 (July).

Alcids

Five alcid species can be expected to occur in the region including Dovekie, Common Murre, Thick-billed Murre, Razorbill, and Atlantic Puffin. All of these species are pelagic species that typically stay away from land except during breeding. In general, these species are most abundant in the waters around Sable Island during the winter months, particularly during the months of January and February (Brown 1986). Numbers decline during the spring as these birds congregate at their breeding colonies. Alcids disperse from these colony sites in the autumn and reach the Sable Island area in early winter. This pattern is similar for all of these species although there are some differences in the time they are present in the Sable Island area (Brown, 1986). The area around Sable Island generally supports a relatively low population density of all of the alcid species in comparison to other areas of Atlantic Canada. The highest densities are typically found in the waters around Newfoundland

Alcid sightings by observers have been quite rare, however, this is not surprising given their coloration and size. Dovekies have only been seen within 300 m of the platforms (likely due to their small size) for all but one sighting. Murres were recorded on 25 occasions in 1999 and 6 occasions in 2000 at Thebaud but were not recorded in 2001.

Figure 3.7 Herring Gull Occurrence at Thebaud

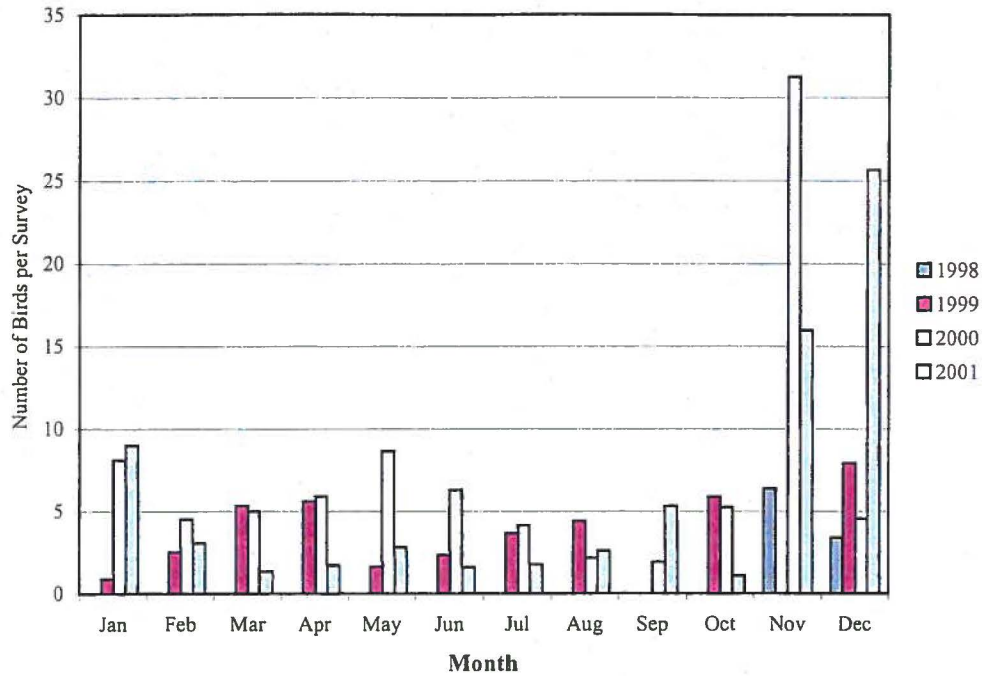


Figure 3.8 Great Black-Backed Gull Occurrence at Thebaud

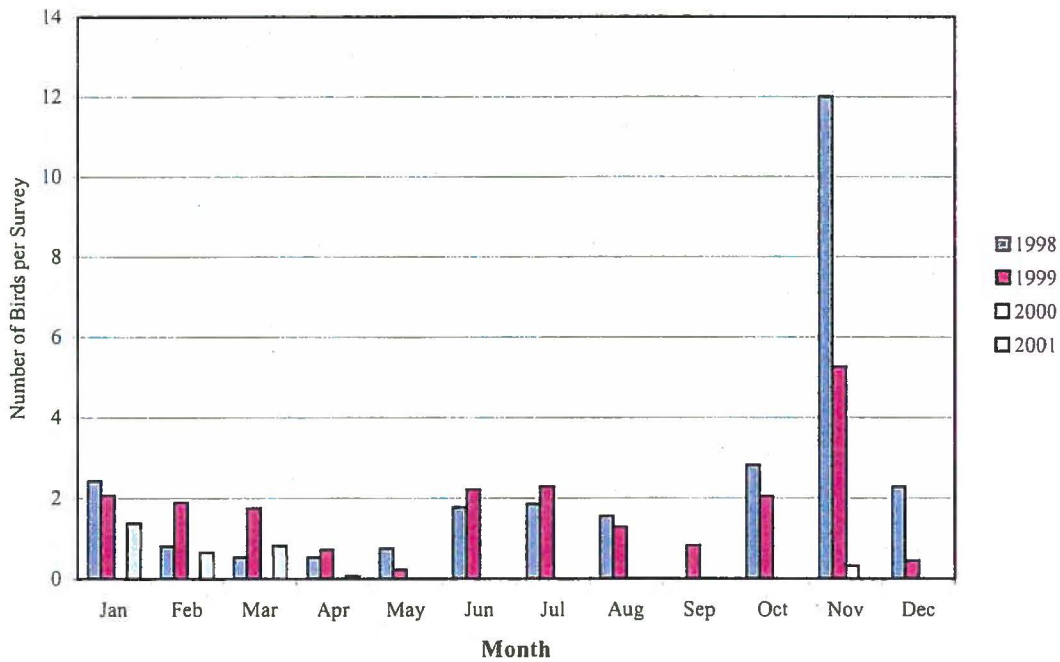


Figure 3.9 Black-legged Kittiwake Occurrence at Thebaud

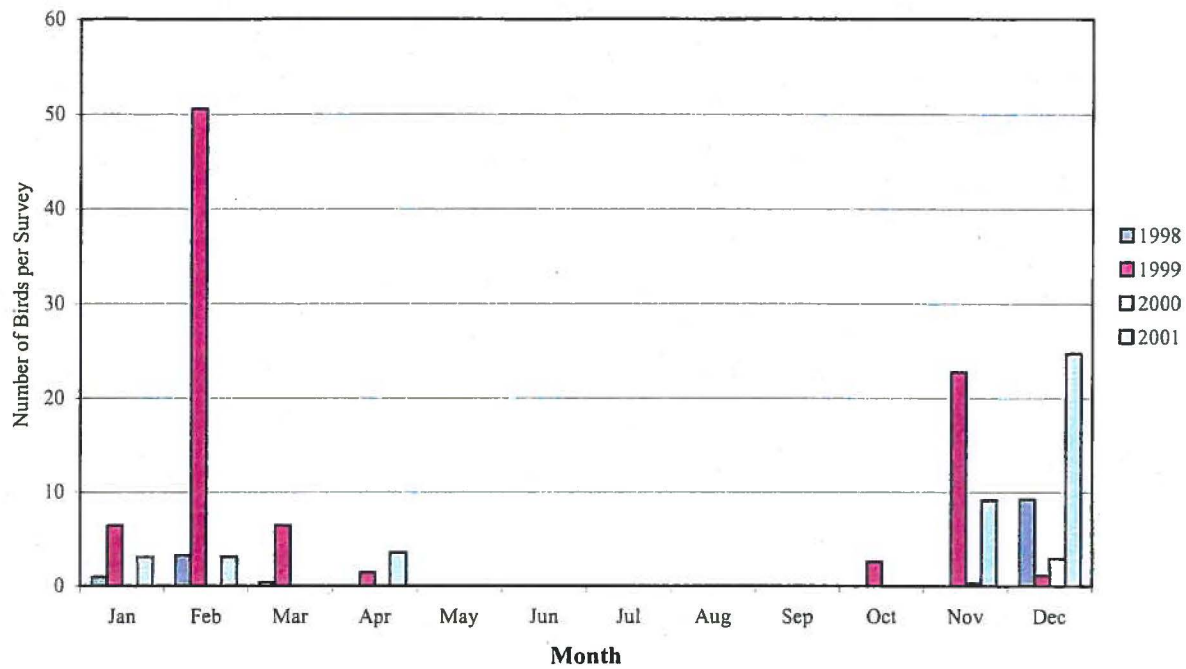
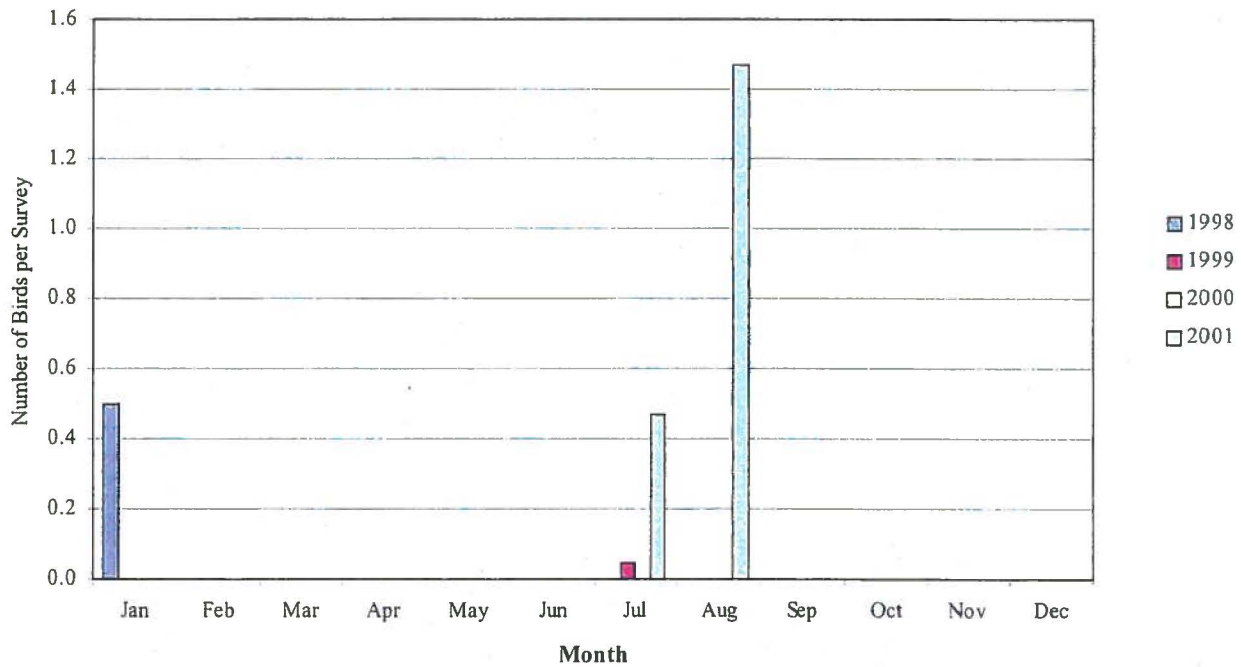


Figure 3.10 Common Tern Occurrence at Thebaud



3.7.3 Summary of Seabird Observations

