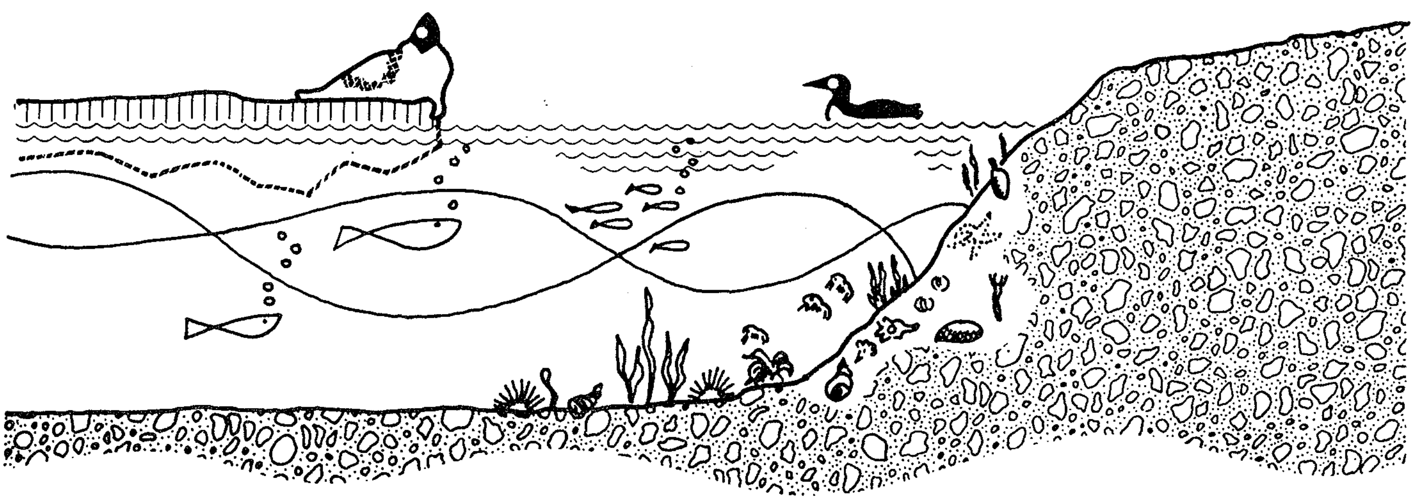
CHEMISTRY

1. Field Sampling and Measurements



Baffin Island Oil Spill Project

WORKING REPORT SERIES
83-1

1983 STUDY RESULTS

BAFFIN ISLAND OIL SPILL PROJECT
WORKING REPORT SERIES

The Baffin Island Oil Spill (BIOS) Project is a multidisciplinary program of research on arctic marine oilspill fate, effects and countermeasures. The Project commenced in the spring of 1980 and has now completed the fourth and final year of planned field work at an experimental site located on the northern end of Baffin Island, Canada. The results of work performed in each of the various study components under the Project have been made available on a yearly basis through this working report series. This has been done prior to a complete integration of findings and interpretation with respect to the Project objectives. The working report series should therefore be considered as interim or data reports. The contents do no necessarily reflect the views or policies of the BIOS Project management or funders.

For further information on the BIOS Project write the BIOS Project Manager, c/o Environmental Emergencies Technology Division, Environmental Protection Service, Ottawa, Ontario, Canada K1A 1C8.

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BAFFIN ISLAND OIL SPILL PROJECT
CHEMISTRY COMPONENT

FINAL
REPORT ON THE 1983
OIL SPILL EXPERIMENTS

VOLUME 1
SUMMARY OF FIELD WORK
AND
SHORELINE HYDROCARBON ANALYSIS

Final Report
Contract No. OSS83-00036

Prepared for

Environment Canada
Environmental Protection Service
Edmonton, Alberta

by

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JUNE, 1984

ABSTRACT

The sampling for the Baffin Island Oil Spill Chemistry component is described. The analytical method for total hydrocarbons and the results of those analyses are presented. Samples taken in 1983 are listed with the results of corresponding analyses from 1980 to 1982. The statistical validity of the sampling protocol is examined.

RÉSUMÉ

Une description de l'échantillonnage pour la partie chimie de BIOS (Déverserment d'huile à l'Ile de Baffin) est inclue.

La méthode d'analyse pour les hydrocarbures totaux et les résultats de ces analyses sont présentés. Des échantillons pris en 83 sont rapportés avec les résultats des analyses correspondantes pour 1980 et 1982. Un examen est fait de la validation de la méthode d'échantillonnage.

ACKNOWLEDGEMENTS

Once again, Dave Hope provided superior support in the field and excellent analytical work. His assistance is appreciated. I would also thank Dr. David R. Green for his advice during the preparations and completion of this project.

I would also like to acknowledge the Project and camp administration, and my colleagues in camp, for their part in making the field seasons so enjoyable. We will miss the Cape Hatt interludes.

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1. INTRODUCTION

Seakem's participation in the fourth year of the Baffin Island Oil Spill Project (BIOS) consisted of two components: the collection of samples in the field for various purposes and the analysis of the shoreline sediments for total hydrocarbon content.

The 1983 field session was significantly shorter than that of previous years. No attempt was made to analyse beach samples in the field. All effort was directed to collecting samples and preparing them for shipment to the appropriate laboratory for analysis. Two people from Seakem were in the field from August 08 to 22,1983. During that time, the following groups of samples were collected:

Shoreline sediments for total hydrocarbon
Shoreline sediments for gas chromatography
Seawater and large volume water samples
Tissue plot sediments
Benthic plot sediments
Floc
Sediment cores

Assistance was given in the collection of the following animals:

Astarte borealis
Mya truncata
Macoma calcarea
Serripes groenlandia
Strongylocentrotus droebrachiensis

This report describes the sampling strategy for 1983. It describes the analytical method for total hydrocarbon content, and provides the results of those analyses. An appendix includes sample lists and historical results for hydrocarbon analyses of those groups of samples collected throughout the BIOS project.

1.1 FIELD LOG

1983-08-08
B. Humphrey and D. Hope arrive in Cape Hatt, 2100. Some parts of the shipment are missing.
1983-08-09
Repaired PE 700 IR. The monochromator mirror had come unglued again. Freight found in Montreal.
1983-08-10
Sampled Bay 9 shoreline for total hydrocarbon. Instucted ABS in extraction procedures for sediment hydrocarbon.
1983-08-11
Freight arrives OK. Calibrate IR and run ABS samples. Strong CH_2 absorbance in all samples; undoubtedly from natural organics. Samples analyse at 110 ppm oil.
Wave gauge on. Begin LVWS sampling in Bay 11, with 16L samples taken simultaneously. Weather disgusting.
1983-08-12
Wave gauge deployed 0910 in 4m water at N end of Bay 11. Continue LVWS and water sampling in Bays 11 and 7. Heavy smoke plume present during LVWS L4003, but no apparatus was open at the time. Heavy rains have produced oil slicks from Bay 11 beach, probably due to heavy fresh water run-off.
1983-08-13
Sample tissues, sediments, and flocs in Bay 11. Continue LVWS and water sampling in Bay 11 and Ragged Channel.
1983-08-14
Sampled Bay 7 for tissues and sediments. Repaired Turner Designs fluorometer. Freon was tested as solvent by ABS, with success.
1983-08-15
Sampled Bay 9 and Milne Inlet for tissues and sediments. LVWS and water samples taken in Bays 11 and Milne Inlet.
1983-08-16
LVWS and water sampling in Bay 11 and Ragged Channel. Tissue and sediments sampled in Bay 10. Total hydrocarbons sampled in Bay 11.
1983-08-17
Sampled all shoreline plots for shoreline GC samples. Packed samples for Boston. D. Hope departs.
1983-08-18
Sampled Bays 7 and Milne Inlet (at S. end of Ragged Island) for LVWS and water.
1983-08-19
LVWS and water in Bay 11.
1983-08-20
LVWS and water in Bay 7. Total hydrocarbon sampling in all plots.
1983-08-21
LVWS in Bay 7. Complete shoreline total hydrocarbon samples. Pack samples.
1983-08-22
Depart Cape Hatt.

2. SAMPLING STRATEGIES

The site of the BIOS experiments at Cape Hatt at the north end of Baffin Island (Figure 2.1) is divided into areas for the two major experiments which are in progress. Around Z Lagoon on the east side of the cape, various shoreline countermeasures experiments have taken place. On the west side, along the shores of Ragged Channel, two experimental oil releases were made in 1981. In Bay 11, about 15,000L of Lago medio crude oil were released gently onto the surface inside a boom enclosing the beach area, about half of which stranded on the beach. In Bay 9, the same amount of oil was mixed 10:1 with a dispersant, Corexit 9527, and released at depth through a diffuser into the water column (Dickins, 1982).

The sampling strategies for the 1983 sampling period were based on the sampling done in previous years, in particular 1981 and 1982.

All samples were logged immediately upon collection. The log sheet included dates for the completion of each step of the analyses, and a signature when the samples were passed to a different laboratory.

2.1 SHORELINE COUNTERMEASURES

In 1980, a number of plots were set out to provide control data for experiments in 1981 and 1982. These plots are:

H1	High energy shoreline, aged crude
H2	High energy shoreline, emulsion
L1	Low energy shoreline, aged crude
L2	Low energy shoreline, emulsion
T1	Backshore control, aged crude
T2	Backshore control, emulsion
TE1	Microbiology control, aged crude
TE2	Microbiology control, emulsion

In 1981, a number of plots were set out to test the efficiency of various shoreline countermeasures:

CC	Control, aged crude
CE	Control, emulsion
MC	Mixing, aged crude
ME	Mixing, emulsion

D[E]C	Exxon dispersant, aged crude
D[E]E	Exxon dispersant, emulsion
D[B]C	BP dispersant, aged crude
D[B]E	BP dispersant, emulsion
SC	Solidifier, aged crude
SE	Solidifier, emulsion

In 1982, a number of plots were set out in a low energy intertidal area to test the efficiency of countermeasures in that regime:

ICC	Control, aged crude
ICE-E	Control, emulsion
ICE-W	Control, emulsion
ID[E]C	Exxon dispersant, aged crude
ID[E]E	Exxon dispersant, emulsion
ID[B]C	BP dispersant, aged crude
ID[B]E	BP dispersant, emulsion
IMC	Backshore, aged crude
IME	Backshore, emulsion
NCC	Norwegian control, crude
NCF	Norwegian fertilized, crude
NEC	Norwegian control, emulsion
NEF	Norwegian fertilized, emulsion

2.1.1 Total Hydrocarbon Sampling.

With the exception of the solidifier plots from 1981 and the microbiology control plots TE1 and TE2, all of the experimental plots have been resampled in 1983. The presence of solidifier interfered with the analysis of the sediments in 1981, so no attempt was made to analyse them in 1982 or 1983, although evidence of solidified oiled material was visible on the beach in both years. As no microbiology was being studied in Bay 102 in 1983, the two control plots were not sampled. As in previous years, both surface and subsurface samples were taken for total hydrocarbon content. Subsurface samples were obtained by carefully removing the surface down to 5 cm, then sampling down to 10 cm. Samples were composites of a number of scoops of sediment taken from predetermined sites in the plots. The locations of the plots are shown in Figure 2.2. The sampling sites for each group of plots are shown in Figures 2.3 to 2.8. Extra samples were collected near H1 and L1, above the plots on Crude Oil Point, and below the plots oiled in 1982, in order to identify the movement of oil outside of the experimental plots. Samples for total hydrocarbon analysis were collected in Whirlpak bags, shipped to Seakem, and frozen until extraction. The results of these analyses are listed in Section 4.1.

2.1.2 Gas Chromatography Samples

Samples for gas chromatographic analysis were collected in most of the sites collected for total hydrocarbons. In 1983, an attempt was made to sample to obtain a better description of the weathering characteristics of the oil than in previous years. Samples were taken from both surface and the sub-surface in order to identify any differences in weathering rates. The samples were collected in baked 8 oz glass jars, covered with a Teflon liner, and stored frozen until analysis. Table 1 lists the samples collected from the experimental plots.

