RIG SEISMIC SURVEY 112, MODERN PROCESSES AND ENVIRONMENTAL MONITORING STRATEGIES OFFSHORE SYDNEY: A JOINT PROGRAM BETWEEN THE AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION AND THE WATER BOARD (SYDNEY)

by

D T Heggie, J Hansen, P Schneider,
G Bickford, P Fagan & Shipboard Scientific Staff

RECORD 1993/8

AGSO
AUSTRALIAN
GEOLOGICAL SURVEY
ORGANISATION

AGSO Record 1993/8

Rig Seismic Survey 112, Modern Processes and Environmental Monitoring Strategies offshore Sydney: a Joint Program between The Australian Geological Survey Organisation and The Water Board (Sydney).

Project 121.37

with contributions from

D. Heggie, G. Bickford (co-chief scientists), J. Bishop
Australian Geological Survey Organisation, Marine Geosciences and Petroleum Geology Program

J. Hansen, P. Schneider, S. Davey P. Fagan
The Water Board, Environment Management Unit

R. Johnstone
University of Stockholm, Sweden

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Minister for Resources: Hon. Michael Lee, MP
Secretary: Greg Taylor

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Executive Director: Harvey Jacka

ISSN: 1039-0073

ISBN: 0 642 19751 2

Executive Summary

This document presents the shipboard results from AGSO Survey 112 Leg A, aboard *RV Rig Seismic* to the eastern Australian continental margin, between Broken Bay to the north and Garie North Head to the south. The survey was conducted during September/October 1992 and included personnel from the AGSO Program in Marine Geoscience and Petroleum Geology, the Environment Management Unit of the Water Board (WB), and the University of Stockholm.

As part of the Australian Government's commitment to ecologically sustainable development, the overall objectives of the program were: (i) to collect baseline data which will be used to assess environmental impact associated with the discharge of anthropogenic materials into the coastal zone, including the accumulation of organic carbon, nitrogen and phosphorus, and heavy metal and toxic organic contaminants in sediments and, (ii) to understand the geochemical, microbial, sedimentological and geological processes controlling the concentrations and distributions of contaminants in the coastal zone, so that environmental monitoring strategies can be developed.

Three distinct research projects were conducted: (1) The sedimentology of part of the continental shelf was investigated, and the concentrations and distributions of contaminants in shelf sediments were also examined with special reference to heavy metals and organic toxicants. (2) The processes controlling the inventories of organic carbon, nitrogen and phosphorus in sediments were investigated, specifically oxygen distributions in sediments and benthic fluxes of nitrogen and phosphorus. (3) Continuous geochemical tracer (CGT) studies of ocean outfall discharges and estuary/ocean exchanges were conducted with special reference to light hydrocarbons (both in seawater and sediments), and to dissolved oxygen distributions in seawater around the ocean outfalls.

To achieve the objectives of the program, sixty nine vibro cores, seventy two box cores, thirty eight grabs and two gravity cores were deployed and recovered, providing seafloor samples from thirty eight stations, including several near the ocean outfalls operated by the WB, to about 40 km offshore. The samples were processed onboard for geochemistry and sedimentology. In addition, approximately 500 line-km of continuous geochemical tracer (CGT) data were collected including Direct Hydrocarbon Detection (DHD), dissolved oxygen, pH, temperature and salinity in the water column of the coastal zone, particularly in the vicinity of the ocean outfalls and the entrances to estuaries.

The shipboard analyses of forty eight vibro cores logged in detail for sedimentology, combined with results of the bathymetric and boomer surveys, indicate the presence of reefal systems interspersed with pockets of fine-grained sediments. The fine-grained sediments are those believed to be important in the storage and transport of contaminants (heavy metals and organochlorines) in the coastal zone. The sediment samples collected from the vibro cores, and interfacial samples collected in the box cores were returned to the Water Board for subsequent analyses of the heavy metal and organochlorine contents.

Geochemical analyses of sediments has characterised the nutrient (nitrogen and phosphorus) status of sediments. Oxygen concentrations in sediments are depleted within the top 0.5 cm (typical of many coastal sediments). These data and the pore water measurements indicate that aerobic metabolism drives the recycling of organic matter in the fine-grained sediments offshore Sydney. The determination of nutrient fluxes between the sediments and the overlying bottom-waters indicate a net flux of both nitrogen (as ammonia) and phosphate from the sediments to the bottom-waters at most sites. These results will be used in developing environmental monitoring strategies to assess the impacts of point and non-point sources of organic matter and nutrient inputs to the coastal zone.