Bird migration trends by the Thebaud platform generally mirror Sable Island patterns. All common species were observed both far and in close proximity to the platform and did not generally appear to avoid the platform area. Low incidence of dead birds and the high frequency of the surveys suggest there was likely no large scale fatalities in the vicinity of the platforms. Few fatalities were observed to occur as a direct result of flaring. As flaring was recorded in few surveys at Thebaud, flaring is likely a rare event during drilling of the wells, and during production.

3.8 Sable Island EEM Studies

This section provides summaries of the oiled seabird beach surveys and the air quality monitoring for detection of flare emissions from the platforms. Both surveys monitor for effects originating from the offshore platforms that may affect Sable Island or can be monitored from the island. Sable Island provides a unique platform upon which to augment the offshore EEM program.

3.8.1 Oiled-Seabird Beach Surveys

During year 2001 twelve beached seabird surveys were carried out on the north and south sides of Sable Island, one in each month except February and December. Beach conditions and presence of grey seal colonies prevented survey during February, but in December two surveys (21 days apart) were carried out, one at the beginning of the month, and one at the end. During 2001, the interval between surveys averaged 28 days, the longest being 36 days (between the January and March surveys). Table 3.15 shows the number, and percent oiled for the main groups of seabirds found as beached carcasses during year 2001: 254 *procellariidae* or tubenoses (Northern Fulmar, shearwaters and petrels); 131 larids (gulls and terns); and 770 auks (Razorbill, Common and Thick-billed Murres, Black Guillemot, Dovekie, and Atlantic Puffin).