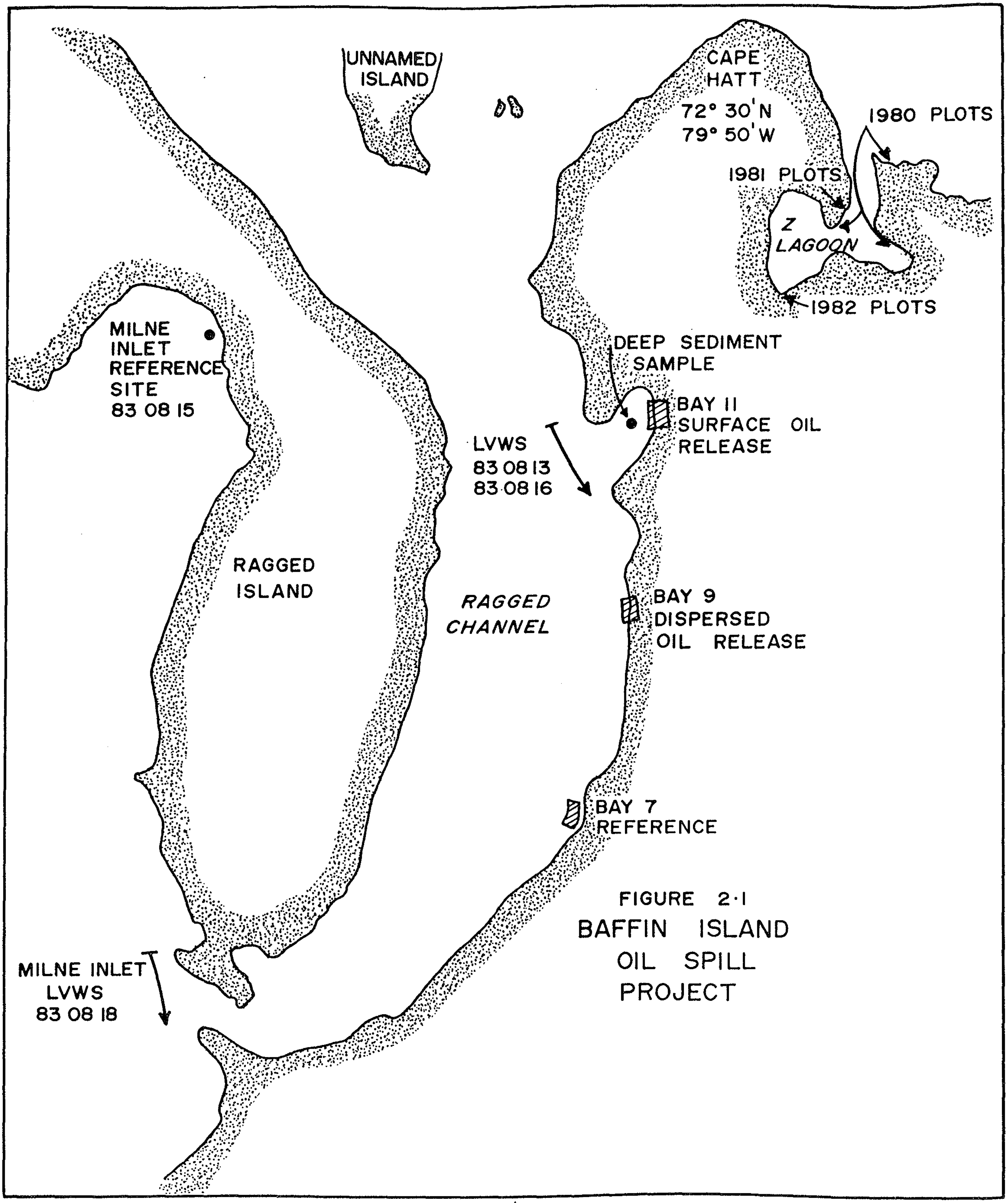

FIGURE 2·1
BAFFIN ISLAND
OIL SPILL
PROJECT

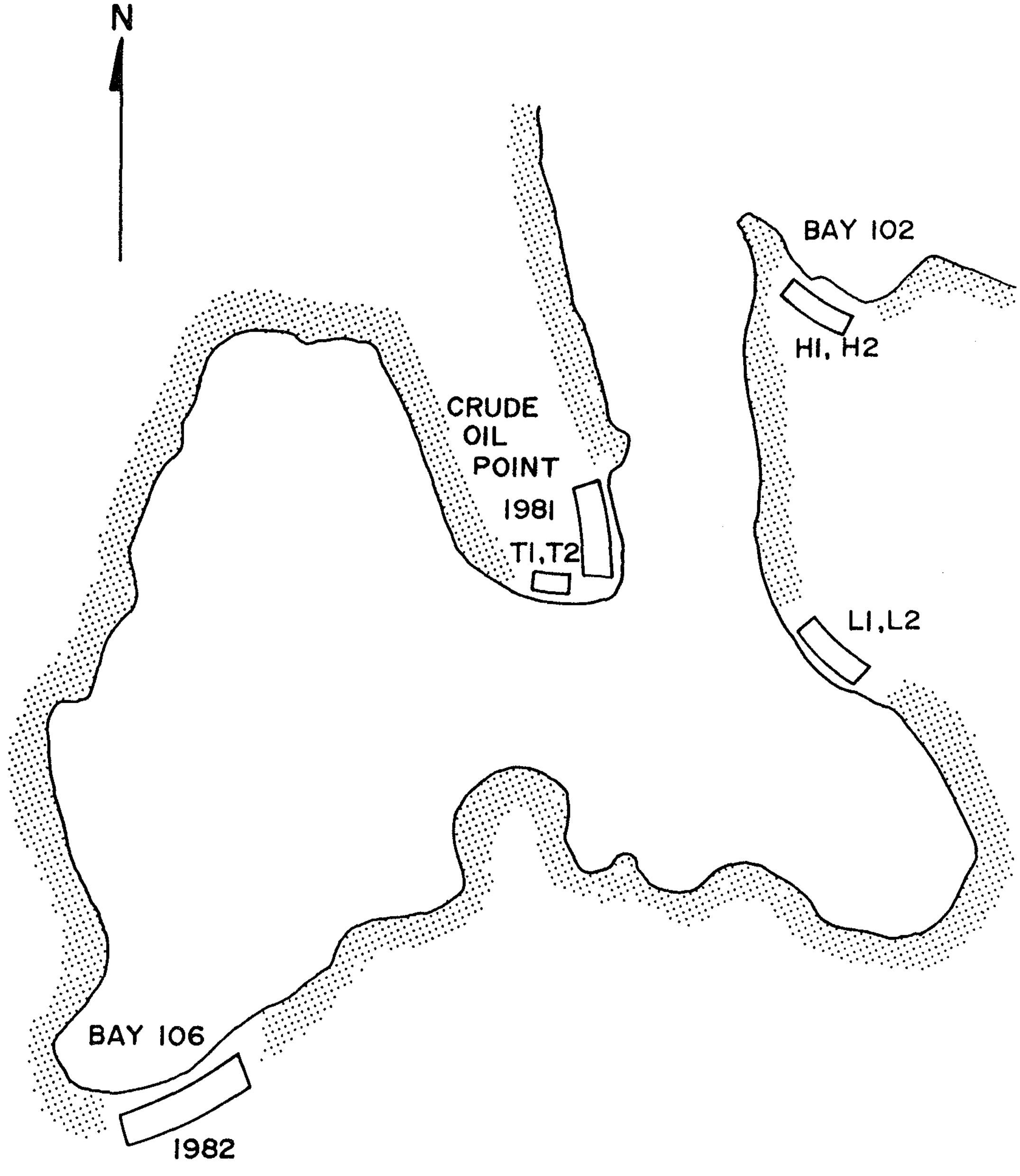

FIGURE 2·2 Z – LAGOON

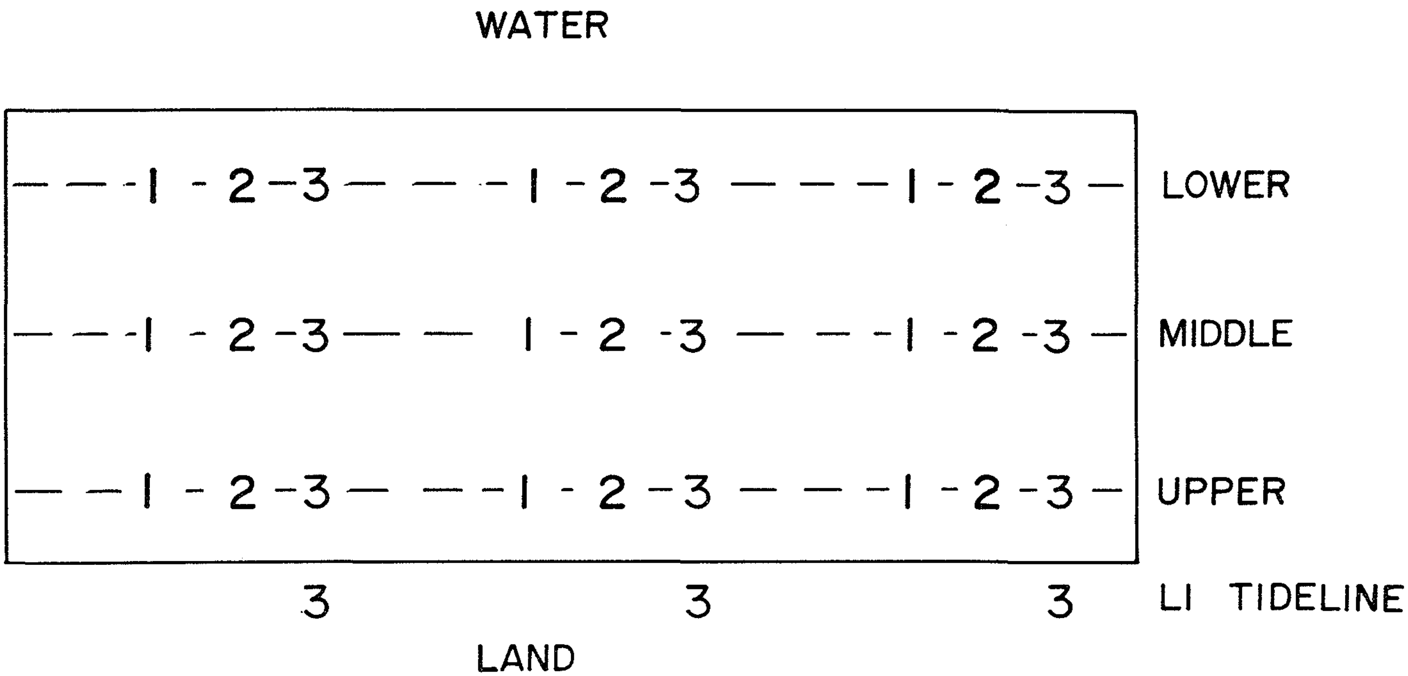

FIGURE 2·3

1980 CONTROL PLOTS H1, H2, L1, L2.

1. SAMPLED 82:08:10
2. SAMPLED 82:09:02
3. SAMPLED 83:08:20

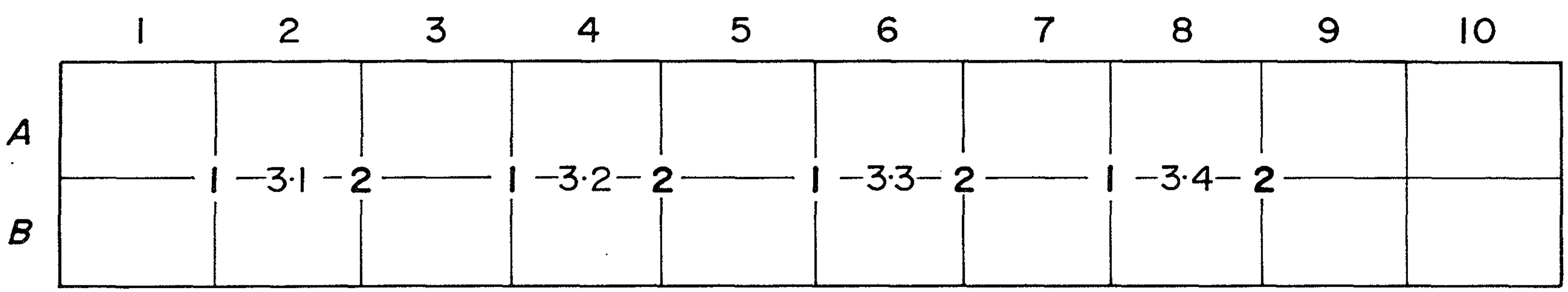

FIGURE 2·4

1981 PLOTS TI, T2.

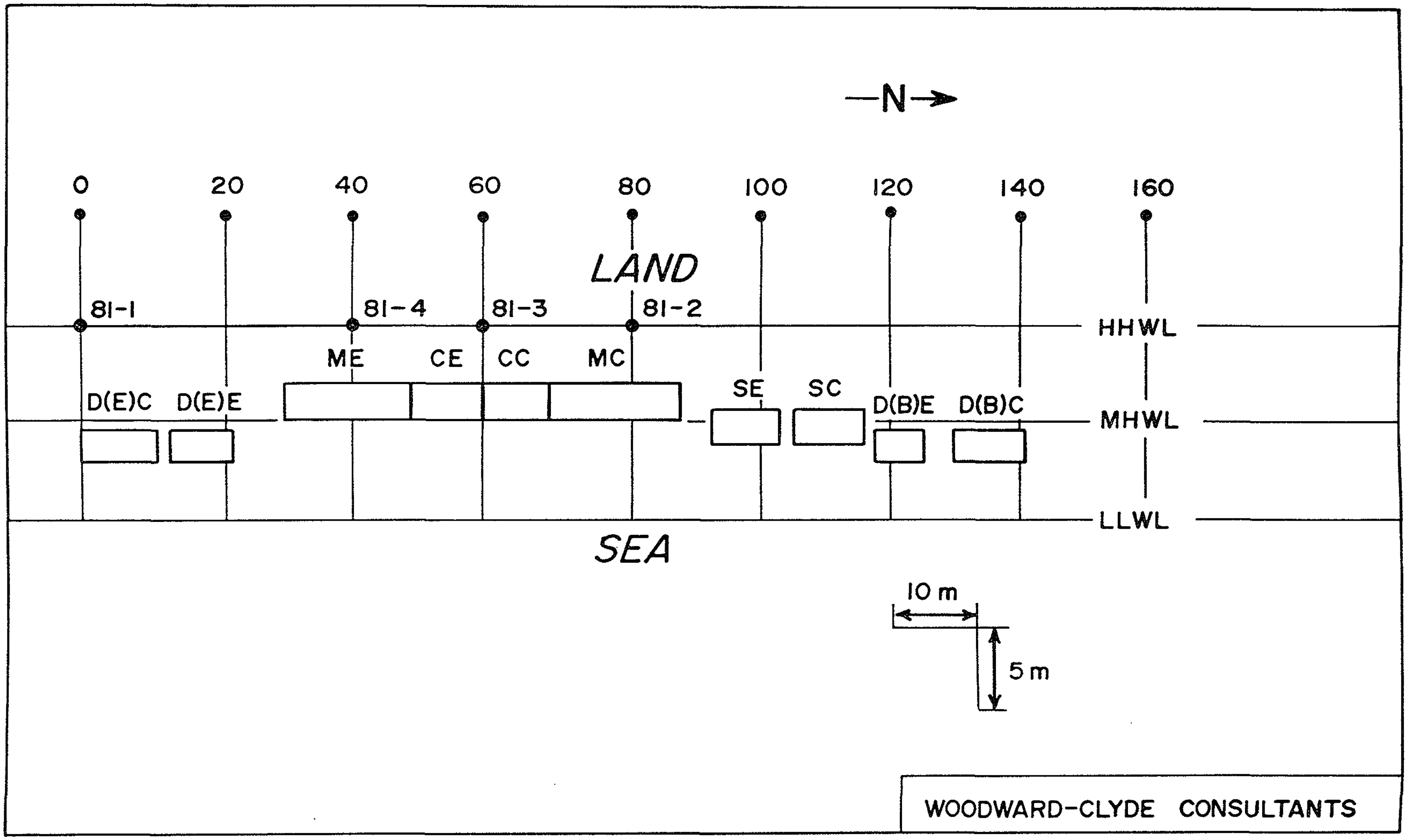

FIGURE 2·5 1981 PLOT LOCATIONS

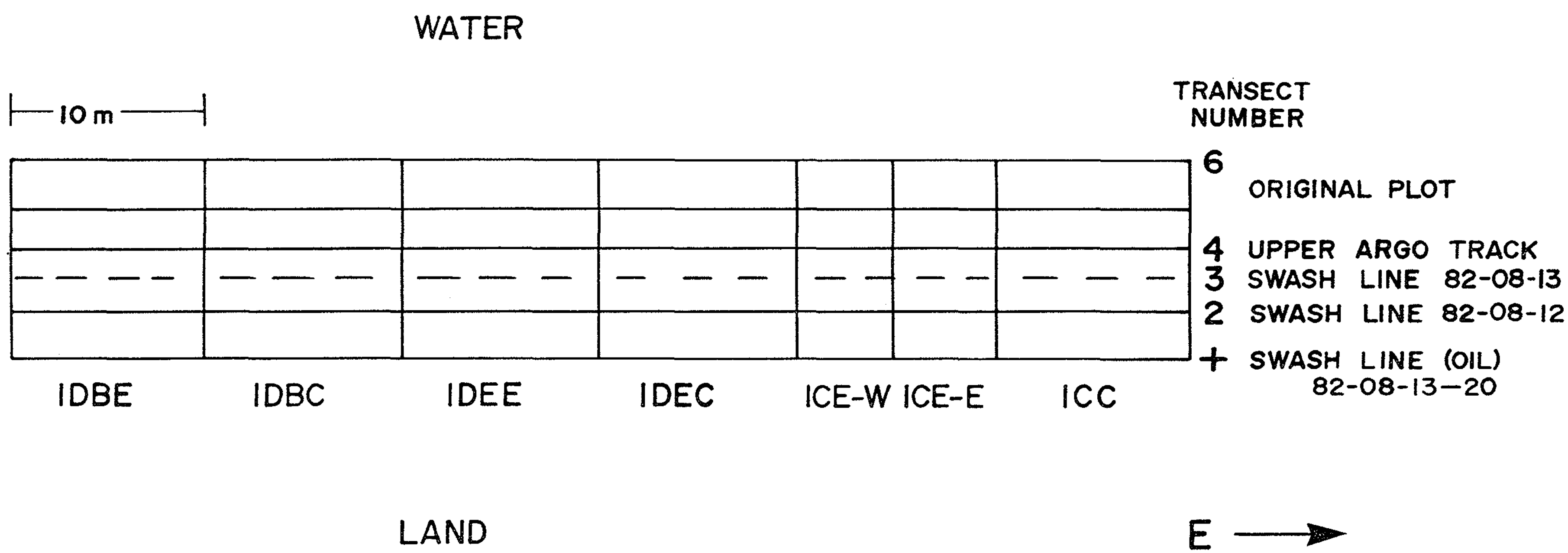

FIGURE 2·6

1982 INTERTIDAL PLOTS

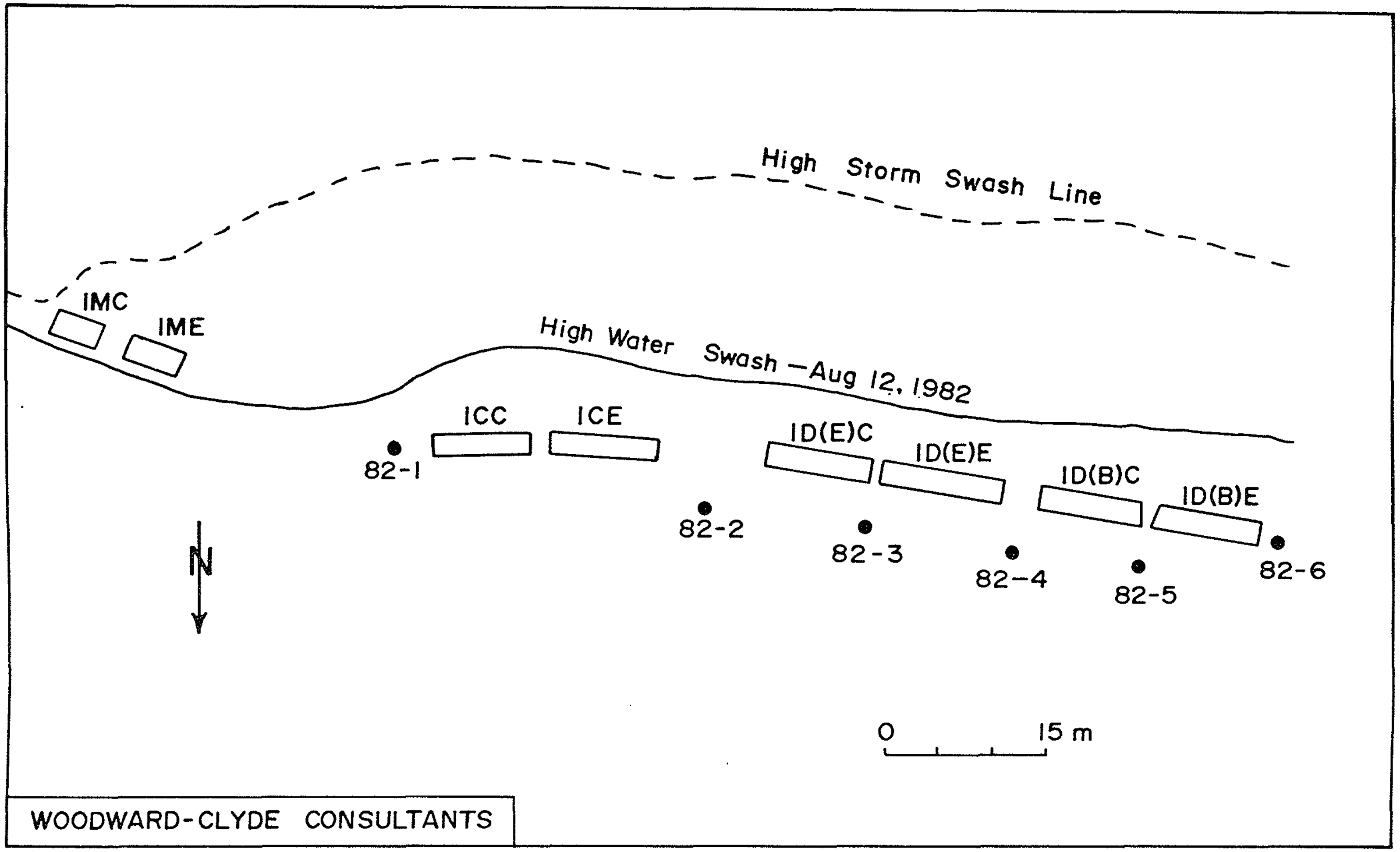

FIGURE 2·7 1982 PLOT POSITION

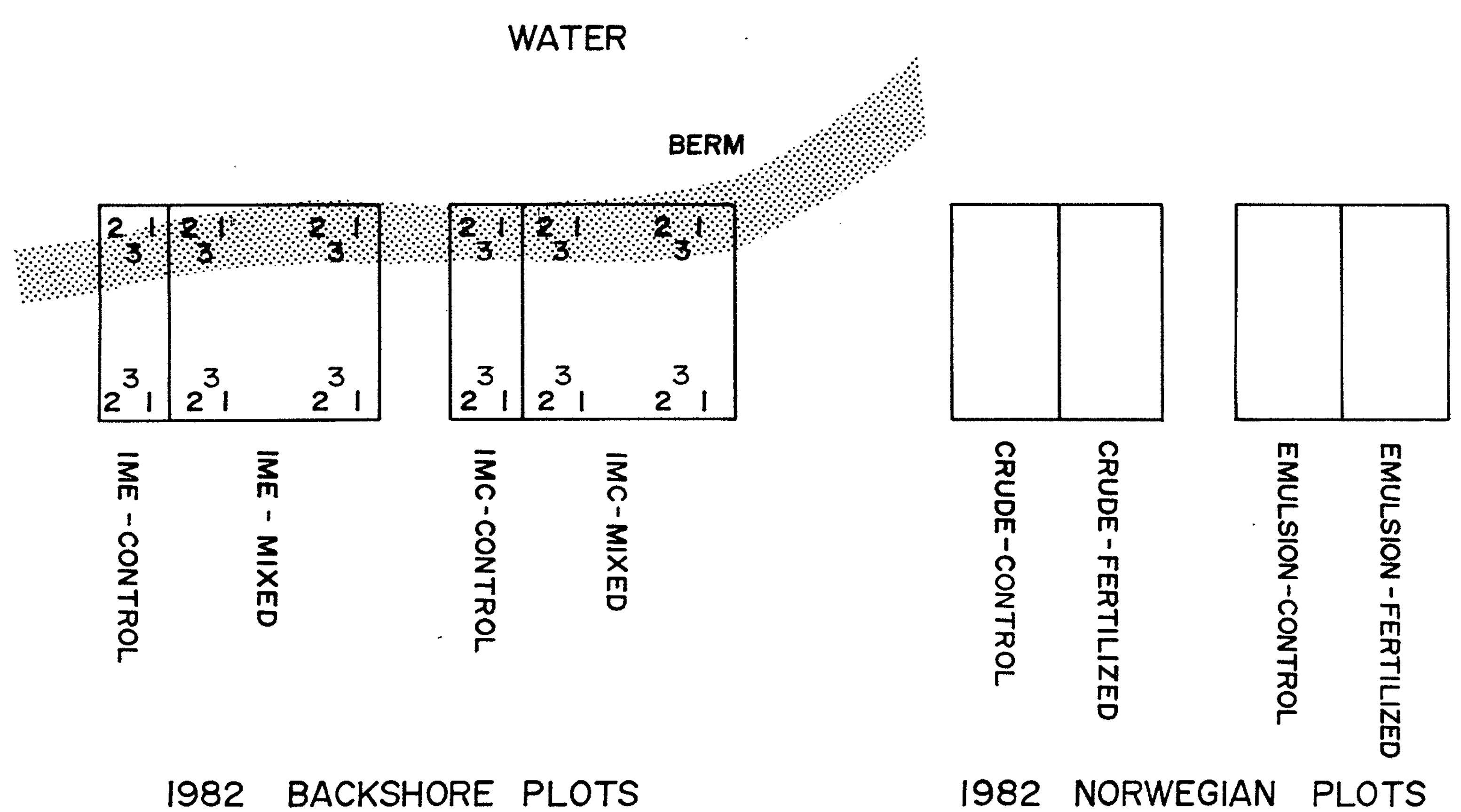
WATER
BERM
IME - CONTROL
IME - MIXED
IMC-CONTROL
IMC-MIXED
1982 BACKSHORE PLOTS
CRUDE-CONTROL
CRUDE-FERTILIZED
EMULSION-CONTROL
EMULSION-FERTILIZED
1982 NORWEGIAN PLOTS

FIGURE 2·8

Table 1: Experimental Plot Gas Chromatography Samples

	PLOT		DEPTH	DATE
1980	Bay 102 Oil Patch			83-08-17
	L1	UPPER	SURFACE	83-08-17
	L1	UPPER	SUB-SURFACE	83-08-17
	L1	LOWER	SURFACE	83-08-17
	L1	LOWER	SUB-SURFACE	83-08-17
	L2		SURFACE	83-08-17
	L2		SUB-SURFACE	83-08-17
	T1		SURFACE	83-08-17
	T1		SUB-SURFACE	83-08-17
	T2		SURFACE	83-08-17
	T2		SUB-SURFACE	83-08-17
1981	CC		SURFACE	83-08-17
	CC		SUB-SURFACE	83-08-17
	CE		SURFACE	83-08-17
	CE		SUB-SURFACE	83-08-17
	Crude Oil Point	X7	SURFACE	83-08-17
	Crude Oil Point	X8	SUB-SURFACE	83-08-17
1982	ICC		SURFACE	83-08-17
	ICC		SUB-SURFACE	83-08-17
	ICE		SURFACE	83-08-17
	ICE		SUB-SURFACE	83-08-17
	IDEC		SURFACE	83-08-17
	IDEC		SUB-SURFACE	83-08-17
	IDEE		SURFACE	83-08-17
	IDEE		SUB-SURFACE	83-08-17
	IDBC		SURFACE	83-08-17
	IDBC		SUB-SURFACE	83-08-17
	IDBE		SURFACE	83-08-17
	IDBE		SUB-SURFACE	83-08-17
	IMC-C	BERM	SURFACE	83-08-17
	IMC-C	BERM	SUB-SURFACE	83-08-17
	IMC-M	BERM	SURFACE	83-08-17
	IMC-M	BERM	SUB-SURFACE	83-08-17
	IMC-C	BACK	SURFACE	83-08-17
	IMC-C	BACK	SUB-SURFACE	83-08-17
	IMC-M	BACK	SURFACE	83-08-17
	IMC-M	BACK	SUB-SURFACE	83-08-17
	IME-C	BERM	SURFACE	83-08-17
	IME-C	BERM	SUB-SURFACE	83-08-17
	IME-M	BERM	SURFACE	83-08-17
	IME-M	BERM	SUB-SURFACE	83-08-17
	IME-C	BACK	SURFACE	83-08-17
	IME-C	BACK	SUB-SURFACE	83-08-17
	IME-M	BACK	SURFACE	83-08-17
	IME-M	BACK	SUB-SURFACE	83-08-17

2.2 RAGGED CHANNEL SHORELINES

2.2.1 Bay 11, Surface oil release