Analysis of the vertical profiles of light hydrocarbons (DHD) in the water column near the ocean outfalls and the entrances to estuaries indicate that light hydrocarbon mixtures from the ocean outfalls are characterised by abundant methane with minor amounts of C_{2+} hydrocarbons. In contrast, light hydrocarbon mixtures from the estuaries are more abundant in C_{2+} hydrocarbons. This distinction provides a potential tool to distinguish different 'sources' of hydrocarbons to the coastal zone. Direct Hydrocarbon Detection (DHD) data from the coastal survey indicate elevated levels of total hydrocarbons (THC) near the ocean outfalls and, on most lines these were coincident with zones of depleted oxygen concentrations. Total hydrocarbons and the molecular abundances of methane and the C_{2+} hydrocarbons were found to be sensitive tracers of anthropogenic inputs to the coastal zone.

Table of Contents

Executive Summary ii
List of Tables. v
List of Figures vii
List of Appendices x
List of Enclosures xi
1. Introduction 1
2. Seafloor sampling results 5
        Van Veen grabs 5
        Vibro cores 5
        Box cores 6
        Gravity cores 6
        Hydrocast 6
        Navigation 7
3. Sedimentology and Contaminant Sampling. 31
    Objectives 31
    Sampling Methods 31
        Van Veen Grab 32
        Vibro corer 32
        Box corer 33
    Sedimentological Observations 33
        Inner-shelf Sands 34
        Mid-shelf Muddy Sands 34
        Outer-shelf Calcareous Sands 35
    Boomer Survey 36
    Bathymetric and sub-bottom profiling (12 and 3.5 KhZ) Surveys 37
    Contaminant Core Collection and Subsampling 37
    Proposed Post-Survey Analyses 38
        Geological Analysis 38
        Organic Carbon Analysis 38
        Organochlorine Analysis 38
        Trace Metal Analysis 39
4. Geochemical characterisation of continental shelf sediments 56
    Objectives 56
    Sampling Sites 57
    Sediment Oxygen Profiles 57
    Pore water nutrients 58
    Solid phase nutrients 58
    Grain-size 59
    Benthic flux measurements 59
    Distribution of pathogenic bacteria 60
    Macrofauna Analysis 60
5. Continuous geochemical tracers (CGT); light hydrocarbons, dissolved oxygen, pH, temperature and salinity in seawater. 73
    Objectives 73
    Vertical distributions of hydrocarbons 74
    Longitudinal profiles of light hydrocarbons in the coastal zone 76
    Carbon isotope sample collection 78
    SDL (temperature, salinity, dissolved oxygen and pH data) 78

6. Exractable (volatile) hydrocarbons in sediments 108
    Objectives 108
7. Summary 116
8. Acknowledgements. 120
9. References 121
    Appendix 1. Core logs provided by the Water Board 125

List of Tables.

Page

Table 2.1. Seafloor sampling sitesWB/AGSO program 8

Table 2.2. Grab sampling sites WB/AGSO program. 15

Table 2.3. Vibro core sampling sites WB/AGSO program. 17

Table 2. 4. Box core sampling sites WB/AGSO program. 20

Table 2.5. Gravity core sites WB/AGSO program. 23

Table 2.6. Hydrocast sampling site WB/AGSO program. 24

Table 3.1. Inventory of samples for shore-based contaminant studies. 42

Table 3.2. Inventory of cores logged by WB scientists. 45

Table 3.3. Navigation data for the boomer survey conducted offshore Sydney. 47

Table 3.4. Way-points for the bathymetric survey conducted offshore Sydney. 48

Table 4.1 Summary of sampling locations and cores collected for sediment geochemistry analysis. 61

Table 4.2 Summary of sampling locations and cores collected for analysis of numbers of *Clostridium perfingrens* spores. 62

Table 4.3 Summary of sub-cores collected at each site, analyses and storage. 63

Table 5.1. Locations of vertical profiles. 80

Table 5.2. Navigation data for the CGT survey. 81

Table 5.3. List of samples collected for determination of the carbon isotopic composition of methane, including locations, approximate methane content and tow-fish depth. 84

Table 6.1. Locations of samples and concentrations of light hydrocarbons measured in sediments. 110