Table 3.15 Monthly Observed Beached Seabird Carcasses on Sable Island – 2001 Survey

Month	Tubenoses		Gulls & Terns		Auks	
	Total No.	% Oiled	Total No.	% Oiled	Total No.	% Oiled
January	3	0	15	0	120	11.4
February	no data	no data	no data	no data	no data	no data
March	3	0	10	14.3	88	31.6
April	2	0	14	0	278	15.6
May	1	0	18	12.5	132	17.1
June	29	4	17	0	44	37.5
July	185	0	8	0	11	40
August	6	0	3	0	3	0
September	17	0	14	0	3	0



October	4	0	7	0	1	0
November	1	0	2	0	0	0
December a	1	0	10	0	3	0
December b	2	0	13	33.3	87	89.7
Totals	254		131		770	

With the exception of the sandy plain area (on the south side of the island), the beach was examined from the tideline to the base of vegetated dunes. Along the sandy plain the area of beach surveyed extends from tideline to approximately 50 metres inland. Seabird carcasses were collected, examined for oiling, entanglement, and experimental marking such as leg bands, and removed from the beach. Protocol provided by John Chardine of the Canadian Wildlife Service was used for recording numbers and rates of oiling.

Oiled bird specimens were sent to Seatech Ltd. in Dartmouth, Nova Scotia for oil identification. Of twenty-three specimens collected during January and March, thirteen contained weathered crude oil, one contained weathered crude oil and possibly some lube oil, four contained weathered Bunker C, four contained unidentifiable heavy oil (weathered), and one contained weathered distillate fuel. Weathered crude oil generally indicates discharges from oil tanker cargo or slop tanks, and contamination containing only Bunker C is possibly from tank washings. Oil specimens collected during the latter half of 2001 are yet to be analysed.

During year 2001 the numbers, timing and species composition of beached seabirds, and the proportion oiled, were consistent with patterns observed on Sable Island in previous years. All oiled carcasses were contaminated with very dark (black-brown) thick oil, the oil usually having a crusty and hardened outer layer.

3.8.2 Upset Flaring Emissions

The study areas for flare emissions are located on the Thebaud Platform, and at the Atmospheric Environment Service station on the western portion of Sable Island. The data are provided in four reports submitted to ExxonMobil by Seatech Ltd. (2001).

3.8.2.1 Passive Collectors

The results for nitrogen dioxide dosimeters, volatile organic carbon (VOC) dosimeters and particulate deposition collectors are reported in Tables 3.16 to 3.19. Stations on Sable Island displayed very low levels of NO₂ and VOCs compared to the station in Halifax. The twelve sets of data from November 1999 to September 2001 for NO₂ and total VOCs are presented in Figures 3.11 and 3.12.



Table 3.16
NO₂, VOC and Deposition Trap Data*
(Average of 2 samples each location for VOC and NO₂)

Client Name: Sable Offshore Energy Incorporated, Halifax, N.S.
Date Collected: December 21 - March 19, 2001 (83 days deployment)
Collected By: Seatech Ltd
Date Received: March 19, 2001

Station ID	NO ₂ ($\mu\text{g}/\text{m}^3$)	VOC ($\mu\text{g}/\text{m}^3$)					Mass Retained By Collector (mg)	Micro Exam
		benzene	toluene	ethylbenzene	xylene	n-hexane		
#1 (Sable)	0.4	ND	ND	ND	ND	ND	NA	Filter partially destroyed. Some dried green algal growth observed. Fine grained sand. No evidence of soot.
#2 (Sable)	0.2	ND	ND	ND	ND	ND	NA	Filter partially destroyed. Some dried green algal growth observed. Fine grained sand. No evidence of soot.
#3 (Sable)	0.4	ND	ND	ND	ND	ND	NA	Filter destroyed.. Fine grained, brown particulate and sand. No evidence of soot.
#4 (Halifax Control)	12.1	0.8	1.5	0.2	1.51	0.63	165	Loose plant material and detritus. Some fine grained brown sediment. No evidence of soot.

* All results corrected for badge and/or solvent blanks.

R = Analysis is rejected duplicate variation >25% or badge damaged (Raw Data in appendix)

Notes:

- Area of particle deposition collector = 0.07 m²
- Traps, VOC and NO₂ badges were deployed for 83 days; December 21, 2000 – March 14, 2001
- Halifax Control Station deployed for 87 days; December 22, 2000 – March 19, 2001
- Nd_{VOC} = <0.2 $\mu\text{g}/\text{m}^3$
- ND_{NO2} = <0.2 $\mu\text{g}/\text{m}^3$
- Trace = Detectable at levels <0.2 $\mu\text{g}/\text{m}^3$



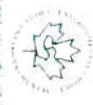


Table 3.17
NO₂, VOC and Deposition Trap Data*
(Average of 2 samples each location for VOC and NO₂)

Client Name: Sable Offshore Energy Incorporated, Halifax, N.S.
Date Collected: March 19- May 23, 2001 (64 days deployment)
Collected By: Seatech Ltd
Date Received: June 4, 2001

Station ID	NO ₂ ($\mu\text{g}/\text{m}^3$)	VOC ($\mu\text{g}/\text{m}^3$)						Mass Retained By Collector (mg)	Micro Exam
		benzene	toluene	ethylbenzene	xylene	n-hexane	total VOCs		
#1 (Sable)	0.8	ND	ND	ND	ND	ND	0.4	NA	Filter partially destroyed. Some dried green algal growth observed. Fine grained sand. No evidence of soot.
#2 (Sable)	0.9	ND	ND	ND	ND	ND	0.6	NA	Filter partially destroyed. Some dried green algal growth observed. Fine grained sand. No evidence of soot.
#3 (Sable)	0.8	ND	ND	ND	ND	ND	0.5	169	Fine grained, brown particulate and sand. No evidence of soot. Some dried green algal growth observed. Six mosquitoes retained by filter. No evidence of soot.
#4 (Halifax Control)	16.8	0.7	1.6	0.5	2.7	0.6	11.8	602	Loose plant material and detritus. Some fine grained brown sediment. No evidence of soot.

* All results corrected for badge and/or solvent blanks.

R = Analysis is rejected duplicate variation >25% or badge damaged (Raw Data in appendix)

Notes:

- Area of particle deposition collector = 0.07 m²
- Traps, VOC and NO₂ badges were deployed for 64 days; March 19 – May 23, 2001
- Halifax Control Station deployed for 74 days; March 23 – June 4, 2001
- Nd_{VOC} = <0.2 $\mu\text{g}/\text{m}^3$
- ND_{NO2} = <0.2 $\mu\text{g}/\text{m}^3$
- Trace = Detectable at levels <0.2 $\mu\text{g}/\text{m}^3$





Table 3.18

NO₂, VOC and Deposition Trap Data*
(Average of 2 samples each location for VOC and NO₂)

Client Name: Sable Offshore Energy Incorporated, Halifax, N.S.
Date Collected: May 21 – August 1, 2001 (72 days deployment)
Collected By: Seatech Ltd
Date Received: August 2, 2001

Station ID	NO ₂ ($\mu\text{g}/\text{m}^3$)	VOC ($\mu\text{g}/\text{m}^3$)						Mass Retained By Collector (mg)	Micro Exam
		benzene	toluene	ethylbenzene	xylene	n-hexane	total VOCs		
#1 (Sable)	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	NA	Filter partially destroyed. Some dried green algal growth present. Fine grained sand. No evidence of soot.
#2 (Sable)	1.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.7	769	Filter partially destroyed. Some dried green algal growth observed. Fine grained sand and wood material present. No evidence of soot.
#3 (Sable)	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	NA	Filter predominantly destroyed.. Fine grained, brown particulate and sand. Algal growth present as well as feathers and small twigs. No evidence of soot.
#4 (Halifax Control)	16.2	<0.2	2.7	0.6	2.9	1.1	11.7	281	Loose plant material and detritus. Some fine grained brown sediment. Slight algal growth. No evidence of soot.