In 1981, on three occasions after the oil release on August 19, the beach in Bay 11 was sampled for hydrocarbon content. The beach was sampled at three levels relative to the tide. The upper level was just below the high tide mark, the lower level at the low tide line at that time, and the middle level was half way between the two. The samples were obtained from three profiles down the beach. No attempt was made to select "representative" samples, rather the sites were selected as points of a grid. Figures 2.9 and 2.10 identify these sites, which were marked with iron spikes. In 1982 and 1983, these sites were resampled with the addition of one more profile. The numbering of profiles has caused confusion throughout this project. The profiles were laid out in 1981; the three subsequent Seakem reports, including this report, are consistent, but incorrect in designations. Seakem Profiles 2,4,6 and 8 correspond to project Profiles 2,4,7 and 8. A number of additional samples were collected in areas selected subjectively to represent different beach areas. Those samples were:

11-1	Beach face, between Profiles 6 and 7
11-2	Flats, between Profiles 7 and 8
11-3	Flats, between Profiles 5 and 6
11-4	Flats, between Profiles 3 and 4
11-5	Ridge, low tide line, Profile 5
11-6	Ridge, see Profile 4 UP
11-7	Ridge, low tide line, Profile 6
11-8	Beach face, between Profiles 3 and 4
11-9	Beach face, base of northern rock boundary

Samples were taken from the surface and from the 5-10 cm subsurface layer. The samples were analysed separately, and the results listed in Section 4.2.

Additional samples were obtained for gas chromatographic analysis, with a view to identifying the weathering characteristics of the oil. Those samples are listed in Table 2.

2.2.2 Bay 9, Dispersed oil release

On August 27,1981, oil was released as a dispersion into the water column in Bay 9. No obvious stranding occurred, but the beach was sampled in the same manner as the Bay 11 beach. Figure 2.11 identifies the sites. The beach was resampled on one occasion in 1982, and some very low level petroleum hydrocarbons were observed by gas chromatography. As a result, the beach was sampled again in 1983, when both total hydrocarbon and gas chromatography samples were collected. The results of the total hydrocarbon analyses are listed in Section 4.2, the gas chromatography samples are listed in Table 2.