Table 6.2. Inventory of samples collected for halogenated hydrocarbon analyses. 113

List of Figures

Page

Figure 1.1 Reprint of BMR Research Newsletter article describing the pilot survey conducted in September/October 1991. 3

Figure 2.1. Map of all seafloor sampling sites AGSO/WB project. 25

Figure 2.2 Map of grab sample locations AGSO/WB project. 26

Figure 2.3 Map of vibro core sample locations AGSO/WB project. 27

Figure 2.4 Map of all box core locations AGSO/WB project. 28

Figure 2.5 Map of gravity core locations AGSO/WB project. 29

Figure 2.6 Map of the the hydrocast location AGSO/WB project. 30

Figure 3.1 Map of sample sites occcupied for contaminant and grain-size analyses. 49

Figure 3.2 Schematic diagram of the protocol for processing and sampling of vibro cores. 50

Figure 3.3 Schematic diagram of the protocol used for processing and sampling of box cores. 51

Figure 3.4. Track map of the boomer survey. 52

Figure 3.5. Track map of the bathymetric survey. 53

Figure 3.6 Map of the bathymetry of the mid-shelf offshore Sydney between Palm beach and Turimetta Head. 54

Figure 3.7 Map of the mid-shelf deposition and adjacent isopachs between Palm Beach and Turimetta Head. 55

Figure 4.1. Map of sampling locations for sediment (nutrient) geochemistry - box core sampling locations. 64

Figure 4.2. General protocol for sediment sampling and analysis. 65

Figure 4.3. Location of sampling sites for sediment microbiology sampling. 66

Figure 4.4. Oxygen profiles in fine-grained coastal sediments. 67

Figure 4.5. Porewater nutrient concentrations in fine-grained coastal sediments. 70

Figure 4.6. Flux rates of ammonia and phosphate from fine-grained coastal sediments. 71

Figure 4.7. Oxygen and carbon utilisation in fine-grained coastal sediments. 72

Figure 5.1 Schematic diagram of the CGT (Continuous Geochemical Tracer) capability aboard *Rig Seismic.* 86

Figure 5.2 Map of the locations of vertical profiles conducted during Survey 112. 88

Figure 5.3 Percent hydrocarbon wetness and methane for the vertical profiles located near the ocean outfalls. 89

Figure 5.4 Percent hydrocarbon wetness and methane for the vertical profiles located near the entrances to estuaries. 90

Figure 5.5 Percent hydrocarbon wetness and methane for all vertical profiles. 91

Figure 5.6 Map of the cruise track for the CGT survey conducted at 5 m water depth. 92

Figure 5.7 Map of the cruise track for the CGT survey conducted at 25 m water depth. 93

Figure 5.8 Map of the cruise track for the CGT survey conducted at 45 m water depth. 94

Figure 5.9 Map of the cruise track for the CGT survey conducted at about 15 m altitude above the seafloor. 95

Figure 5.10. Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112005. 96

Figure 5.11 Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112009. 99

Figure 5.12 Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112013. 102

Figure 5.13 Longitudinal profiles of dissolved oxygen and THC along survey line 112005. 105

Figure 5.14 Longitudinal profiles of dissolved oxygen and THC along survey line 112009. 106

Figure 5.15. Longitudinal profiles of dissolved oxygen and THC along survey line 112013. 107

Figure 6.1. Map of the locations of LHC (light hydrocarbon) sampling sites. 115

List of Appendices

Appendix 1. Core logs of sedimentology provided by the Water Board.

List of Enclosures

Enclosure 1 Map of the sampling sites occupied during the WB/AGSO component of Survey 112.

Enclosure 2 Map of the locations of Van Veen grab sampling stations.

Enclosure 3 Map of the locations of vibro core sampling stations.

Enclosure 4. Map of the locations of box core sampling stations.

Enclosure 5. Map of the locations of gravity core sampling locations.

Enclosure 6. Map of the location of the single hydrocast.

Enclosure 7. Map of the locations of vertical profiles conducted in the coastal zone.

Enclosure 8. Map of the locations of sediments sampled for light hydrocarbon analyses.

Enclosure 9. Posted value plot of THC (total light hydrocarbons) in sediments.

1. Introduction

Increasing population densities in coastal areas, the diversity of human activities, and multiple sources of pollution all contribute to the potential for adverse environmental impacts on the marine environment in proximity to metropolitan areas. Fundamental to achieving an effective coastal zone strategy to manage the impacts of urban activities is an understanding of the effects of pollutants on marine organisms and processes.