* All results corrected for badge and/or solvent blanks.

R = Analysis is rejected duplicate variation >25% or badge damaged (Raw Data in appendix)

Notes:

- Area of particle deposition collector = 0.07 m²
- Traps, VOC and NO₂ badges were deployed for 72 days; May 21 – August 2, 2001
- Halifax Control Station deployed for 59 days; June 4 – August 2, 2001
- Nd_{VOC} = <0.2 $\mu\text{g}/\text{m}^3$
- ND_{NO2} = <0.2 $\mu\text{g}/\text{m}^3$
- Trace = Detectable at levels <0.2 $\mu\text{g}/\text{m}^3$





Table 3.19
NO₂, VOC and Deposition Trap Data*
(Average of 2 samples each location for VOC and NO₂)

Client Name: Sable Offshore Energy Incorporated, Halifax, N.S.
Date Collected: August 1 – September 24, 2001 (55 days deployment)
Collected By: Seatech Ltd
Date Received: October 23, 2001

Station ID	NO ₂ (µg/m ³)	VOC (µg/m ³)						Mass Retained By Collector (mg)	Micro Exam
		benzene	toluene	ethylbenzene	xylenes	n-hexane	total VOCs		
#1 (Sable)	1.1	<0.09	<0.03	<0.08	<0.09	<0.26	<0.26	71.8	Algal growth, sand particles and organic debris detected. No evidence of soot.
#2 (Sable)	Invalid Data ¹	Invalid Data ¹	Invalid Data ¹	Invalid Data ¹	Invalid Data ¹	Invalid Data ¹	Invalid Data ¹	510	Algal growth, sand and 'dirt' particles, organic debris detected. No evidence of soot.
#3 (Sable)	Invalid Data ²	Invalid Data ²	Invalid Data ²	Invalid Data ²	Invalid Data ²	Invalid Data ²	Invalid Data ²	N/A	Filter destroyed.
#4 (Halifax Control)	17.1	<0.08	3.08	0.43	2.08	3.2	30.30	496.2	Heavily covered in loose plant material, detritus and brown sediment. No evidence of soot.

* All results corrected for badge and/or solvent blanks.

R = Analysis is rejected duplicate variation >25% or badge damaged (Raw Data in appendix)

Notes:

- Area of particle deposition collector = 0.07 m²
- Traps, VOC and NO₂ badges were deployed for 55 days; August 1 – September 24, 2001
- Halifax Control Station deployed for 61 days; August 2 – October 1, 2001

- Nd_{VOC} = <0.2 µg/m³

- ND_{NO2} = <0.2 µg/m³

- 1. Data invalid as duplicate varied by more than 25%
 2. Samples returned not capped (i.e. diffusion membrane removed and plastic cap installed)