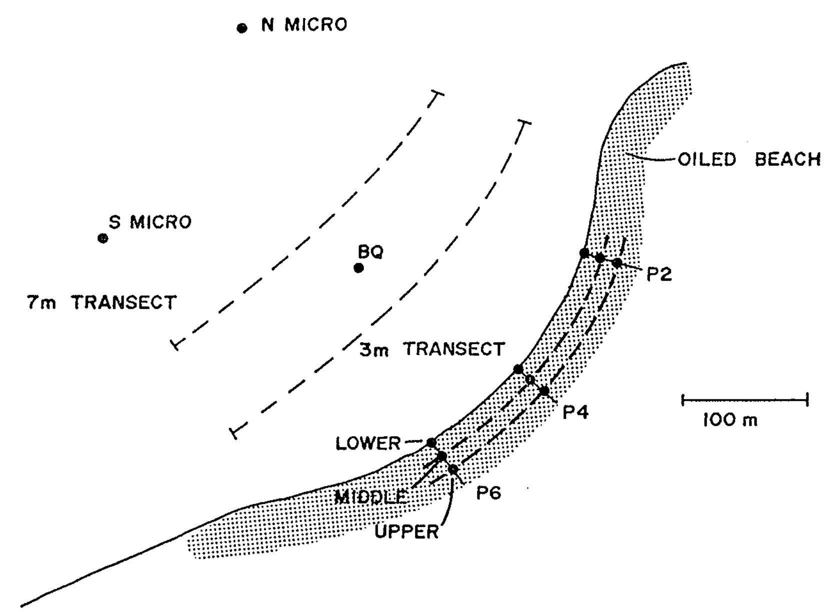

FIGURE 2·9
BAY 11

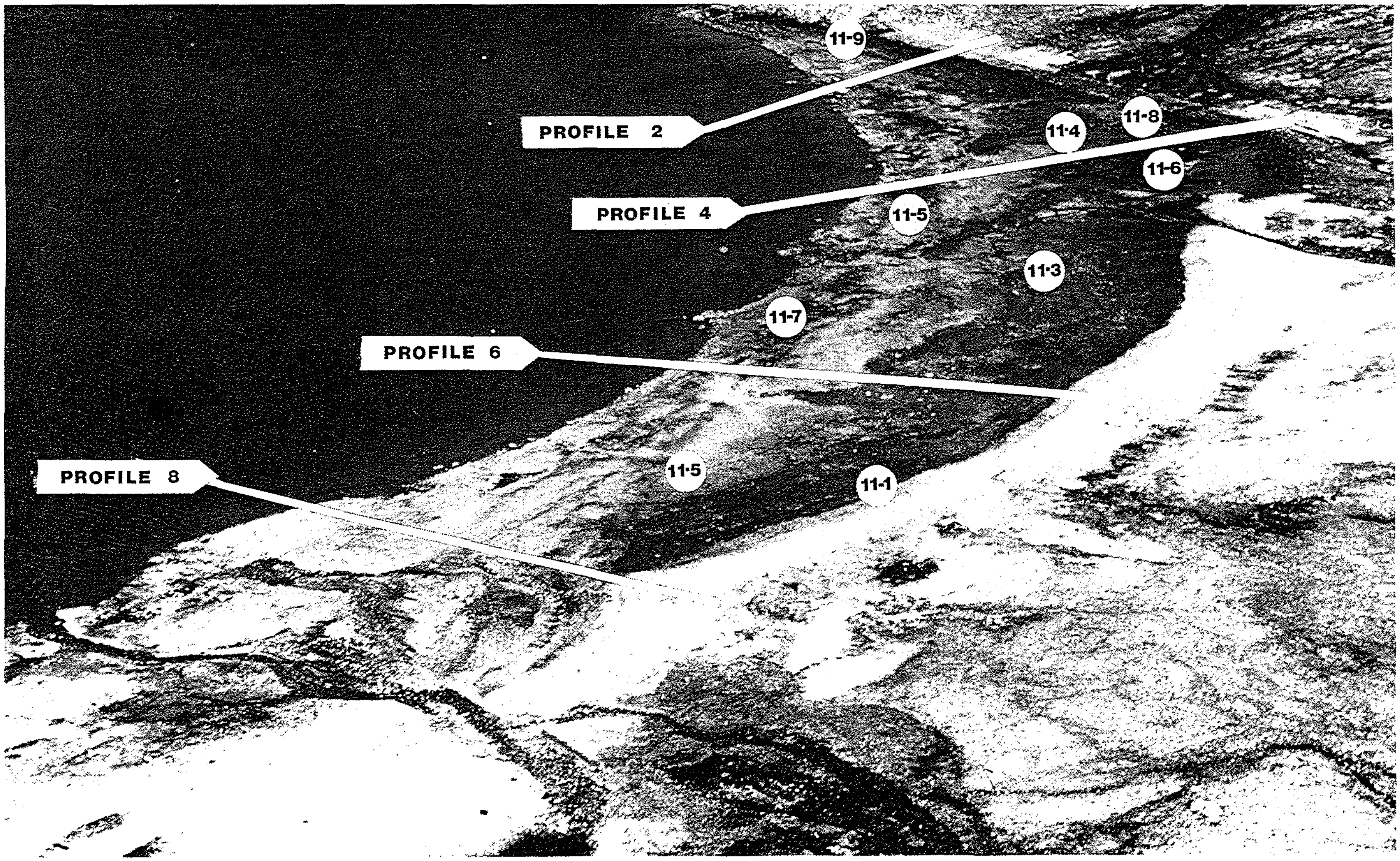

FIGURE 2·10 BAY II PROFILES

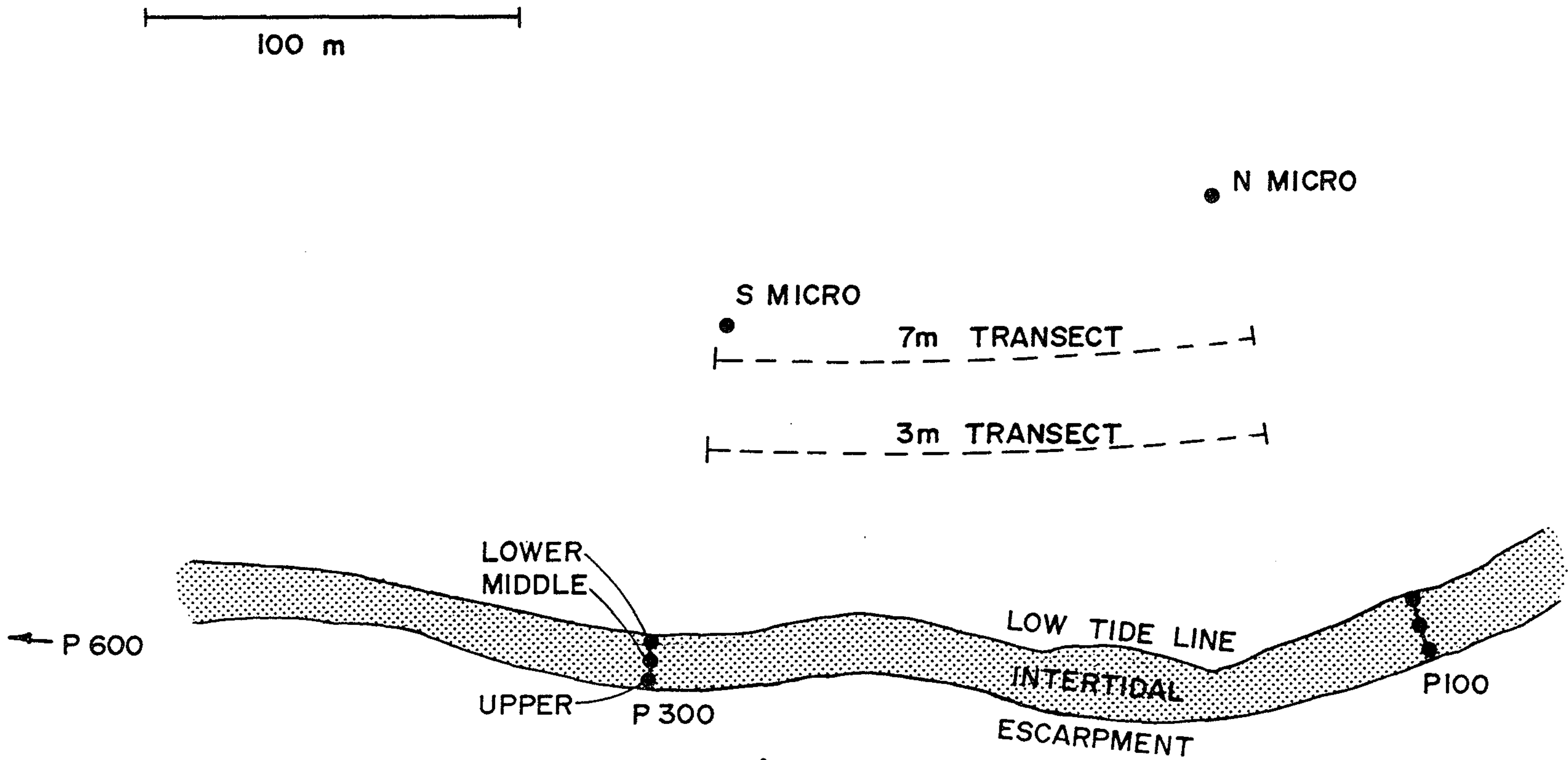

FIGURE 2·11

BAY 9

Table 2: Ragged Channel Shoreline Gas Chromatography Samples

PLOT		DEPTH	DATE
Bay 11	2, UP	SURFACE	83-08- 16
Bay 11	6, UP	SURFACE	83-08- 16
Bay 11	2, MID	SURFACE	83-08- 16
Bay 11	6, MID	SURFACE	83-08- 16
Bay 11	2, LOW	SURFACE	83-08- 16
Bay 11	6, LOW	SURFACE	83-08- 16
Bay 11	4, UP	SURFACE	83-08- 16
Bay 11	8, UP	SURFACE	83-08- 16
Bay 11	4, MID	SURFACE	83-08- 16
Bay 11	8, MID	SURFACE	83-08- 16
Bay 11	4, LOW	SURFACE	83-08- 16
Bay 11	8, LOW	SURFACE	83-08- 16
Bay 11	11-1	SURFACE	83-08- 16
Bay 11	11-2	SURFACE	83-08- 16
Bay 11	11-3	SURFACE	83-08- 16
Bay 11	11-4	SURFACE	83-08- 16
Bay 11	11-5	SURFACE	83-08- 16
Bay 11	11-1	SUB-SURFACE	83-08- 16
Bay 11	11-2	SUB-SURFACE	83-08- 16
Bay 11	11-3	SUB-SURFACE	83-08- 16
Bay 11	11-4	SUB-SURFACE	83-08- 16
Bay 11	11-5	SUB-SURFACE	83-08- 16
Bay 11	11-6	SUB-SURFACE	83-08- 16
Bay 9	100,UP	SURFACE	83-08- 10
Bay 9	100,UP	SUB-SURFACE	83-08- 10
Bay 9	100,MID	SURFACE	83-08- 10
Bay 9	100,MID	SUB-SURFACE	83-08- 10
Bay 9	100,LOW	SURFACE	83-08- 10
Bay 9	100,LOW	SUB-SURFACE	83-08- 10
Bay 9	300, UP	SURFACE	83-08- 16
Bay 9	300, UP	SUB-SURFACE	83-08- 16
Bay 9	300,MID	SURFACE	83-08- 10
Bay 9	300,MID	SUB-SURFACE	83-08- 10
Bay 9	300,LOW	SUB-SURFACE	83-08- 16
Bay 9	300,LOW	SURFACE	83-08- 10
Bay 9	600,MID	SURFACE	83-08- 10

2.3 SEAWATER AND LARGE VOLUME WATER SAMPLES

The results of the 1982 sea water analyses showed an inconsistency between the bulk water samples and the large volume water samples. In order to investigate this problem, the sea water sampling was tied directly to the LVWS sampling protocol.

Seawater samples were collected directly from the outlet of the LVWS pumping system after the sampler had been removed. They were collected in four 4 L glass jugs which had been baked clean before being sent to Cape Hatt. Each jug was extracted three times with 40 mL glass-distilled Freon 113 and the extracts combined. The extracts were evaporated to about 20 mL, dried, and stored in a freezer until analysis. If a jug was reused, it was dried with clean acetone then rinsed twice with glass-distilled Freon 113.

In 1980, a novel sampling system described by de Lappe and Risebrough (de Lappe et al, 1979) was used to collect samples for very low levels of hydrocarbons in sea water. In 1981 and 1982 this sampler was modified slightly to make it more easily handled and more consistent. In 1980 and 1981, the volumes passed through the sampler were not consistently measured because of the possibility of leaks at the sampler, which was under water and thus out of view. In 1982 the sampler was modified to have the sampler in view so that leaks could be checked. The sampler as it was used in 1982 and 1983 appears in Figure 2.11.

The samples consisted of a glass fiber filter paper (Gelman type AE) containing particulate matter and a tube packed with 6 polyurethane foam plugs containing dissolved organic matter. These plugs, about 2.5 x 5 cm each, were cut from polyurethane foam and cleaned by continuous extraction with a 1:1 acetone:hexane mixture for 72 hours, the solvent being changed every 24 hours. Both filters and columns were wrapped in baked aluminum foil and frozen until analysis.

2.3.1 Bay 11, Surface oil release

During and after the surface oil release in 1981, samples of seawater were collected to identify the movement of oil into the water column. During the release, continuous pumped fluorometery monitored three depths in the experimental area. After the release, water was sampled at various depths for three weeks. In 1982, samples were collected at some of the same stations as the previous year. The results of the analyses of the water and LVWS samples were inconsistent. In 1983, therefore, samples of both types were collected from both 1 m and 10 m on six occasions at the south Micro station in Bay 11 (see Figure 2.9).

2.3.2 Bay 7, Reference

It became apparent from the physical oceanographic measurements made in 1980 and 1981 that both Bays 9 and 10 would be impacted by dispersed oil, so Bay 7 to the south was selected as an alternative control bay. Samples were taken in 1981 as part of the microbiology studies. In 1982, this was repeated, and some LVWS samples collected. In 1983, samples of both types were collected from 5 m at the north Micro station (see Figure 2.12).

2.3.3 Other samples

To monitor the water in areas remote from the experimental areas, samples of both types were collected in Ragged Channel and in Milne Inlet, once near the southern mouth of Ragged Channel, and once at the location of the control animal collections on the west side of Ragged Island, all at 5 m. The inset of Figure 2.1 shows the location of these sites.

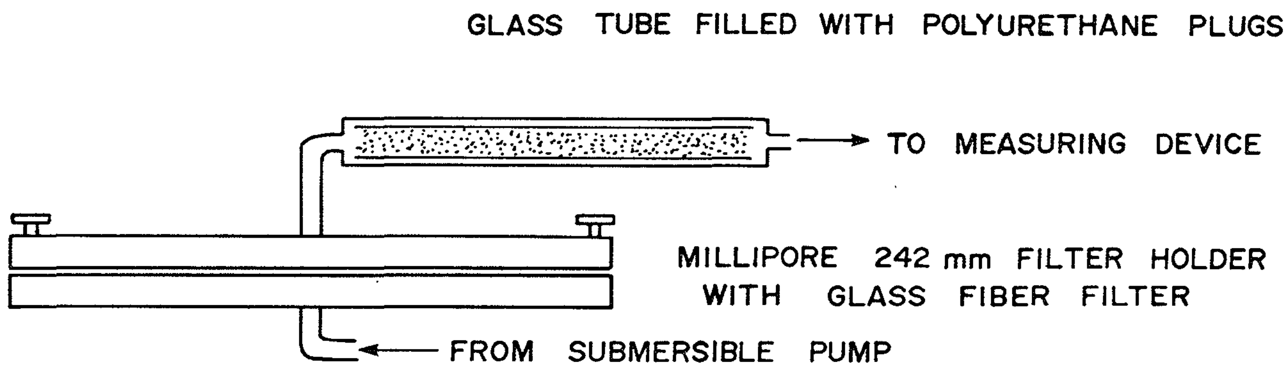

FIGURE 2·12

LARGE VOLUME WATER SAMPLER

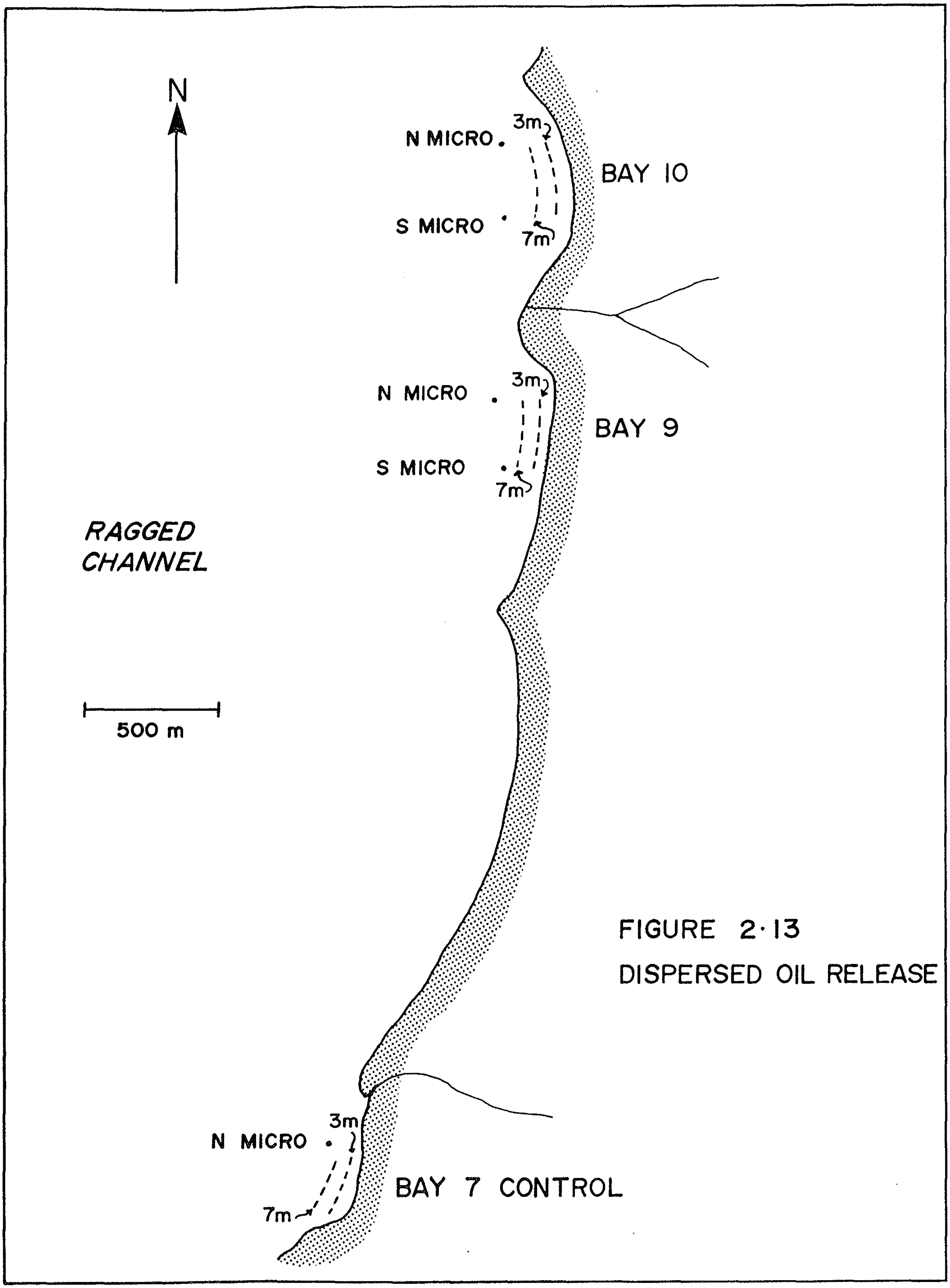

FIGURE 2·13
DISPERSED OIL RELEASE

2.4 BOTTOM SEDIMENTS

Bottom sediments have been taken in all four years of the project. In 1981, the experimental areas were layed out in a consistent pattern in all four bays. Figure 2.13 outlines the pattern for plots in a bay.