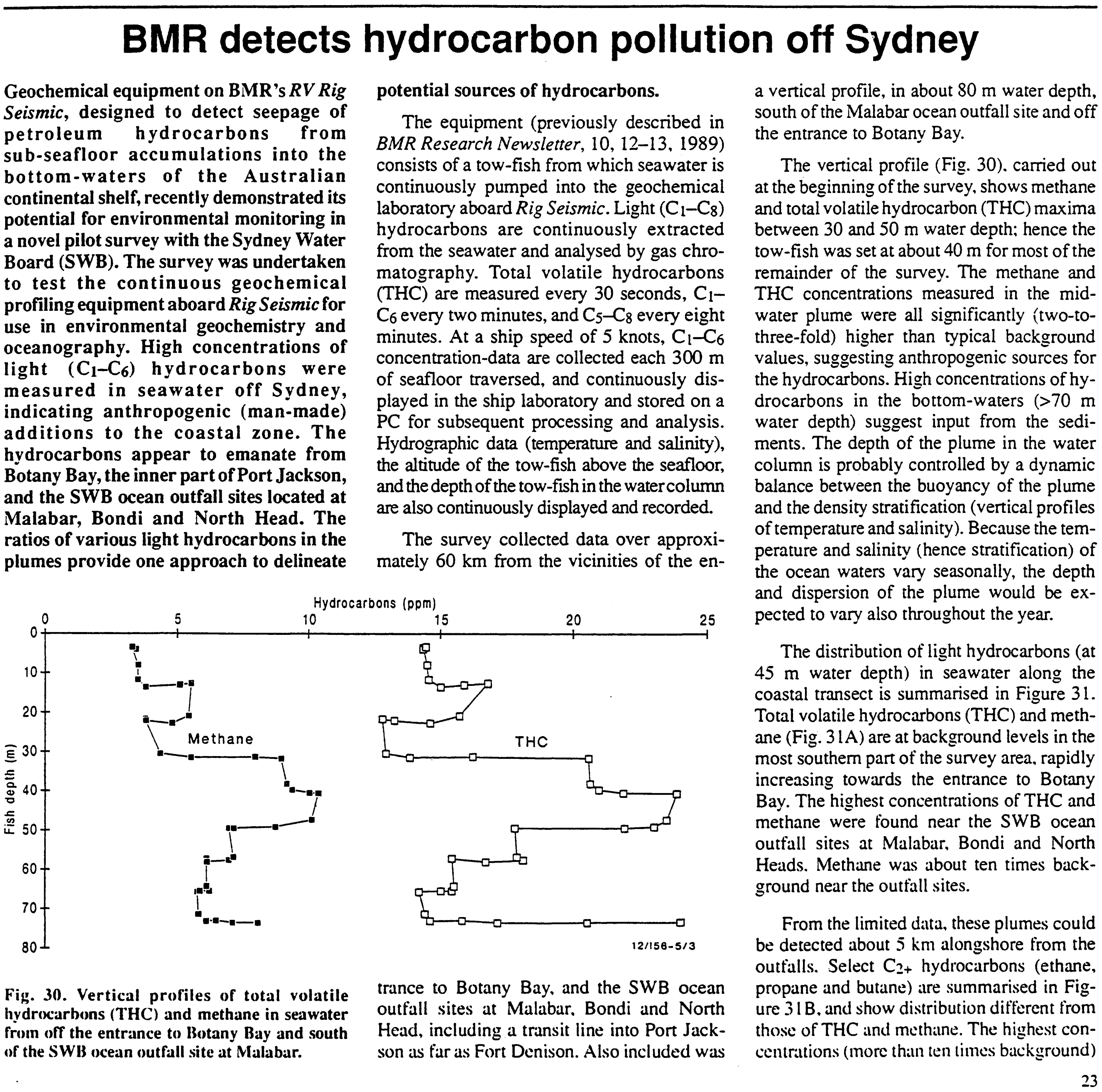
In the coastal waters near Sydney, pollutants derive from a number of sources such as sewage effluents, industrial input, agricultural runoff, stormwater discharges and non-point source urban runoff. Pollutants of concern include contaminants such as pesticides and trace metals, organic matter and nutrients, and pathogenic organisms. Many of these constituents can be introduced to the coastal zone from natural or human-derived sources.