NO₂ Dosimeter Data for Sable Island Stations and Halifax Control Sample

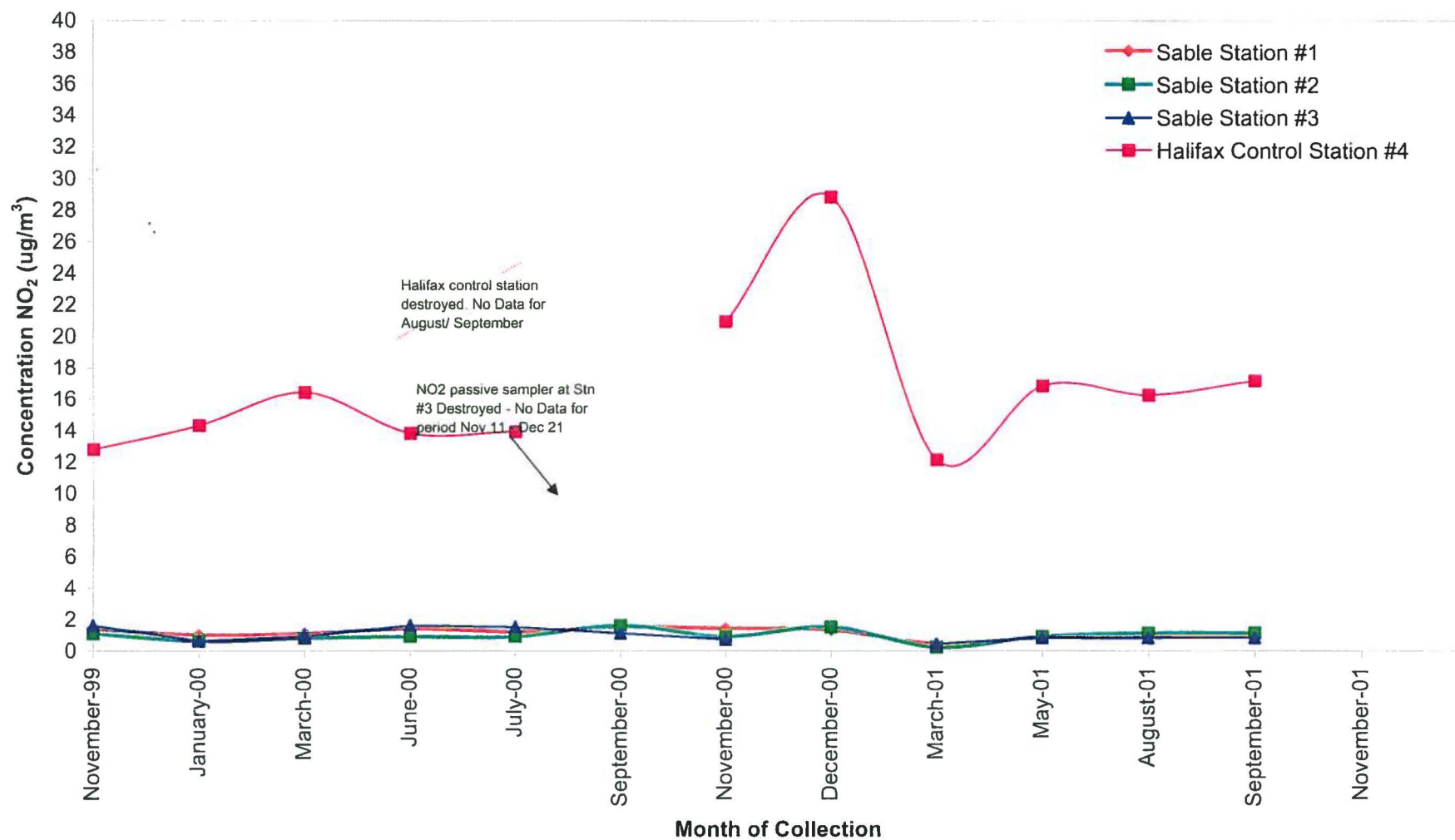


Figure 3.11

Total VOC Data for Sable Island Stations and Halifax Control Sample

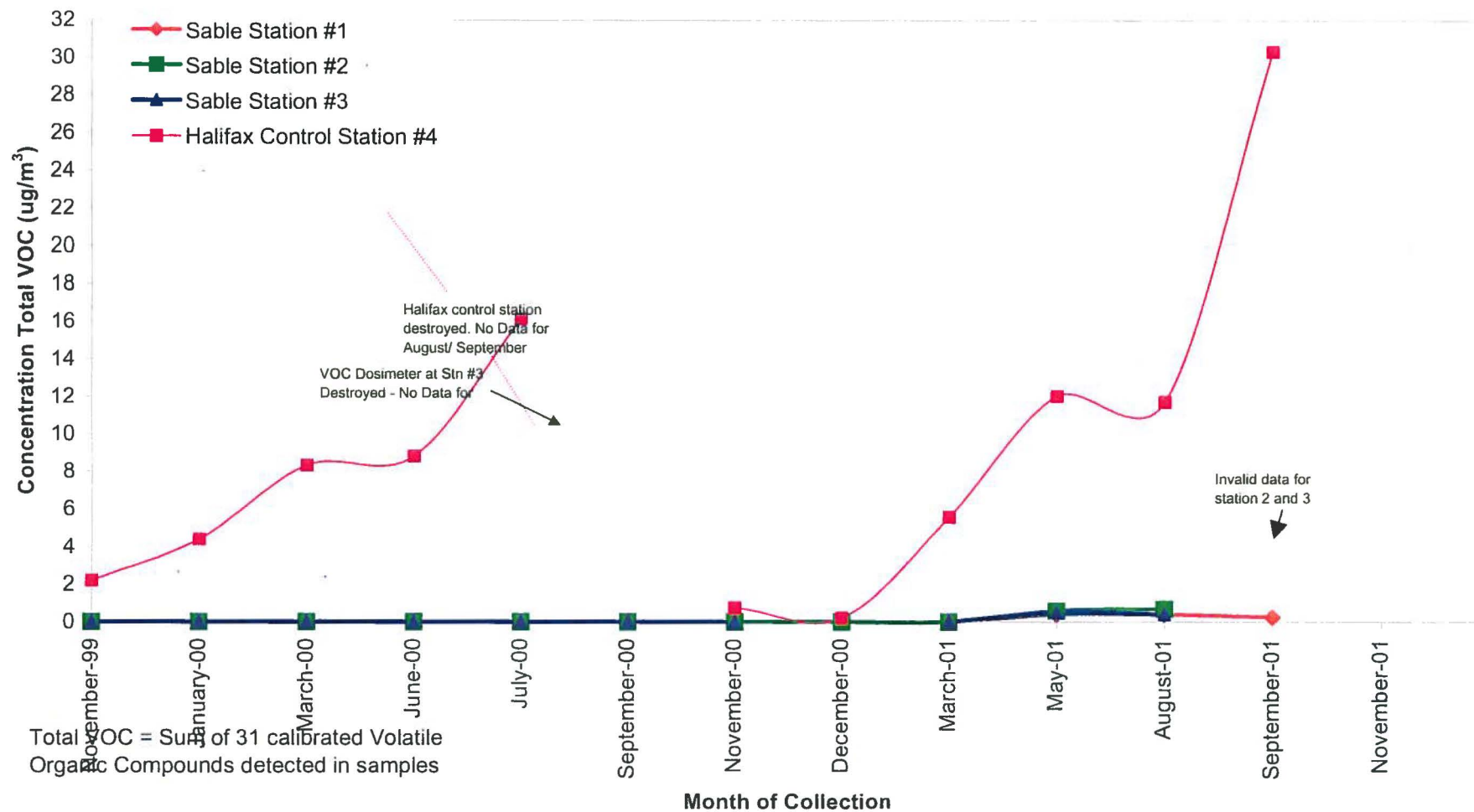


Figure 3.12

In two instances, VOC data were rejected as invalid. There were two different reasons for rejecting each of the two sets of Sable Island VOC data: duplicates for one Sable Island station varied by more than 25%; and the samples received were not properly sealed. In both cases, very high levels of VOCs were detected in the dosimeters.

The only unusual handling of these dosimeters compared to previous monitoring periods was their temporary loss (a few weeks) at the Provincial Airlines hangar at the Halifax International Airport.

This was the twelfth period in which data were recovered. Data were similar to previously collected data. There are no specific downwind ambient air regulations or guidelines for offshore flares. A previous review of the literature found some general guidelines used in other parts of the world by various agencies (Applicable Downwind Flare Gas Emission Standards As Suggested From A Literature Review prepared by Seatech Ltd. for ExxonMobil, Jan, 2000). From this literature review Seatech Ltd. suggested the standards shown below as both reasonable and supportable from an international regulatory and health effect basis.

Nitrogen dioxide (NO ₂)	Annual mean	<40 ug/m ³
Total VOC (as toluene)	Annual mean	<30 ug/m ³

The nitrogen dioxide levels recorded at Sable Island ranged from 0.3 to 1.0 ug/m³. At the Halifax Station, nitrogen dioxide levels ranged from 12.0 to 17.0 ug/m³. Urban levels for nitrogen dioxide have been reported over the range 20 to 90 ug/m³ with rural levels in the range 1 to 9 ug/m³.