The samples were collected in 8 oz wide mouth jars by divers. The jars were sent to the bottom closed, in a jar holder. The diver removed the lid, used the jar to scrape sediment from the 0-2 cm layer into the jar, closed it, and returned it to the surface. A Teflon liner was placed under the lid and the sample frozen until analysis.

2.4.1 Tissue plot sediments

In 1981, before and after the experimental spills, the tissue plots were sampled for hydrocarbons in the sediments. Each plot was sampled once before the release and twice after, close to the times the animals were being taken from the same plots. In 1982, samples were taken in the five tissue plots at the 7 m depth only in each bay. In 1983, these sites were resampled, and the 3 m plots in Bay 11 included. To collect the samples, a diver would follow the benthic transect line to the distance corresponding to the center of the tissue plot, swim 5 m seaward, and collect the required samples from close to the center of the plot, in an arbitrary fashion. The number of samples taken in each plot is marked in the corresponding box in Figure 2.13. Where more than one sample was collected in a plot, all were taken from the same location and no distinction was made between samples.

As a control experiment, samples were collected from the control animal collection area on the west side of Ragged Island.

2.4.2 Benthic plot sediments

In 1981, additional samples were taken from the benthic plots in each bay late in the season. In 1982 and 1983 this was repeated at all benthic plots in each bay. The number of samples from each plot is indicated in Figure 2.13. The samples were taken at predetermined random distances along the benthic transect, but the 1982 samples were not identified as to location within each plot. In 1983, the location of each sample was recorded.

2.4.3 Deep sediments

In 1982, four samples of sediment from 15 m depth were collected in Bays 9 and 11, slightly deeper than, but close to, the Micro stations. In

1983, samples were collected using a modified van Veen grab sampler from about 35 m in depth. These samples were collected from half way between Bays 11 and 12, in the deepest part of the bay, in what may be a sink for any sediment which is transported by the gyre observed by current measurements in 1980 (de Lange Boom, personal communication). The location of this site is shown in Figure 2.1.

2.5 FLOC SAMPLES

The very light, newly settled layer of sediment is of particular interest in this project. Called "floc", this material may contain the bulk of the oiled material entering the sediments from the water column. In order to sample this material, an underwater filtering apparatus was developed (Figure 2.15). This device was operated by divers. It was sent down to the diver with a fresh glass fiber filter in the bypass position. When the diver was in place, he directed the pumped water through the filter and sucked up the loose surface material in a 1 m^2 area in the tissue plot as identified in Figure 2.13. The filter was then bypassed and the sampler returned to the surface. The filter was wrapped in baked aluminum foil and frozen until analysis.

In 1981, samples were taken from all tissue plots in all four bays. In 1982 and 1983, samples were taken from all tissue plots in Bay 11 only.

2.6 CORES

Sediment cores were collected in 1982 and 1983. In 1983, divers obtained cores at each end of the biology transects in Bay 11. The samples were collected using hand corers. Each sample was frozen in the sampler immediately after collection. Samplers were warmed to facilitate removal of the core, the core was cut into sections of 5 cm lengths, placed in baked 8 oz jars, which were sealed with Teflon and kept frozen until analysis.

The nature of the samplers and the sediments precluded obtaining complete samples from all locations. The samples collected were:

Date	Bay 11	0-5 cm	5-10 cm	10-15 cm
83-08-20	N 7 m	x	x	x
83-08-20	S 7 m	x	x	NS
83-08-20	N 3 m	x	x	x
83-08-20	S 3 m	x	x	NS

[NS = no sample]

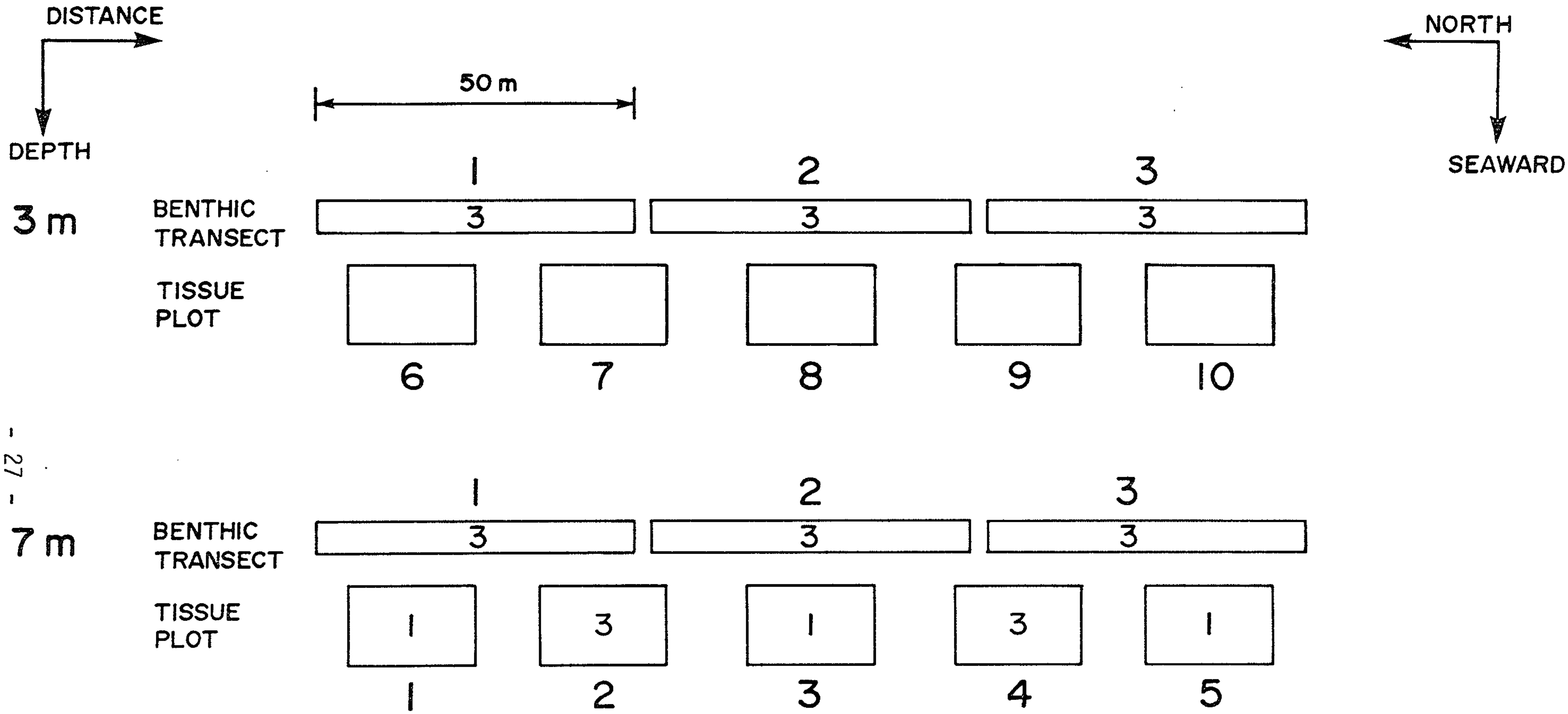

FIGURE 2·14

BOTTOM SEDIMENT PLOTS

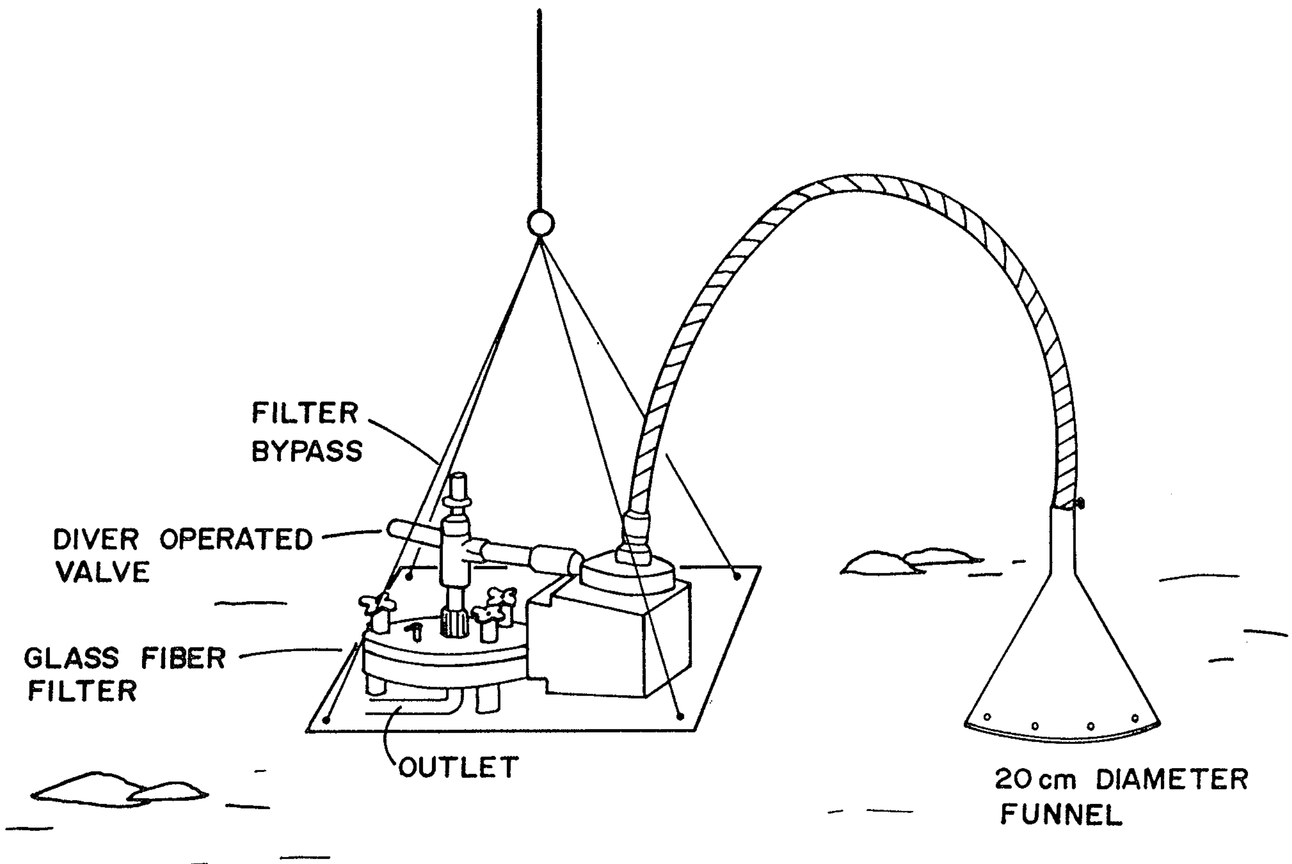

FIGURE 2·15

FLOC SAMPLER

2.7 TISSUE SAMPLES

Over the four years of the project, many animals have been collected for hydrocarbon content analysis. In 1980, seven animal and three plant species were collected. In 1981, six animal species were collected, of which three had been collected in 1980. In 1982 and 1983, five animal species were collected, all of which had been collected in 1981, and three of which had been collected in 1980.

The animals were collected by divers. *Astarte* and *Strongylocentrotus* were hand picked at all times, all the others were usually sampled using an airlift technique, although *Serripes* was hand picked if found on the surface. The samples were taken from anywhere within the 7 m tissue plots in each bay (Figure 2.13). When the samples were brought ashore, they were sorted according to species. Ten animals of each species from each plot were wrapped in aluminum foil and frozen until analysis.

A suite of animals was collected from the control animal collection area on the west side of Ragged Island.

The species collected in 1983 were:

Astarte borealis
Mya truncata
Macoma calcarea
Serripes groenlandia
Strongylocentrotus droebrachiensis

3. ANALYTICAL METHOD

Shoreline sediments have been analysed for total hydrocarbon in all three years of the project. The method of analysis has changed each year to reflect the changing program.

In 1980, much of the analysis was to determine baseline levels of hydrocarbon in the beach sediments. In consequence, a precise but time-consuming method was used. The detection limit for this method was 0.25 mg/kg (Green 1981).

In 1981, in response to the need for the analysis of large numbers of samples to reduce the problem of sampling a large plot, subsamples were taken in a number of sites within a plot. Some sites were composited before extraction, and composited again after extraction with samples from other sites in the same plot. Over three hundred samples were analysed in 1981 (Green et al, 1982).

Carbon tetrachloride was used as solvent in 1981, as it is the most effective solvent available for the determination of oils by IR. The ventilation conditions in the laboratory at Cape Hatt were found to be inadequate for using a toxic solvent of this nature.

In 1982, the solvent was changed to the less toxic Freon 113, for safety reasons. The procedure remained the same, with the exception that the amount of extract used for ultimate analysis depended on the visual appearance of the extract.

3.1 EXTRACTION PROCEDURE

Between 0.5 and 2.0 kg of beach sediment were placed in a Teflon extraction jug with a Teflon lid. About 0.2 kg of Freon 113 was added and the sample shaken on a paint shaker for 5 minutes. If the extract showed visible oil content, a 4 mL aliquot was transfered to a small break-neck ampoule which was then sealed in a flame. If there was no visible oil in the extract, two 20 mL aliquots were transferred to two large break-neck ampoules. The weight of each aliquot was recorded.