Determining the environmental impacts of urban pollution on the marine environment requires an understanding of baseline conditions with regard to naturally-occurring marine processes in the coastal zone, particularly those that control the flow of energy and materials through the system and the recycling of many elements, such as oxygen and carbon and the essential nutrients (nitrogen and phosphorus) required to sustain the activities of the various marine communities. It also requires identification of the sources and loads of the pollutants reaching the coastal zone. As a potentially significant contributor of a number of pollutants to the coastal zone, the long term impacts of discharge of Sydney's sewage effluent through three deep water ocean outfalls are being assessed by the Water Board through ongoing monitoring and investigation.

During 1991, the Australian Geological Survey Organisations (AGSO) and the Water Board (Sydney) conducted a pilot survey to test if light hydrocarbons in seawater may be sensitive indicators of the plumes from the ocean outfalls, operated by the Water Board, which discharge into the sea offshore Sydney. The results of that survey are briefly summarised and presented in Figure 1.1. The outcomes of that survey lead to this Survey 112, and an Agreement between AGSO and the Water Board to conduct expanded scientific, baseline and process studies on the continental shelf offshore Sydney. The Environment Management Unit of the Water Board and the Marine Geoscience Program of AGSO combined facilities and skills to carry out a twelve day survey aboard the research vessel *Rig Seismic*. Three major issues were to be addressed during the survey:-

(i) Sedimentology of continental shelf sediments and the accumulation of contaminants (metals and organic toxicants) in the sediments;
(ii) Geochemical characterisation of continental shelf sediments - with special reference to the microbiology, oxygen demand and the cycling of nutrients, nitrogen and phosphorus and,
(iii) Continuous geochemical tracer studies of ocean outfalls and estuary/ocean exchanges with special reference to light hydrocarbons.

This Record: (i) documents the samples collected, analysed and inventoried for later analyses, during the joint program and, (ii) presents a preliminary interpretation and a brief summary of the results of the analyses conducted in the shipboard laboratories during the survey. The survey was focussed on the continental shelf offshore Sydney between Broken Bay and offshore Garie North Head, south of Port Hacking.



BMR detects hydrocarbon pollution off Sydney

Geochemical equipment on BMR's *RV Rig Seismic*, designed to detect seepage of petroleum hydrocarbons from sub-seafloor accumulations into the bottom-waters of the Australian continental shelf, recently demonstrated its potential for environmental monitoring in a novel pilot survey with the Sydney Water Board (SWB). The survey was undertaken to test the continuous geochemical profiling equipment aboard *Rig Seismic* for use in environmental geochemistry and oceanography. High concentrations of light (C_1–C_6) hydrocarbons were measured in seawater off Sydney, indicating anthropogenic (man-made) additions to the coastal zone. The hydrocarbons appear to emanate from Botany Bay, the inner part of Port Jackson, and the SWB ocean outfall sites located at Malabar, Bondi and North Head. The ratios of various light hydrocarbons in the plumes provide one approach to delineate potential sources of hydrocarbons.

The equipment (previously described in *BMR Research Newsletter*, 10, 12–13, 1989) consists of a tow-fish from which seawater is continuously pumped into the geochemical laboratory aboard *Rig Seismic*. Light (C_1–C_8) hydrocarbons are continuously extracted from the seawater and analysed by gas chromatography. Total volatile hydrocarbons (THC) are measured every 30 seconds, C_1–C_6 every two minutes, and C_5–C_8 every eight minutes. At a ship speed of 5 knots, C_1–C_6 concentration-data are collected each 300 m of seafloor traversed, and continuously displayed in the ship laboratory and stored on a PC for subsequent processing and analysis. Hydrographic data (temperature and salinity), the altitude of the tow-fish above the seafloor, and the depth of the tow-fish in the water column are also continuously displayed and recorded.

The survey collected data over approximately 60 km from the vicinities of the entrance to Botany Bay, and the SWB ocean outfall sites at Malabar, Bondi and North Head, including a transit line into Port Jackson as far as Fort Denison. Also included was a vertical profile, in about 80 m water depth, south of the Malabar ocean outfall site and off the entrance to Botany Bay.

Fig. 30. Vertical profiles of total volatile hydrocarbons (THC) and methane in seawater from off the entrance to Botany Bay and south of the SWB ocean outfall site at Malabar.