For VOCs the recommended ambient air exposure levels to avoid negative health effects vary from < 1 ug/m³ for benzene to <870 ug/m³ for xylenes. Industrial workplace safety levels vary from <1,600 ug/m³ for benzene to <434,000 ug/m³ for xylenes. Total VOC levels detected on Sable Island ranged from 0 to 0.5 ug/m³ and at the Halifax Control Station VOCs levels ranged from 5.7 to 30.3 ug/m³. Urban levels for VOCs vary from 14 to 60 ug/m³ (based as toluene) with rural levels in the range 0.5 to 2 ug/m³. The average total VOC concentration of 30.3 ug/m³ was observed at the Halifax Control Station with half of this concentration being attributed to tetrachloroethylene. The control station has recently been relocated (about two blocks from the previous site) and is now two blocks from a dry cleaner. In summary, no VOCs, as typically detected in flare emissions, were detected at Sable Island.

4.0 DRILLWASTE AND PRODUCED WATER: EIS AND EEM COMPARISON

This section provides a comparison of data results from the various EEM study components obtained from monitoring surveys conducted in the vicinity of the Venture, Thebaud and North Triumph platforms with the EIS model predictions (MacLaren Plansearch 1997a,b). An objective of the EEM program is to test whether the effects of discharging drill wastes or produced water into the marine environment occur within the zones of influence predicted by the EIS.

4.1 Model Predictions

The long- and short-term fate of drill cuttings and drill mud in the benthic boundary layer (BBL) and on the seafloor were predicted in the EIS using existing knowledge and modeling techniques at that time (MacLaren Plansearch 1997a).

4.1.1 Drill Waste Deposition

Modelled distribution of drill muds and cuttings on the seafloor were presented as areal spread and thickness of deposit based on estimated drilling waste quantities (MacLaren Plansearch 1997b). Table 4.1 shows the radii of hydrocarbon concentrations from the discharge of drill wastes at Venture, Thebaud and North Triumph as predicted in the EIS.

Table 4.1 Predicted Concentrations, Layer Thickness and Biological Effects From Drill Wastes at Venture, Thebaud and North Triumph					
Drill Waste Layer Thickness	Hydrocarbon Concentration	Biological Effect	Radius From Platform		
			Venture	Thebaud	N.Triumph
1 cm	10,000 ppm	smothering with pronounced toxicity and tainting	150-300 m	100 m	40-80 m
1 mm	1,000 ppm	50% reduction in abundance and diversity	300-400 m	400-600 m	100-200 m
0.1 mm	100 ppm	diversity and abundance at background, only sensitive species lost	600-700 m	600-800 m	500-1000 m
0.01 mm	10 ppm	no noticeable effect	>700 m	>800 m	>1000 m

Through modelling, the cutting mounds were predicted to be a maximum height of 3.5 m at Venture, with an initial spread to 1 mm thickness out to 400–500 m radius. At Thebaud, the estimated maximum mound height is 1.0 m with an initial spread to 1 mm thickness out to 500–600 m. Because of the dynamic nature of the ocean in these shallow sites, it was predicted that 80–90% of the deposited cuttings would be dispersed to below detectable levels within one year. Sediment transport modelling predicted that the spread of fine-grained materials will be to the east, north, and west-southwest directions from North Triumph, and to the north and east from Venture and Thebaud, respectively (MacLaren Plansearch 1997b)

4.1.2 Taint

The zone of influence upon scallops, as predicted by modelling (MacLaren Plansearch 1997a,b), to be the extent of drill mud transport. From the results of lab experiments conducted at the Bedford Institute of Oceanography, an oil based mud (OBM) concentration of 1-2 mg/L in the BBL is considered sublethally toxic to scallops (Cranford and Grant 1990, MacLaren Plansearch 1997a,b). This concentration is predicted to extend 10–15 km from Venture and 10–12 km from Thebaud. Fish exposed to drilling mud do not readily accumulate hydrocarbons; only fish feeding in the zone of severe benthic community effects (where the hydrocarbon concentrations are >1,000 ppm) may develop taint (MacLaren Plansearch 1997b). Distances of 300–400 m and 400–600 m from Venture and Thebaud, respectively, includes these predicted zones of influences.

4.2 Drill Waste and Produced Water Effects at Venture

For Venture, at 150–300 m from the cuttings discharge point the EIS predicted the drill waste layer to:

- be 1.0 cm thick;
- contain hydrocarbon concentration at the 10,000 ppm range,
- smother all benthos, and
- have pronounced toxicity and tainting effects.

The remotely operated vehicle (ROV) survey showed that the cuttings pile is gradually decreasing in height and areal extent. The benthos is smothered under a thick drill waste layer to the edge of the pile. The pile edge is abrupt with little evidence of smothering beyond. Therefore, despite the extremely energetic shallow water environment at Venture the prediction that 80–90% of the deposited cuttings will be dispersed to below detectable levels within one year has not occurred. The cohesive nature of the OBM cuttings is likely responsible for maintaining the pile.

Elevated levels of total petroleum hydrocarbons in sediments were detected in the first (November 1998) and second drilling surveys (June 1999), at the 250 m distance along the northeast and southwest



directions (Axes 3 and 7) at concentrations between 75 mg/kg and 20–40 ppm, respectively. These concentrations are well below the 10,000 ppm predicted. Hydrocarbon concentrations at 500 m and beyond were within background levels and below the predicted 10 ppm where biological effects are expected. The 2000 EEM surveys show that sediment chemistry at 250 m and beyond are within background levels of total petroleum hydrocarbon (TPH). The 2001 sediment chemistry results show slightly elevated levels of hydrocarbons at 250 m on Axis 7 compared with the 2000 EEM results, but they are within background levels. Of interest is the transport of drill cuttings along Axis 7 (southwest) which was not predicted in the modelling.

Sediment metal concentrations were not modelled in the EIS. Barium has proven to be a reasonable indicator of drill wastes (Hartley 1996, Kennicutt *et al.* 1996). There were no significant increases in barium in the Venture field samples; however barium concentration at the 250 m station on Axis 5 in the November 1999 survey shows a slight increase indicating a potential for an effect in this area. Subsequent surveys show that barium in sediments is within background concentrations. The 2001 EEM survey results show barium increases of the highest concentrations observed to date within the 500 m radius. The drilling at V2 and subsequent disposal of water-based mud (WBM) overboard would account for this increase in the near-field.

No toxic effects upon amphipod survival or Microtox tests were found at any of the Venture or Gully stations during any of the surveys. Pronounced toxic effects were predicted to result where hydrocarbon concentrations were in the 10,000 ppm range. Such high levels have not been detected at any Venture sampling station.

Sensory evaluations and body burden testing for hydrocarbons at Venture have shown petrogenic aliphatic hydrocarbons in the OBM region in blue mussel tissues. Subsequently, tainting has not been detected in mussels tested over the past three years of offshore drilling and production at Venture.