When very highly oiled samples were extracted, some dark precipitate remained in the extraction jug. This was not the case when CCl_4 was used. This material was soluble in CCl_4. A solution of this material in CCl_4, which was opaque to visible light, was analysed in the same manner as the extracts. No CH_2 absorption at 2850 cm^{-1} was observed. As the analytical method is based on this CH_2 absorption it was felt that the change to Freon 113 would not bias the results relative to the CCl_4 extraction method.

3.2 ANALYSIS

The analysis of oil by Infra-red absorption is based on the CH_2 absorption at 2850 cm^{-1}. A calibration curve based on the absorption of Lago medio standard solutions was used to determine the concentration of the sample.

Sample extracts that were visibly very concentrated were diluted gravimetrically before analysis. Samples that were visibly dilute were concentrated by gentle evaporation with a stream of dry nitrogen before analysis.

The extracts were analysed on a Perkin-Elmer 337 Infra-red Spectrometer. This instrument has adjustable slits and scan speeds.

Daily calibrations were done using seven standard Lago medio crude solutions in Freon 113. The concentrations of the standards varied from 100 mg/kg to 2000 mg/kg. The corresponding peak heights varied from 12 mm to 102 mm. The standard error of the absorption of the standards over 21 days of analysis was 1 mm at all concentrations. A second order regression curve was determined each day. The sample concentrations were calculated from this curve.

Based on a 15x concentration of dilute extracts, the detection limit is 30 mg/kg (0.003%), defined as a signal height three times the width of the noise, with a precision of 10 mg/kg (0.001%). At higher concentrations, the precision of the analysis is 1% of value, based on the measurement precision of the absorption.

4. RESULTS

4.1 SHORELINE TOTAL HYDROCARBON ANALYSES

The results of the shoreline analyses for all years of the project are given in the following pages. The results are reported to two significant figures only. The validity of the results as a measure of the oil content of a plot or a beach does not depend on the precision of the analyses, but on the consistency of the coverage. This point will be discussed later.

In the following tables the entries tr and 0 refer to extracts with no measurable hydrocarbon but visible colour (tr) and to no measurable hydrocarbon and no colour (0).

4.1.1 1980 SHORELINE COUNTERMEASURE CONTROL PLOTS

Table 3 **High energy shoreline; aged crude Plot H1**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Plot	80-08-23	0	3.6	1.2
Plot	80-08-25	2	0.007	0.33
Plot	80-08-27	4	0.009	0.67
Plot	80-08-31	8	0.12	1.0
Plot	81-07-28	339	.008	.008
Plot	81-08-29	371	0	0
Plot	82-08-10	717	0	0
Plot	82-09-02	740	0	0
Plot	83-08-20	1092	0	0
Oil patch	"	1092	0.13	

Table 4 **High energy shoreline; emulsion Plot H2**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Plot	80-08-23	0	1.4	1.1
Plot	80-08-25	2	0.001	0.001
Plot	80-08-27	4	0.004	0.005
Plot	80-08-31	8	0	0
Plot	81-07-28	339	0	0
Plot	81-08-29	371	0	0
Plot	82-08-10	717	0	0
Plot	82-09-02	740	0	0
Plot	83-08-20	1092	0	0

Table 5 **Low energy shoreline; aged crude Plot L1**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Upper	80-08-21	0	0.67	0.88
Middle	"	0	0.87	1.30
Lower	"	0	3.6	2.5
Plot	**"**	**0**	**1.7**	**1.6**
Upper	80-08-23	2	0.46	0.80
Middle	"	2	0.47	0.009
Lower	"	2	0.61	0.69
Plot	**"**	**2**	**0.51**	**0.50**
Upper	80-08-25	4	0.45	0.77
Middle	"	4	0.25	0.94
Lower	"	4	0.47	0.47
Plot	**"**	**4**	**0.39**	**0.72**
Upper	80-08-29	8	0.57	1.26
Middle	"	8	0.77	1.83
Lower	"	8	0.60	1.08
Plot	**"**	**8**	**0.64**	**1.39**
Upper	81-07-28	341	0.48	0.58
Middle	"	341	0.29	0.75
Lower	"	341	0.65	0.18
Plot	**"**	**341**	**0.47**	**0.50**
Upper	81-08-29	373	0.25	0.53
Middle	"	373	0.11	0.47
Lower	"	373	0.13	0.45
Plot	**"**	**373**	**0.16**	**0.48**
Upper	82-08-10	719	0.22	1.57
Middle	"	719	0.18	0.98
Lower	"	719	0.55	0.30
Plot	**"**	**719**	**0.32**	**0.95**
Upper	82-09-02	742	0.26	0.85
Middle	"	742	1.2	1.3
Lower	"	742	0.044	0.38
Plot	**"**	**742**	**0.49**	**0.85**
Upper	83-08-20	1094	0.12	2.3
Middle	"	1094	0.028	0.19
Lower	"	1094	0.040	0.073
Plot	**"**	**1094**	**0.06**	**0.85**
Tideline(upper)	"	1094	0.15	0.11

Table 6 **Low energy shoreline; emulsion Plot L2**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Upper	80-08-21	0	0.19	0.050
Middle	"	0	0.45	0.22
Lower	"	0	0.37	-
Plot	**"**	**0**	**0.34**	**0.13**
Upper	80-08-23	2	0.021	0.011
Middle	"	2	0.034	0.001
Lower	"	2	0.014	0.005
Plot	**"**	**2**	**0.023**	**0.006**
Upper	80-08-25	4	0.008	0.002
Middle	"	4	0.034	0.001
Lower	"	4	0.006	0.001
Plot	**"**	**4**	**0.016**	**0.001**
Upper	80-08-29	8	0.037	0.002
Middle	"	8	0.001	0.016
Lower	"	8	0.001	0.005
Plot	**"**	**8**	**0.013**	**0.008**
Upper	81-07-28	341	0.007	tr
Middle	"	341	0.029	0.013
Lower	"	341	0.005	0.007
Plot	**"**	**341**	**0.014**	**0.010**
Upper	81-08-29	373	0.017	0.019
Middle	"	373	0.017	0.016
Lower	"	373	0.010	0.013
Plot	**"**	**373**	**0.015**	**0.016**
Upper	82-08-10	719	0	0
Middle	"	719	0	0
Lower	"	719	0.023	0
Plot	**"**	**719**	**0.008**	**0**
Upper	82-09-02	742	0	0
Middle	"	742	0.004	0
Lower	"	742	0	0
Plot	**"**	**742**	**0.001**	**0**
Upper	83-08-20	1094	0.002	0
Middle	"	1094	0	0
Lower	"	1094	0	0
Plot	**"**	**1094**	**0**	**0**

Table 7 **Backshore control; aged crude Plot T1**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Mean	80-08-20	0	4.0	2.3
Mean	80-08-22	2	5.8	3.0
Composite	80-08-24	4	3.4	3.0
Composite	80-08-28	8	6.6	1.7
Composite	81-07-28	342	2.8	2.4
Composite	81-08-29	374	3.4	2.1
Composite	82-08-10	720	2.8	1.6
Composite	82-09-02	743	2.9	1.5
T1-1	83-08-20	1095	1.0	0.67
T1-2	"	1095	0.87	0.87
T1-3	"	1095	0.64	0.95
T1-4	"	1095	1.0	1.3
Plot	**"**	**1095**	**0.88**	**0.95**

Table 8 **Backshore control; emulsion Plot T2**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Mean	80-08-20	0	1.3	1.5
Mean	80-08-22	2	2.0	2.7
Composite	80-08-24	4	1.3	1.3
Composite	80-08-28	8	6.0	5.8
Composite	81-07-28	342	1.4	2.1
Composite	81-08-29	374	1.6	1.8
Composite	82-08-10	720	1.7	1.7
Composite	82-09-02	743	1.8	1.4
T2-1	83-08-20	1095	2.1	0.84
T2-2	"	1095	2.4	1.0
T2-3	"	1095	2.8	0.47
T2-4	"	1095	1.7	0.057
Plot	**"**	**1095**	**2.3**	**0.59**

4.1.2 1981 SHORELINE COUNTERMEASURE PLOTS

Table 9 **1981 Control; aged crude Plot CC**

Sample Description	Date	Day	Total hydrocarbon %	
			Surface	Subsurf.
Composite	81-08-14	8	1.7	0.15
Composite	81-09-16	41	0.31	0.015
Composite	82-08-10	369	0.030	0.34
Composite	82-09-02	392	0.008	0.022
Composite	83-08-20	744	0.002	0.043

Table 10 **1981 Control; emulsion Plot CE**

Sample Description	Date	Day	Total hydrocarbon %	
			Surface	Subsurf.
Composite	81-08-14	8	-	0.038
Composite	81-09-16	41	0.093	0.011
Composite	82-08-10	369	0.009	0.039
Composite	82-09-02	392	0.050	0.030
Composite	83-08-20	744	0.002	0.019

Table 11 **1981 Mixing; aged crude Plot MC**

Sample Description	Date	Day	Total hydrocarbon %	
			Surface	Subsurf.
Pretest Comp.	81-08-06	0	2.1	0.30
Posttest Comp.	81-08-06	0	2.8	1.0
Composite	81-08-14	8	0.50	1.6
Composite	81-09-16	41	1.9	0.19
Composite	82-08-10	369	0.016	0.13
Composite	82-09-02	392	0.014	0.23
Composite	83-08-20	744	0.003	0.32

Table 12 **1981 Mixing; emulsion Plot ME**

Sample Description	Date	Day	Total hydrocarbon % Surface	Total hydrocarbon % Subsurf.
Pretest Comp.	81-08-06	0	1.2	0.11
Posttest Comp.	81-08-06	0	2.1	0.029
Composite	81-08-14	8	1.9	0.031
Composite	81-09-16	41	0.19	0.019
Composite	82-08-10	369	0.023	0.017
Composite	82-09-02	392	0.010	0.045
Composite	83-08-20	744	0.002	0.008

Table 13 **1981 Exxon dispersant; aged crude Plot D[E]C**

Sample Description	Date	Day	Total hydrocarbon % Surface	Total hydrocarbon % Subsurf.
Pretest Comp.	81-08-07	0	2.5	0.03
Posttest Comp.	81-08-07	0	0.61	0.59
Composite	81-08-14	7	0.044	0.24
Composite	81-09-16	40	0.036	0.017
Composite	82-08-10	368	0.008	0.090
Composite	82-09-02	391	0.009	0.005
Composite	83-08-20	743	0.002	0.002

Table 14 **1981 Exxon dispersant; emulsion Plot D[E]E**

Sample Description	Date	Day	Total hydrocarbon % Surface	Total hydrocarbon % Subsurf.
Pretest Comp.	81-08-07	0	2.4	0.015
Posttest Comp.	81-08-07	0	2.0	0.051
Composite	81-08-14	7	0.24	0.029
Composite	81-09-16	40	0.033	tr
Composite	82-08-10	368	0.013	0.017
Composite	82-09-02	391	0.037	0.026
Composite	83-08-20	743	0	0.012

Table 15 **1981 BP dispersant; aged crude Plot D[B]C**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Pretest Comp.	81-08-07	0	0.43	-
Posttest Comp.	81-08-07	0	1.0	0.31
Composite	81-08-15	8	tr	0.32
Composite	81-09-16	40	tr	tr
Composite	82-08-10	368	0	0.003
Composite	82-09-02	391	0	0
Composite	83-08-20	743	0	0

Table 16 **1981 BP dispersant; emulsion Plot D[B]E**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Pretest Comp.	81-08-07	0	0.74	0.007
Posttest Comp.	81-08-07	0	0.27	0.44
Composite	81-08-15	8	0.007	0.008
Composite	81-09-16	40	tr	tr
Composite	82-08-10	368	0	0
Composite	82-09-02	391	0	0
Composite	83-08-20	743	0	0

Table 17 **1981 Experimental Plots; Berm Samples**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
81-1	83-08-20	743	0.009	0.011
81-2	"	743	0.044	0.017
81-3	"	743	0.12	0.011
81-4	"	743	0.068	0.021

4.1.3 1982 SHORELINE COUNTERMEASURE PLOTS

Table 18 **1982 Control; aged crude Plot ICC**

Sample Description	Date	Day	Total hydrocarbon % Surface	Total hydrocarbon % Subsurf.
Oil laying	82-08-12	-1	1.5	
Pretest T6	82-08-13	0	0.15	0.004
Pretest T4	"	0	0.016	0
Pretest T2	"	0	1.1	0.005
Pretest	**"**	**0**	**0.42**	**0.003**
T6	82-08-20	7	0.52	0
T4	"	7	0.010	0
T3	"	7	0.062	0
T2	"	7	0.69	0
T1	"	7	-	0
Plot	**"**	**7**	**0.26**	**0**
T6	82-09-15	33	0.21	0
T4	"	33	0.062	0
T3	"	33	0.065	0.042
T2	"	33	0.020	0.005
T1	"	33	0.040	0.005
Plot	**"**	**33**	**0.080**	**0.01**
T6	83-08-20	372	0.038	0.002
T4	"	372	0.021	0.002
T3	"	372	0.013	0.011
T2	"	372	0.91	0.025
T1	"	372	0.007	0.003
Plot	**"**	**372**	**0.020**	**0.009**

Table 19 **1982 Control; emulsion Plot ICE**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
EAST				
Pretest	82-08-13	0	0.28	0)
Posttest	82-08-14	1	1.1	0.003)
Plot	82-08-20	7	1.0	0)
Plot	82-09-15	33	0.59	0.018)
WEST				
Pretest	82-08-13	0	0.278	0.003)
Posttest	82-08-14	1	0.24	0.004)
Plot	82-08-20	7	0.12	0)
Plot	82-09-15	33	0.20	0.12)
COMBINED				
T6	83-08-20	372	0.78	0.044
T4	"	372	0.14	0.004
T3	"	372	0.045	0.016
T2	"	372	0.13	0
T1	"	372	0.003	0
Plot	**"**	**372**	**0.22**	**0.013**

Table 20 **1982 Exxon dispersant; aged crude Plot ID[E]C**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Oil laying	82-08-12	-1	0.409	
Pretest T6	82-08-13	0	0.44	0.54
Pretest T4	"	0	0.007	0
Pretest T2	"	0	2.1	0.003
Pretest	**"**	**0**	**0.85**	**0.18**
Posttest T6	82-08-14	1	0.042	0.046
Posttest T4	"	1	0.013	0
Posttest T3	"	1	0.20	0
Posttest T2	"	1	0.88	0
Posttest T1	"	1	0.008	0
Posttest	**"**	**1**	**0.23**	**0.009**
T6	82-08-20	7	0.012	0
T4	"	7	0.026	0
T3	"	7	0.093	0.005
T2	"	7	0.88	0
T1	"	7	0.008	0
Plot	**"**	**7**	**0.20**	**0.001**
T6	82-09-15	33	0.003	0
T4	"	33	0.13	0
T3	"	33	0.027	0.25
T2	"	33	0.55	0.13
T1	"	33	0.033	0
Plot	**"**	**33**	**0.15**	**0.076**
T6	83-08-20	372	0.017	0.002
T4	"	372	0.007	0
T3	"	372	0.016	0.002
T2	"	372	0.31	0.035
T1	"	372	0.009	0
Plot	**"**	**372**	**0.072**	**0.008**