The vertical profile (Fig. 30), carried out at the beginning of the survey, shows methane and total volatile hydrocarbon (THC) maxima between 30 and 50 m water depth; hence the tow-fish was set at about 40 m for most of the remainder of the survey. The methane and THC concentrations measured in the mid-water plume were all significantly (two-to-three-fold) higher than typical background values, suggesting anthropogenic sources for the hydrocarbons. High concentrations of hydrocarbons in the bottom-waters (>70 m water depth) suggest input from the sediments. The depth of the plume in the water column is probably controlled by a dynamic balance between the buoyancy of the plume and the density stratification (vertical profiles of temperature and salinity). Because the temperature and salinity (hence stratification) of the ocean waters vary seasonally, the depth and dispersion of the plume would be expected to vary also throughout the year.

The distribution of light hydrocarbons (at 45 m water depth) in seawater along the coastal transect is summarised in Figure 31. Total volatile hydrocarbons (THC) and methane (Fig. 31A) are at background levels in the most southern part of the survey area, rapidly increasing towards the entrance to Botany Bay. The highest concentrations of THC and methane were found near the SWB ocean outfall sites at Malabar, Bondi and North Heads. Methane was about ten times background near the outfall sites.

From the limited data, these plumes could be detected about 5 km alongshore from the outfalls. Select C_{2+} hydrocarbons (ethane, propane and butane) are summarised in Figure 31B, and show distribution different from those of THC and methane. The highest concentrations (more than ten times background)

23

Figure 1.1 Reprint of BMR Research Newsletter article describing the pilot survey conducted in September/October 1991.

of propane and butane were found in the southern sector of the survey, near the entrance to Botany Bay and south of the outfall site off Malabar, while minor amounts of ethane (about twice background) were associated with the entrance of Botany Bay and the outfall sites off Malabar, Bondi and North Head. During the transit along Sydney Harbour, the highest concentrations of C_{2+} hydrocarbons were found toward the 'inner' harbour, as Fort Denison was approached.

Hydrocarbons added to seawater are rapidly dispersed by mixing, so that their lateral distribution may not be a unique indicator of their source. To further investigate source, a variety of cross-plots of the hydrocarbon compositions in the plumes may be used. A cross-plot of ethane vs. propane for all data collected during the survey (Fig 32) shows the data falling into three sectors: a coastal transect, the vertical profile (off Botany Bay), and the Sydney Harbour transit. Typical backgrounds plot to the left origin, while trends to higher concentrations plot away from the background, reflecting the different potential sources of hydrocarbons contributing to the anomalies.

In the plot, two types of hydrocarbon source with different ethane/propane ratios can be identified. (1) A trend of increasing ethane concentration with minor propane increase includes data from the coastal transect (Botany Bay to North Head) – including the ocean outfall sites – and data from Sydney Harbour. (2) A distinctive trend of increasing ethane with very significant propane increase includes the coastal data off the entrance to Botany Bay and the vertical profile. Thus, different generic sources of hydrocarbons can be characterised by their distinctive molecular compositions in coastal seawater samples.

The equipment on *Rig Seismic* can detect parts per billion concentrations of light hydrocarbons in seawater. The data from this pilot survey demonstrate that the equipment is very sensitive in both detecting and tracing the dispersion of light hydrocarbon plumes. Furthermore, the composition of the plumes may be used to identify generic sources of the hydrocarbons.

This continuous profiling capability aboard *Rig Seismic* is a unique tool with potentially wide application. For example, analytical instruments can be fitted to the tow-fish for continuous profiling of other parameters, such as dissolved oxygen fluorescence and turbidity in seawater, while, simultaneously, volatile compounds can be determined by instruments linked to the gas flow extracted from the seawater. This gas can be collected for subsequent shore-based isotopic analyses. Other dissolved (but non-volatile) compounds, such as seawater nutrients (nitrogen, phosphate and silicon), dissolved organic carbon, and heavy metals, can be analysed at sea, in the flowing seawater stream, or samples may be collected for later shore-based analysis.

Furthermore, continuous geochemical tracer (CGT) data can be obtained on *Rig Seismic* simultaneously with remotely sensed high-resolution seismic reflection, side-scan sonar and bathymetric data. These integrated data-collection systems have a wide range of applications in marine geoscience, including exploration for offshore resources and environmental monitoring.