4.3 Drill Waste and Produced Water Effects at Thebaud

For Thebaud, at 100 m from the cuttings discharge point the EIS predicted the drill waste layer to:

- be 1.0 cm thick;
- contain hydrocarbon concentration at the 10,000 ppm range;
- smother all benthos, and
- have pronounced toxicity and tainting effects.

The ROV survey showed that the maximum radius of the cuttings pile was observed to be approximately 30 m at its longest horizontal spread. These observations indicate that modeling overestimated the areal extent of the cuttings pile boundary, but underestimated the time of dispersion. Smothering of benthic fauna would result within the 30 m radius which is more than half the distance predicted. Hermit crabs and Jonah crabs occupy the perimeter of the pile and fish were observed on the cuttings.



The closest sampling distance is 250 m from the platform. Between 400–600 m, the EIS predicted the drill waste layer to:

- be 1.0 mm thick;
- contain hydrocarbon concentrations of 1,000 ppm; and
- cause a 50% reduction in abundance and diversity.

The 1.0 mm thickness in drill waste layer is virtually impossible to measure as this would represent a dusting over the surface of the sandy seafloor of the thickness equivalent to the grain size of sand. However, benthic photographs at 250 m on Axis 3 show patches of light-coloured drill waste material in the sand ripples.

Elevated petroleum hydrocarbons were detected at 250 and 500 m sampling radii in the first drilling survey (June 1999). Axes 3 and 7, located along the direction of predicted prevailing current exhibited highest concentrations. The highest TPH level was at the 250 m station (1550 ppm), which falls within the prediction concentration for the 400–600 m range. The other stations at 250 and 500 m had levels <590 ppm, which is approximately half of the predicted concentration for that distance range. At distances >800 m, there was a slight elevation along Axis 3 at 1000 m (35.5 ppm) which is within the predicted order of magnitude. Attenuation of drill waste from source appears to occur along Axis 3 in an easterly direction as predicted. The high concentrations at the 250 and 500 m distance are not evident in the following November 1999 survey indicating that sediment transport is burying surficial sediments and/or biodegradation of the synthetic-based mud is occurring. Between November 1999 and 2000, TPH concentrations at 1000 m returned to background levels. The June 2000 survey showed re-elevation of TPH at the 250 and 500 m Stations on Axis 3 which decreased at the 500 m distance but not at the 250 m radius in the November 2000 survey. These results confirm that sediment transport affects surficial sediment chemistry on a seasonal (storm) basis. The June 2001 survey shows persistent TPH in sediments at 250 m and 500 m along Axis 3.

Elevated barium concentration in sediments correlates positively with elevated TPH values at the 250 m stations on Axes 3 and 7, and with the 500 m station on Axis 7 in the June 1999 survey. Barium levels at all stations are similar to background for all other remaining surveys at 250 m. The barium results from the 2001 survey showed barium at its highest concentration at 500 m.

No reduction to the magnitude of 50% in abundance or diversity was evident in the dominant epifauna species. The diversity of the epibenthic and infaunal communities is naturally very low. Crabs (hermit and Jonah) are abundant around the cuttings pile.

Amphipod mortalities at the toxic effect criterion occurred in the June 1999 drilling survey at the two 250 m stations where high levels of hydrocarbon at Axis 3 (1550 mg/kg) and Axis 7 (586 mg/kg) were detected. The toxic effect reappeared at Station 250 m on Axis 3 during the June and November 2000

and June 2001 surveys. In the 2001 survey, amphipod mortalities occurred at 500 m on Axis 3 for the first time. This response positively correlates with the elevated TPH concentration.

Sensory evaluations and body burden testing for hydrocarbons at the Thebaud production platform have not shown evidence of tainting from petrogenic aliphatic hydrocarbons in blue mussels.

The receiving environment of produced water within several metres of Thebaud's produced water caisson does not exhibit toxic responses in sea urchins or three-spine stickleback. Chemical analysis of produced water tracers in receiving waters show no evidence of produced water at the time of sampling. The predicted dilution at the platform is 1:1000 within 50 m of discharge, therefore, no lethal or sublethal effects on marine organisms are expected outside of the discharge caisson.

4.4 Drill Waste Effects at North Triumph

For the North Triumph, the closest EEM sampling distance is 250 m from the platform. Between 100–200 m, the EIS predicted the drill waste layer to:

- be 1.0 mm thick;
- contain hydrocarbon concentrations of 1,000 ppm; and
- cause a 50% reduction in abundance and diversity.

In the 2000 EEM survey, drill wastes were observed by ROV to be incorporated into the sediment at the 250 m distances from the jacket. During the first drilling survey for this field in the November 1999, three of the four 250 m stations (on Axes 1, 5 and 7) had elevated TPH between 53.4 and 2440 mg/kg. Axis 7 had the highest level and is the direction of predicted prevailing current (southwest). However, the high TPH levels on Axis 1 in a northerly direction was not predicted. TPH concentration attenuates to 500 m at 613.0 ppm and to 1000 m at 52.7 ppm, beyond which TPH is at background levels. TPH concentration decreased at the 250 m stations, but remain considerably elevated above background through to November 2000. TPH levels at the 500 m station on Axis 7 are slightly elevated but near background levels by June 2000. Drill wastes were not visible at the 250 m stations in the 2001 EEM survey. The concentration of TPH decreased to background levels at 250 m and 500 m distances.

In November 1999, barium concentrations were elevated by an order of magnitude at the same 250 m and 500 m stations with elevated hydrocarbons noted above. Barium in sediments at 250m on Axis 1 and 7 fluctuated and remain elevated. Sediment barium at Station 500 m on Axis 7 decreased to background by June 2000. In 2001, barium concentration in sediments at 250 m and 500 m distances were within background levels.

No reduction in the magnitude of 50% in abundance or diversity was evident in the dominant epifauna species. The infaunal community was quite diverse and there is no statistical evidence to indicate changes as a result of drilling operations. Snow crabs were abundant around the platform and at 50 m

distance, likely drawn to the mussels fallen from the platform providing a readily accessible food source. Sea stars and sea cucumbers were also abundant on the platform leg supports and concrete protective mattresses.

In November 1999, following commencement of drilling at North Triumph, amphipod mortality tests show toxic effects at the 250 m stations along Axes 1 and 7. The station on Axis 7 had the highest overall TPH and barium levels. Sieved sediment from Axes 1 and 7 had visible black oil globules. No further toxic effects on amphipods were observed in subsequent survey samples.

5.0 CONCLUSIONS

Conclusions for 2001 EEM Program specific components are as follows.