Table 21 **1982 Exxon dispersant; emulsion Plot ID[E]E**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Oil laying	82-08-12	-1	0.49	
Pretest T6	82-08-13	0	0.17	0
Pretest T4	"	0	0.069	0
Pretest T2	"	0	0.21	0
Pretest	**"**	**0**	**0.15**	**0**
Posttest T6	82-08-14	1	0.15	0
Posttest T4	"	1	0.023	0
Posttest T3	"	1	0.13	0.003
Posttest T2	"	1	0.22	0.010
Posttest	**"**	**1**	**0.13**	**0.004**
T6	82-08-20	7	0.15	0
T4	"	7	0.053	0
T3	"	7	0.22	0
T2	"	7	1.5	0.010
T1	"	7	0.091	0
Plot	**"**	**7**	**0.41**	**0.002**
T6	82-09-15	33	0.019	0
T4	"	33	0.12	0.003
T3	"	33	0.038	0.020
T2	"	33	0.15	0
T1	"	33	0.045	0
Plot	**"**	**33**	**0.075**	**0.004**
T6	83-08-20	372	0.005	0
T4	"	372	0.031	0
T3	"	372	0.041	0
T2	"	372	0.64	0.009
T1	"	372	0.010	0
Plot	**"**	**372**	**0.145**	**0.002**

Table 22 **1982 BP dispersant; aged crude Plot ID[B]C**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Oil laying	82-08-12	-1	0.88	
Pretest T6	82-08-13	0	0.084	0.005
Pretest T4	"	0	0.29	0
Pretest T2	"	0	0.97	0.037
Pretest	**"**	**0**	**0.45**	**0.014**
Posttest T6	82-08-14	1	0.83	0
Posttest T4	"	1	0.003	0.71
Posttest T3	"	1	1.9	0.004
Posttest T2	"	1	2.0	0.020
Posttest	**"**	**1**	**1.2**	**0.18**
T6	82-08-20	7	0.30	0
T4	"	7	0.51	0
T3	"	7	1.1	0.005
T2	"	7	2.8	0.007
T1	"	7	0.11	0
Plot	**"**	**7**	**0.95**	**0.002**
T6	82-09-15	33	0.017	0.021
T4	"	33	0.32	0.32
T3	"	33	0.17	0.22
T2	"	33	1.2	0.23
T1	"	33	0.032	0.003
Plot	**"**	**33**	**0.36**	**0.16**
T6	83-08-20	372	0.013	0
T4	"	372	0.026	0.009
T3	"	372	0.16	0.008
T2	"	372	1.1	0.048
T1	"	372	0.010	0
Plot	**"**	**372**	**0.26**	**0.013**

Table 23 **1982 BP dispersant; emulsion Plot ID[B]E**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Oil laying	82-08-12	-1	0.83	
Pretest T6	82-08-13	0	0.73	0.041
Pretest T4	"	0	0.054	0
Pretest T2	"	0	0.52	0
Pretest	**"**	**0**	**0.44**	**0.013**
Posttest T6	82-08-14	1	2.0	0.005
Posttest T4	"	1	0.90*	0.006
Posttest T3	"	1	3.4	0.003
Posttest T2	"	1	4.1	0.13
Posttest	**"**	**1**	**3.2**	**0.037**
T6	82-08-20	7	1.2	0
T4	"	7	0.48*	0
T3	"	7	0.63	0
T2	"	7	2.9	0.003
T1	"	7	0.039	0
Plot	**"**	**7**	**1.2**	**0**
T6	82-09-15	33	0.069	0.026
T4	"	33	0.16*	0.43
T3	"	33	0.18	0.036
T2	"	33	0.69	0.79
T1	"	33	0.053	0.015
Plot	**"**	**33**	**0.25**	**0.26**
T6	83-08-20	372	0.017	0
T4	"	372	0.19	0.033
T3	"	372	0.021	0
T2	"	372	0.53	0.009
T1	"	372	0.009	0
Plot	**"**	**372**	**0.15**	**0.008**

[Values marked * were shown by GC analysis to be primarily gasoline and are not included in the calculations of plot means.]

Table 24 **1982 Experimental Plots; Water side samples**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
82-1	83-08-20	370-4	0	0
82-2	"	370-4	0.003	0
82-3	"	370-4	0.002	0
82-4	"	370-4	0.010	0
82-5	"	370-4	0.005	
82-6	"	370-4	0	0.008

Table 25 **1982 Backshore; aged crude Plot IMC**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Control berm				
Pretest	82-08-14	0	5.7	0.70
Posttest	82-08-15	1	2.3	-
	82-08-22	7	1.9	2.7
	82-09-15	31	3.1	2.3
	83-08-20	370	6.2	0.093
Control backbeach				
Pretest	82-08-14	0	4.2	0.027
Posttest	82-08-15	1	1.3	0.84
	82-08-22	7	1.5	0.94
	82-09-15	31	1.8	0.75
	83-08-20	370	2.2	0.048
Mixed berm				
Pretest	82-08-14	0	10	0.22
Posttest	82-08-15	1	6.7	0.14
	82-08-22	7	8.9	0.19
	82-09-15	31	5.7	0.53
	83-08-20	370	3.1	0.23
Mixed backbeach				
Pretest	82-08-14	0	2.4	0.010
Posttest	82-08-15	1	2.1	0.057
	82-08-22	7	3.8	0.017
	82-09-15	31	3.3	6.52
	83-08-20	370	1.1	0.45

Table 26 **1982 Backshore; emulsion Plot IME**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Control berm				
Pretest	82-08-14	0	1.7	1.8
Posttest	82-08-15	1	0.93	1.3
	82-08-22	7	1.4	0.77
	82-09-15	31	0.85	1.2
	83-08-20	370	1.1	0.71
Control backbeach				
Pretest	82-08-14	0	4.2	0.036
Posttest	82-08-15	1	1.2	1.2
	82-08-22	7	2.5	1.5
	82-09-15	31	1.7	1.5
	83-08-20	370	1.4	0.028
Mixed berm				
Pretest	82-08-14	0	1.2	1.5
Posttest	82-08-15	1	0.77	1.1
	82-08-22	7	0.86	1.2
	82-09-15	31	0.54	1.3
	83-08-20	370	0.74	0.78
Mixed backbeach				
Pretest	82-08-14	0	1.8	0.014
Posttest	82-08-15	1	3.5	0.012
	82-08-22	7	4.0	0.022
	82-09-15	31	6.5	0.31
	83-08-20	370	1.1	0.55

4.2 RAGGED CHANNEL BEACHES

Table 27 **Surface oil release, Bay 11 Shoreline**

Sample Description	Date	Day	Total hydrocarbon % Surface	Subsurf.
Posttest	81-08-19			
Upper mean	"	0	2.8	
Middle mean	"	0	1.9	
Lower mean	"	0	0.49	
Posttest mean	**"**	**0**	**1.7**	
Upper mean	81-08-20	1	0.88	0.026
Middle mean	"	1	0.38	0.009
Lower mean	"	1	0.86	0.015
Mean	**"**	**1**	**0.71**	**0.017**
Upper mean	81-08-28	8	0.70	0.21
Middle mean	"	8	0.80	0.029
Lower mean	"	8	0.50	0.036
Mean	**"**	**8**	**0.67**	**0.090**
Upper mean	81-09-15	27	0.71	0.007
Middle mean	"	27	0.68	0.031
Lower mean	"	27	0.38	0.026
Mean	**"**	**27**	**0.59**	**0.021**
Upper mean	82-08-10	356	0.83	0.26
Middle mean	"	356	0.30	0.031
Lower mean	"	356	0.19	0.013
Mean	**"**	**356**	**0.44**	**0.10**
Upper	83-08-16	737		
Profile 2			0.091	0.008
Profile 4			2.7	0.15
Profile 6			5.8	0.055
Profile 8			0.33	0.022
Upper Mean	"	737	2.2	0.059
Middle	83-08-16	737		
Profile 2			0.083	0.042
Profile 4			0.31	0.23
Profile 6			1.4	0.11
Profile 8			0.18	0.75
Middle Mean	"	737	0.49	0.28

Lower	83-08-16	737		
Profile 2			0.011	0.004
Profile 4			0.006	0.003
Profile 6			0.28	0.12
Profile 8			0.14	0.047
Lower Mean	"	737	0.11	0.044
Plot Mean "	**737**	**0.93**	**0.13**	
Beach Face	83-08-21	742		
11-1			2.7	0.46
11-9			0.28	0.049
Beach face Mean	"	742	1.5	0.26
Beach Flats	83-08-21	742		
11-2			0.047	0
11-3			0.018	0
11-4			0.081	0.003
Beach flats Mean	"	742	0.049	0.001
Beach Ridges	83-08-21	742		
11-5			0.97	0.59
11-7			0.055	0.002
Beach ridge Mean	"	742	0.51	0.30
Bay 11 Mean	**83-08-**	**737-42**	**0.81**	**0.14**

Table 28 **Dispersed oil release, Bay 9 Shoreline**

Sample Description	Date	Day	Total hydrocarbon %	
			Surface	Subsurf.
Posttest	81-08-28	1	0.13*	
	82-08-12	349	0**	0**
	83-08-10	712	0***	0***

[* one sample, five others 0]
[** nine samples, Profiles 100,300,600, all 0]
[*** six samples, Profiles 100 and 300, all 0]

5. DISCUSSION

The significance of the total hydrocarbon content analyses to the countermeasure experiments and the Ragged Channel experiments are discussed elsewhere (Woodward-Clyde, 1984).

The usefulness of the quantitative analytical results depends less on the precision of the method of analysis than on the sampling strategy and the environmental variability of the oil coverage. In every part of the project the sampling strategy was based on an attempt to determine the hydrocarbon content of the whole plot or beach. The sampling sites within a plot were predetermined to avoid subjectivity and samplers did not deviate from these sites. It was apparent for many of the plots that samples collected by this method, although the best method available, may not adequately describe the plot. The patchy distribution of oil on a plot or beach reduces the confidence of the results. The sampling of the 1982 experimental plots in Bay 106, in particular, is biased to high oil coverage, in that the sampling transects were chosen by visual observation of the oil deposited by tide changes.

Over the four years of the project, a very large number of samples have been taken and analysed. The sampling strategies from 1981 to 1983 have been consistent. The statistical usefulness of these results may be estimated by examining the data for one particular set which includes a large number of samples which may be taken as members of the same set. The data for Bay 11 is such a set. In the attempt to estimate the coverage of the entire beach, a minimum of nine samples were collected in each set. Some of these data have been left out of Table 27, but may be found in the 1982 season's report (Humphrey 1983).

The mean for the entire beach is determined from 9 or 12 samples. For each case, a mean and standard deviation may be calculated. It is then possible to apply tests for statistical equivalence, and to determine any **statistically valid** change. The results of that analysis on the surface oil coverage of Bay 11 is as follows:

DATE	# OF SAMPLES	MEAN OIL (%)	STD.DEV	CONFIDENCE LEVEL OF CHANGE
81-08-20	9	0.707	0.618	
				40%
81-08-28	9	0.665	0.539	
				40%
81-09-15	9	0.588	0.541	
				90%
82-08-10	9	0.440	0.390	
				99%
83-08-16	12	0.944	1.72	

This analysis suggests that for a beach, the sampling coverage was not adequate to estimate the coverage of the whole beach, in that the only difference with a high level of confidence is not physically reasonable. A similar analysis of the plot ID[E]C, gives the following results:

DATE	# OF SAMPLES	MEAN OIL (%)	STD.DEV	CONFIDENCE LEVEL OF CHANGE
82-08-13	3	0.849	1.105	
				90%
82-08-14	5	0.229	0.373	
				NO CHANGE, 90%
82-08-20	5	0.204	0.380	
				50%
82-09-15	5	0.149	0.230	
				90%
83-08-20	5	0.072	0.133	

The results of these analyses are not surprising to those familiar with this type of work. Workers must be careful when comparing results which are within one order of magnitude of each other. Rather than assuming that the numbers represent the plot, it may be more useful to accept that the numbers represent the concentrations at a single point, and compare the temporal changes at that point only.

6. REFERENCES

Boehm,P.D.,1981, Chemistry:2. Hydrocarbon Chemistry - 1980 Study Results. (BIOS) Baffin Island Oil Spill Working Report 80-2: 184p.

Boehm,P.D.,D.L.Fiest,P. Hirtzer, 1982, Chemistry:2. Analytical Biogeochemistry - 1981 Study Results. (BIOS) Baffin Island Oil Spill working Report 81-2: 354p.

Boehm,P.D., 1983, Chemistry:2. Analytical Biogeochemistry - 1982 Study Results. (BIOS) Baffin Island Oil Spill Working Report 82-2: 210p.

Boehm,P.D., 1984, Chemistry:2. 1983 Study Results. (BIOS) Baffin Island Oil Spill Working Report 82-2: in press

deLappe,B.W.,R.W.Risebrough,A.M.Springer,T.T.Schmidt,J.C.Shropshire, E.F.Letterman,J.R.Payne.1979, The sampling and measurement of hydrocarbons in natural waters. In Hydrocarbons and Halogenated Hydrocarbons in the Aquatic Environment B.K.Afghan, D.McKay, editors, Plenum Press,N.Y.

Dickins,D.F., 1982, Discharge Systems - 1981 Study Results. (BIOS) Baffin Island Oil Spill Working Report 81-9 62p.

Engelhardt,F.R.,R.J.Norstrom, 1982, Petroleum hydrocarbons in two benthic invertabrates, the urchin Strongylocentrotus droebrachiensis and the polychaete Pectinaria granulosa. In Special Studies - 1981 Study Results. (BIOS) Baffin Island Oil Spill Working Report 81-10

Green,D.R., 1981, Chemistry:1. Field Sampling and Environmental Chemistry- 1980 Study Results. (BIOS) Baffin Island Oil Spill Project Working Report 80-1: 93 p.

Green,D.R., B. Humphrey, B.Fowler, 1982, Chemistry:1. Summary of field work- 1981 Study Results. (BIOS) Baffin Island Oil Spill Project Working Report 81-1.

Humphrey,B., 1983, Chemistry:1. Field Sampling and Measurements- 1982 Study Results. (BIOS) Baffin Island Oil Spill Working Report 82-1: 64p.

Woodward-Clyde Consultants, 1983, Shoreline Countermeasures - 1982 Study Results. (BIOS) Baffin Island Oil Spill Working Report 82-4: 129p.

Woodward-Clyde Consultants, 1984, Shoreline Countermeasures - 1983 Study Results. In press.

7. APPENDIX

HYDROCARBON ANALYSIS RESULTS

The results listed in the following pages summarize the results obtained from 1980 to 1982 as they relate to the samples collected in 1983. The samples collected in 1983 are included in the tables, with results where possible. The large number of results pertaining to sample groups which were not collected again are not included. Those results may be obtained by referring to the references listed.