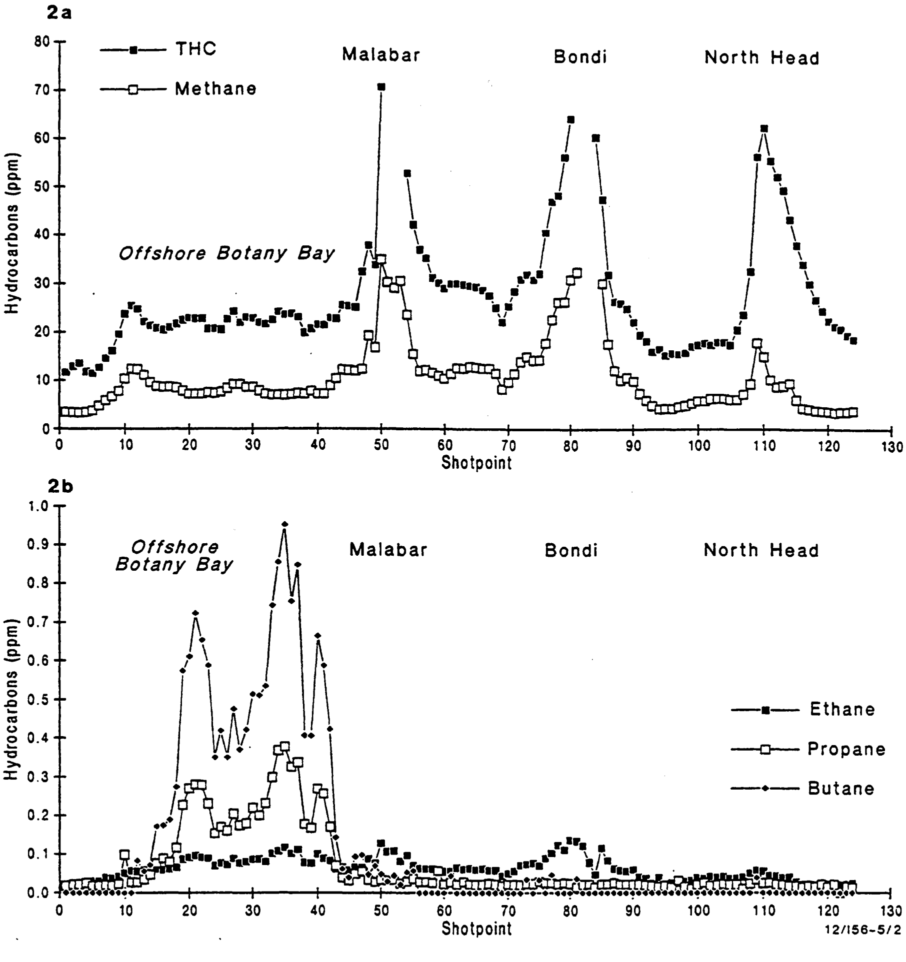


Fig. 31. A – Concentrations of total volatile hydrocarbons (THC) and methane in the coastal transect survey from Botany Bay to North Head. B – Concentrations of ethane, propane and butane in the coastal transect survey from Botany Bay to North Head.

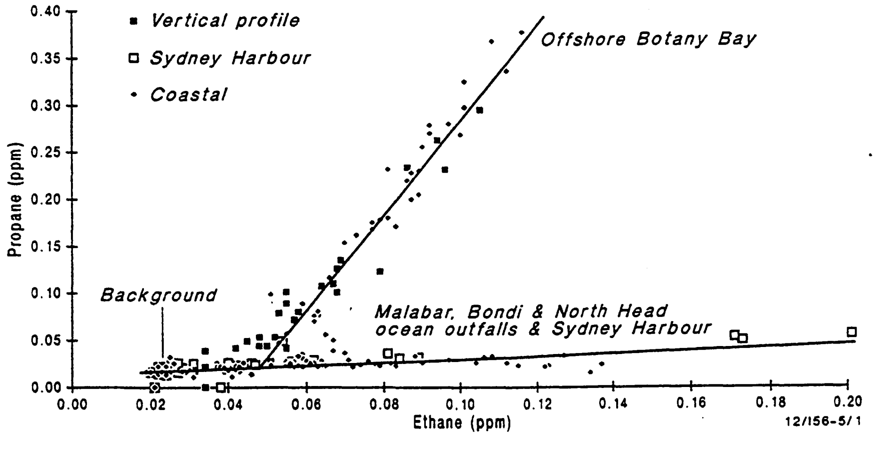


Fig 32. Cross-plot of ethane vs. propane for all data collected during the survey.