- Samples of the marine receiving water adjacent to the produced water caisson at Thebaud shows no acute or sublethal toxicity or any tracers typical of produced water.
- The concentration of petroleum hydrocarbons and barium in sediment are elevated above background levels within 250 m and 500 m only at Thebaud. These parameters are present at background levels in the near-field environment at Venture and North Triumph.
- Amphipod mortality was evident in association with elevated petroleum hydrocarbon and barium concentrations in sediment only at Thebaud near-field 250 m and 500 m stations on Axis 3.
- The epibenthic communities at Venture and Thebaud beyond the cutting pile are not adversely affected by the discharge of drill wastes. The drill cuttings pile at Venture and Thebaud persist in virtually the same dimensions as originally deposited, and have not dispersed within one year from cessation of drill waste discharge as predicted. The benthic habitat on the cuttings pile is different from the surrounding area. The cuttings pile material at Thebaud is classified as a sandy silt (30.9% sand and 69.1% silt & clay) which differs from the 98% sand content at the field. The platform leg supports and the protective mattresses at North Triumph support high densities of sea cucumbers and snow crabs.
- Elevated concentrations of petrogenic aliphatic hydrocarbons are detected in mussel tissues within 20 m of the Venture and Thebaud produced water caisson platform but are not causing tainting. Sensory evaluations of snow crabs captured adjacent to North Triumph are not different in odour or taste compared with snow crabs from 20 km away.
- The whales, dolphins and seal species observed from the platforms are those species which typically frequent the area. It is reasonable to assume that the marine mammals observed from Thebaud are within the acoustic range of the sound spectra radiating from the drilling and production activities.
- Low incidence of dead birds and the high frequency of the surveys on Thebaud indicate that there is no large scale bird fatalities in the vicinity of the platforms. None of the oiled seabird carcasses found on Sable Island contained hydrocarbons traceable to the SOEP Tier 1 operations.
- There is no evidence of natural gas and condensate production atmospheric emissions causing measurable impacts on Sable Island.

6.0 REFERENCES

- Brown, R.G.B. 1986. Revised Atlas of Eastern Canadian Seabirds: 1. Shipboard Surveys. Canadian Wildlife Service, Environment Canada. 111 pp.
- COA (MacNeil, J.M. & S. Hurlbut), 1997. Meaningful Change in Flux and Stratification – Marine Environmental Effects Monitoring for the Confederation Bridge Project. Report for Jacques Whitford Environment Ltd., Charlottetown, PE.
- Cranford, P.J. and J. Grant. 1990. Particle clearance and absorption of phytoplankton and detritus by the sea scallop *Placopecten magellicanus* (Gmelin). J. Exp. Mar. Biol. Ecol. 137:105–121.
- Cranford, P.J., D.C. Gordon Jr., K. Lee, S.L. Armsworthy and G. H. Tremblay. 1999. Chronic toxicity and physical disturbance effects of water- and oil-based drilling fluids and some major constituents on adult sea scallops (*Placopecten magellanicus*). Mar. Env. Res. 48:225–256.
- CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Summary Tables. In: Canadian Environmental Quality Guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
- Hartley, J.P. 1996. Environmental monitoring of offshore oil and gas drilling discharges – a caution on the use of barium as a tracer. Mar. Poll. Bull. 32(10):727–733.
- JWEL (Jacques Whitford Environment Limited). 1999. Offshore Environmental Effects Monitoring Program 1998 Annual Report. Venture, South Venture and Thebaud. Report to Sable Offshore Energy Project
- JWEL. 1998. Offshore Environmental Effects Monitoring Program Baseline and Drilling Phases. Venture, Thebaud and North Triumph EEM Program.
- Kennicutt, M.G., R.H. Green, P. Montagna and P.F. Roscigno. 1996. Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX), Phase I: Sublethal Responses to Contaminant Exposure - Introduction and Overview. Canadian Journal of Fisheries and Aquatic Sciences 53(11): 2540-2553.
- MacLaren Plansearch. 1997a. Physical Fate of Drilling and Production Effluent Discharges and Impact on Marine Environment. Phase A: Interim Report. Prepared for Sable Offshore Energy Project. February 1997.

MacLaren Plansearch. 1997b. Physical Fate of Drilling and Production Effluent Discharges and Impact on Marine Environment. Phase B: Impact Assessment Final Report. Prepared for Sable Offshore Energy Project. March 1997.

MacLaren Plansearch. 1997c. Physical Fate of Drilling and Production Effluent Discharges and Impact on Marine Environment. Part 2: Produced Water Discharges. Prepared for Sable Offshore Energy Project. March 1997.

Milligan, T.G., D.K. Munchenheim, K.S. Saunders and A. Prior. 1997. Suspended Particulate Material Observations At The Hibernia Oil Field Developments Site, July 1995. Can Data. Rep. Fish. Aquat. Sci. 1009:1X, 110 pp.

Muschenheim, D.K., T.G. Milligan and D.C. Gordon, Jr. 1995. New Technology and Suggested Methodologies for Monitoring Particulate Wastes Discharged from Offshore Oil And Gas Drilling Platforms and Their Effects On the Benthic Boundary Layer Environment. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2049. Department of Fisheries and Oceans, Atlantic Region. Bedford Institute of Oceanography. 55 pp.

Muschenheim, D.K., and T.G. Milligan. 1996. Flocculation and Accumulation of Fine Drilling Waste Particulates on the Scotian Shelf (Canada). Mar. Poll. Bull. 32(10): 740–745.

Sable Offshore Energy Project 1999. SOEP Environmental Management Plan. November 1999.

Sable Offshore Energy Project (SOEP). 1996. Volume 3: Environmental Impact Statement Prepared by MacLaren Plansearch (1991) Limited.

Seatech Ltd. 2001. Assessment of Flare Emission Impacts on Sable Island From Sable Offshore Energy Project Offshore Operations. Report No. 1 December 21, 2000 – March 19, 2001; Report No. 2 March 19, 2001 – May 21, 2001; Report No. 3 May 21, 2001 – August 2, 2001; Report No. 4 August 1 – September 24, 2001.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach. Second Edition. McGraw-Hill, New York. 633 pp.

Sutcliffe, W.H. and P.F. Brodie. 1977. Whale distribution in Nova Scotia waters. Fish. Mar. Serv. Tech. Rept. 722. 83 p.

Zhou, S., R.G. Ackman and J. Parsons. 1996. Very long chain aliphatic hydrocarbons in lipids of mussels (*Mytilis edulis*) suspended in the water column near petroleum operations off Sable Island. Nova Scotia. Canada. Marine Biology 126:499–507.