The references used in the appendix are:

Number	Reference
[1]	Boehm, 1981
[2]	Boehm et al, 1982
[3]	Boehm, 1983
[4]	Engelhardt, 1982
[5]	Boehm, 1984

Table 29 **SEAWATER SAMPLES**

Bay 7 Reference

Date	Depth	Analyses	[Oil]	Reference
81-09-03	5m	GC/MS	5µg/L	[2]
81-09-12	5m	GC/MS	3µg/L	[2]
82-08-14	5m	not analysed		[3] 2 samples
82-08-20	5m	not analysed		[3] 2 samples
83-08-12	5m		0.5µg/L	[5]
83-08-18	5m		0.2µg/L	[5]
83-08-21	5m			[5]

Samples remote from the experimental bays

Date	Location, Depth	Analyses	[Oil]	Reference
83-08-16	Ragged Ch., 5m		2.7µg/L	[5]
83-08-13	Ragged Ch., 5m			[5]
83-08-15	Milne Inlet,5m		0.1µg/L	[5]
83-08-18	Milne Inlet,5m			[5]

Bay 11 Surface oil release

Date	Depth	Analyses	[Oil]	Reference	
80-06-14	1,5,10m	GC/MS	N.D.	[1]	
80-08-26	1,5m	UV/F	N.D.	[1]	
80-09-01	1m	GC/MS	N.D.	[1]	
80-09-17	5m	GC/MS	N.D.	[1]	
80-09-19	1,5,10m	UV/F	N.D.	[1]	
81-08-19	0-2m	GC/MS	37μg/L	[2]	mean of 4
81-08-19	3m	GC/MS	5μg/L	[2]	mean of 2
81-08-20	0-2m	GC/MS	370μg/L	[2]	mean of 2
81-08-21	3m	GC/MS	4μg/L	[2]	mean of 2
81-08-22	0-2m	GC/MS	720μg/L	[2]	
81-08-29	5m	GC/MS	62μg/L	[2]	mean of 2
81-09-05	5m	UV/F	29μg/L	[2]	
81-09-12	5m	GC/MS	5μg/L	[2]	mean of 2
82-08-16	5m	not analysed		[3]	2 samples
82-08-22	Surface sheen		535μg/L	[3]	3 samples
82-08-25	0.5m		1.3μg/L	[3]	
82-08-25	Bottom		1.8μg/L	[3]	
82-08-28	Intertidal		1.2μg/L	[3]	
82-08-30	5m	not analysed		[3]	2 samples
83-08-11	10m	not analysed		[5]	
83-08-11	1m	not analysed		[5]	
83-08-12	10m		-	[5]	
83-08-12	1m		tr	[5]	
83-08-13	10m		-	[5]	
83-08-13	1m		-	[5]	
83-08-15	10m		-	[5]	
83-08-15	1m		-	[5]	
83-08-16	10m		tr	[5]	
83-08-16	1m		-	[5]	
83-08-19	10m		tr	[5]	
83-08-19	1m		-	[5]	

(tr refers to oil as determined by GC trace, but too low for quantification
- refers to the presence of hydrocarbon, but without the presence of obvious oil peaks)

Table 30 **LARGE VOLUME WATER SAMPLES**

Bay 7 Reference

Date	Depth	[Oil] Filt.	Part.	Reference
81-08-27	2m	1.9μg/L	0.7μg/L	[2]
81-08-29	2m	1.0μg/L	2.2μg/L	[2]
81-09-06	6m	0.2μg/L	0.1μg/L	[2]
82-08-18	10m	0.03μg/L	0.08μg/L	[3]
82-08-25	Bottom	0.01μg/L	0.01μg/L	[3]
83-08-12	5m	combined	-	[5]
83-08-18	5m	combined	tr	[5]
83-08-21	5m	not analysed		[5]

Samples remote from the experimental bays

Date	Location, Depth	[Oil] Filt.	Part.	Reference
83-08-16	Ragged Ch., 5m	not analysed		[5]
83-08-13	Ragged Ch., 5m	combined	0.09μg/L	[5]
83-08-15	Ragged Isl.,5m	combined	-	[5]
83-08-18	Milne Inlet,5m	not analysed		[5]

Bay 11 Surface oil release

Date	Depth	[Oil] Filt.	Part.	Reference
80-09-11	8m	2ng/L*	1ng/L*	[1]
81-08-12	4m	0.5µg/L	0.2µg/L	[2]
81-08-19	3m	5.9µg/L	0.005µg/L	[2]
81-08-20	1m	10.2µg/L	0.5µg/L	[2]
81-08-21	1m	2.0µg/L	0.05µg/L	[2]
81-08-22	1m	3.5µg/L	0.3µg/L	[2]
81-08-22	6m	0.6µg/L	4.7µg/L	[2]
81-08-24	6m	0.9µg/L	0.2µg/L	[2]
81-08-25	1m	2.2µg/L	0.6µg/L	[2]
81-08-25	6m	0.9µg/L	0.4µg/L	[2]
81-09-06	6m	1.3µg/L	0.05µg/L	[2]
82-08-17	0.5m	0.02µg/L	0.06µg/L	[3]
82-08-17	10m	0.01µg/L	0.09µg/L	[3]
82-08-21	Intertidal	0.01µg/L	1.1µg/L	[3]
82-08-25	Bottom	0.01µg/L	0.01µg/L	[3]
82-08-25	0.5m	0.01µg/L	0.03µg/L	[3]
82-08-25	Intertidal	0.29µg/L	0.04µg/L	[3]
83-08-11	10m	not analysed		[5]
83-08-11	1m	not analysed		[5]
83-08-12	10m	combined	tr	[5]
83-08-12	1m	combined	tr	[5]
83-08-13	10m	combined	-	[5]
83-08-13	1m	combined	-	[5]
83-08-15	10m	combined	-	[5]
83-08-15	1m	combined	-	[5]
83-08-16	10m	combined	-	[5]
83-08-16	1m	combined	tr	[5]
83-08-19	10m	combined	tr	[5]
83-08-19	1m			[5]

* These samples were analysed by fractionation and subsequent GC analysis. The results can not be directly compared to the other listings.

Table 31 **TISSUE PLOT SEDIMENTS**

Bay 7 Reference

Date	[Oil] 3m	7m	Reference
81-08-17	0.36μg/g	0.43μg/g	[2]
81-08-31	0.34μg/g	0.67μg/g	[2]
81-09-10	0.45μg/g	1.1μg/g	[2]
82-08-18	-	1.3μg/g	[3]
83-08-14	-	4.5μg/g	[5]

Bay 9 Dispersed oil release

Date	[Oil] 3m	7m	Reference
81-08-10	0.34μg/g	0.38μg/g	[2]
81-08-28	3.1μg/g	2.1μg/g	[2]
81-09-13	0.45μg/g	9.0μg/g	[2]
82-08-17	-	2.5μg/g	[3]
83-08-15	-	7.7μg/g	[5]

Bay 10 Dispersed oil release

Date	[Oil] 3m	7m	Reference
81-08-14	0.45μg/g	0.49μg/g	[2]
81-08-29	1.40μg/g	0.88μg/g	[2]
81-09-11	0.73μg/g	1.7 μg/g	[2]
82-08-16	-	1.7 μg/g	[3]
83-08-16	-		[5]

Bay 11 Surface oil release

Date	[Oil] 3m	7m	Reference
81-08-12	0.22μg/g	0.55μg/g	[2]
81-08-21	0.16μg/g	0.18μg/g	[2]
81-09-08	0.70μg/g	1.1 μg/g	[2]
82-08-15	10.3μg/g	9.5μg/g	[3]
83-08-13	35μg/g	13μg/g	[5]

Ragged Island Control

Date	[Oil]	Reference
83-08-15	0.8μg/g	[5]

Table 32 **BENTHIC PLOT SEDIMENTS**

Bay 7 Reference

Date	[Oil] 3m	7m	Reference
81-09-10	0.80μg/g	1.2μg/g	[2]
82-08-18	-	-	[3]
83-08-14	1.6μg/g	-	[5]

Bay 9 Dispersed oil release

Date	[Oil] 3m	7m	Reference
81-09-10	2.7μg/g	3.8μg/g	[2]
82-08-17	0.8μg/g	-	[3]
83-08-15	3.8μg/g	-	[5]

Bay 10 Dispersed oil release

Date	[Oil] 3m	7m	Reference
81-09-11	0.99μg/g	1.6μg/g	[2]
82-08-16	0.77μg/g	-	[3]
83-08-16	-	-	[5]

Bay 11 Surface oil release

Date	[Oil] 3m	7m	Reference
81-09-08	0.90μg/g	3.8μg/g	[2]
82-08-15	7.0μg/g	5.3μg/g	[3]
83-08-13	57μg/g	19μg/g	[5]

[Deep Sediments: 82-09-10 2 samples, detection limit oil [3]
83-08-11 5 samples 4.6ug/g [5]]

Table 33 **FLOC SAMPLES**

Bay 11 Surface oil release

Date	[Oil] 3m	7m	Reference
81-08-12	0.084μg	0.96μg	[2]
81-08-21	-	0.23μg	[2]
81-09-08	0.071μg	0.11μg	[2]
82-08-15	0.61μg	0.23μg	[3]
83-08-13	1.6μg/g	0.3μg/g	[5]

Table 34 **TISSUE SAMPLES**

Astarte borealis

Bay 7 Reference

Date	Depth	[Oil]	Reference
81-08-17	7m	22μg/g	[2]
81-09-01	7m	51μg/g	[2]
81-09-11	7m	56μg/g	[2]
82-08-18	7m	6.8μg/g	[3]
83-08-14	7m	1.7μg/g	[5]

Bay 9 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-08	7m	0.81μg/g	[2]
81-08-28	7m	463μg/g	[2]
81-09-11	7m	171μg/g	[2]
82-08-17	7m	19.0μg/g	[3]
83-08-15	7m	7.0μg/g	[5]

Bay 10 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-14	7m	0.43μg/g	[2]
81-09-01	7m	364μg/g	[2]
81-09-12	7m	310μg/g	[2]
82-08-16	7m	25.0μg/g	[3]
83-08-16	7m	-	[5]

Bay 11 Surface oil release

Date	Depth	[Oil]	Reference
81-08-13	7m	0.47μg/g	[2]
81-08-25	7m	2.7μg/g	[2]
81-09-11	7m	140μg/g	[2]
82-08-15	7m	37.0μg/g	[3]
83-08-13	7m	15.2μg/g	[5]

Ragged Island Control

Date	Depth	[Oil]	Reference
83-08-15	5m	-	[5]

Mya truncata

Bay 7 Reference

Date	Depth	[Oil]	Reference
81-08-17	7m	0.34μg/g	[2]
81-08-31	7m	114μg/g	[2]
81-09-11	7m	47μg/g	[2]
82-08-18	7m	0.41μg/g	[3]
83-08-14	7m	1.1μg/g	[5]

Bay 9 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-07	3m	0.40μg/g	[2]
81-08-07	7m	0.35μg/g	[2]
81-08-28	3m	215μg/g	[2]
81-08-28	7m	121μg/g	[2]
81-09-10	3m	135μg/g	[2]
81-09-10	7m	114μg/g	[2]
82-08-17	7m	0.81μg/g	[3]
83-08-15	7m	2.9μg/g	[5]

Bay 10 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-14	3m	0.78μg/g	[2]
81-08-14	7m	0.57μg/g	[2]
81-08-29	3m	368μg.g	[2]
81-08-29	7m	277μg/g	[2]
81-09-11	3m	131μg/g	[2]
81-09-11	7m	157μg/g	[2]
82-08-16	7m	0.96μg/g	[3]
83-08-16	7m	-	[5]

Bay 11 Surface oil release

Date	Depth	[Oil]	Reference
81-08-12	7m	0.43μg/g	[2]
81-08-21	7m	2.0μg/g	[2]
81-09-08	7m	93μg/g	[2]
82-08-15	7m	1.3μg/g	[3]
82-09-12	7m	4.7μg/g	[3]
83-08-13	7m	4.0μg/g	[5]

Ragged Island Control

Date	Depth	[Oil]	Reference
83-08-15	5m	-	[5]

Macoma calcarea

Bay 7 Reference

Date	Depth	[Oil]	Reference
81-08-17	7m	1.0μg/g	[2]
81-09-01	7m	82.1μg/g	[2]
81-09-11	7m	85.5μg/g	[2]
82-08-18	7m	1.9μg/g	[3]
83-08-14	7m	5.2μg/g	[5]

Bay 9 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-08	7m	0.73μg/g	[2]
81-08-28	7m	74.9μg/g	[2]
81-09-11	7m	836μg/g	[2]
82-08-17	7m	25μg/g	[3]
83-08-15	7m	12.6μg/g	[5]

Bay 10 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-14	7m	2.1μg/g	[2]
81-09-01	7m	406μg/g	[2]
81-09-12	7m	440μg/g	[2]
82-08-16	7m	14μg/g	[3]
83-08-16	7m	-	[5]

Bay 11 Surface oil release

Date	Depth	[Oil]	Reference
81-08-13	7m	2.5μg/g	[2]
81-08-25	7m	24.5μg/g	[2]
81-09-11	7m	246μg/g	[2]
82-08-15	7m	60μg/g	[3]
83-08-13	7m	64μg/g	[5]

Ragged Island Control

Date	Depth	[Oil]	Reference
83-08-15	5m	-	[5]

Serripes groenlandicus

Bay 7 Reference

Date	Depth	[Oil]	Reference
81-08-17	7m	1.2μg/g	[2]
81-09-01	7m	517μg/g	[2]
81-09-11	7m	73μg/g	[2]
82-08-18	7m	5.2μg/g	[3]
83-08-14	7m	1.2μg/g	[5]

Bay 9 Dispersed oil release

Date	Depth	[Oil]	Reference	
81-08-08	7m	0.68μg/g	[2]	
81-08-28	7m	482μg/g	[2]	
81-08-28	7m	186μg/g	[2]	Hand picked
81-09-10	3m	160μg/g	[2]	Hand picked
81-09-10	7m	116μg/g	[2]	
81-09-10	7m	97μg/g	[2]	Hand picked
82-08-17	7m	5.2μg/g	[3]	
83-08-14	7m	1.0μg/g	[5]	

Bay 10 Dispersed oil release

Date	Depth	[Oil]	Reference	
81-08-14	7m	1.4μg/g	[2]	
81-08-29	3m	698μg/g	[2]	Hand picked
81-08-29	7m	278μg/g	[2]	
81-08-29	7m	329μg/g	[2]	Hand picked
81-09-11	7m	149μg/g	[2]	
81-09-11	7m	141μg/g	[2]	Hand picked
82-08-16	7m	3.0μg/g	[3]	
83-08-16	7m	-	[5]	

Bay 11 Surface oil release

Date	Depth	[Oil]	Reference
81-08-13	7m	-	[2]
81-08-21	7m	6.0μg/g	[2]
81-09-11	7m	394μg/g	[2]
82-08-15	7m	13μg/g	[3]
83-08-13	7m	10.9μg/g	[5]

Ragged Island Control

Date	Depth	[Oil]	Reference
83-08-15	5m	-	[5]

Strongylocentrotus droebachiensis

Bay 7 Reference

Date	Depth	[Oil]	Reference
81-08-17	7m	12.8μg/g	[4]
81-08-31	7m	47.2μg/g	[4]
81-09-11	7m	43.7μg/g	[4]
82-08-18	7m	4.6μg/g	[3]
83-08-14	7m	12.2μg/g	[5]

Bay 9 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-07	7m	16.5μg/g	[4]
81-08-28	7m	45.9μg/g	[4]
81-09-10	7m	237.1μg/g	[4]
82-08-17	7m	46.0μg/g	[3]
83-08-15	7m	150μg/g	[5]

Bay 10 Dispersed oil release

Date	Depth	[Oil]	Reference
81-08-14	7m	24.9μg/g	[4]
81-08-29	7m	91.7μg/g	[4]
81-09-11	7m	111.2μg/g	[4]
82-08-16	7m	20.0μg/g	[3]
83-08-16	7m	-	[5]

Bay 11 Surface oil release

Date	Depth	[Oil]	Reference
81-08-12	7m	12.6μg/g	[3]
81-08-21	7m	78.0μg/g	[3]
81-09-08	7m	430.0μg/g	[3]
82-05-	7m	180.0μg/g	[3]
82-08-15	7m	46.0μg/g	[3]
82-09-	7m	67.0μg/g	[3]
83-08-13	7m	103μg/g	[5]

Ragged Island Control

Date	Depth	[Oil]	Reference
83-08-15	5m	-	[5]

NOTE: the averages from reference 4 are arithmetic means, those from reference 3 are geometric means.