For further information contact Dr David Heggie, Mr Gary Bickford or Mr Jeremy Bishop at BMR (Marine Geosciences and Petroleum Geology Program).

BMR
GEOLOGY AND GEOPHYSICS
AUSTRALIA

The BMR Research Newsletter is published twice a year, in April and October. For further information please contact BMR Marketing & Information Section, tel. (06) 249 9623, fax 257 6466. Correspondence relating to the BMR Research Newsletter should be addressed to The Editor, BMR Research Newsletter, Bureau of Mineral Resources, GPO Box 378, Canberra ACT 2601, tel. (06) 249 9111, fax (06) 247 2728.

ISSN 0813-751 X.
B92/21419 Cat. No. 92 2018 3. Printed by Pirie Printers Pty Limited, PO Box 438, Fyshwick ACT 2609.

2. Seafloor sampling results

Multiple seafloor samples were collected for the sedimentology and geochemical programs using a variety of sampling devices . The success, or otherwise, of these sampling devices in various locations on the Australian continental margin not only provides important clues to the effectiveness of these sampling tools in different environments, but also provides insights into technological gaps that need be filled to provide the sampling requirements for various geological and geochemical programs.

Sediment samples were collected from four transects running east-west from Broken Bay, near Port Jackson, near Botany Bay and south of Port Hacking. The positions of the sampling sites, the seafloor sampler deployed, the sediment recovery and brief notes on samples collected are shown in chronological order in Table 2.1. The locations of each of the sampling sites are shown in Figure 2.1 (sample sites not numbered), and in detail in Enclosure 2.1.

Van Veen grabs

At most sites a Van Veen grab was deployed to determine the sediment type present, to collect samples for hydrocarbon and bacteriological analyses, and to collect an archive sample. The location, water depth, presence or absence of recovery and additional comments for each of the grab samples are shown in Table 2.2. The seafloor positions of the grab sample sites are shown in Figure 2.2 and Enclosure 2.2.

Of the thirty-eight Van Veen grab deployments, thirty one were successful (Table 2.6). The grab sampler was unsuccessful at Site 26 after two attempts, and also at Sites 24, 25 ,22, 21 and 20. These sites were composed of either a hard surface, or else compacted coarse grain sands that were not able to be penetrated (Table 2.2).

Vibro cores

Following a successful grab sample, a vibro core was attempted at the site. The vibro core sample was obtained within 100 metres of the grab sample site. Vibro coring was carried out using the AGSO vibro coring system, which consists of a large diameter head containing two, 415-volt electric motors. The head was attached directly to a 3 m long, 76 mm internal diameter aluminium tube, with a stainless steel core catcher attached to the leading edge. The aluminium tube is used once then replaced with a new clean tube for the next sampling attempt. The head and core tube are contained in a 4 metre steel frame. The vibro corer was deployed from the helicopter deck using the ships crane. Vibrating time was usually in the vicinity of one minute. The location of sample sites, core recovery and additional comments are detailed in Table 2.3. The position of the vibro coring sample sites are shown in Figure 2.3 and Enclosure 2.3.

The vibro corer was deployed on sixty-nine occasions with fifty of these being successful. The unsuccessful vibro cores resulted from either a hard seafloor, devoid of sediment (Sites 25,14), or mechanical failure of the equipment.

Box cores

After a successful grab, the sediment type was visually evaluated to determine whether a box core sample would be attempted. Box-coring is generally only successful in fine-grained sediments, thus the sandy sediments were generally rejected for box coring. The location, recovery and sub-sample details of the box cores are shown in Table 2.4. The position of the box core sites are shown in Figure 2.4 and Enclosure 2.4. Forty-five of seventy-seven box cores deployed successfully recovered more than ten cm of sediments (Table 2.4).

Gravity cores

Gravity cores are not usually successful when deployed on continental shelf sediments, because of the generally sandy composition of shelf sediments. Only two gravity cores were deployed during this part of the survey, and these were in a shallow depression offshore of Broken Bay, seaward of a small bathymetric high. Both deployments successfully recovered over one metre of sediment. Details of the gravity cores are presented in Table 2.5. The location of the gravity core sites are shown in Figure 2.5 and Enclosure 2.5.

Hydrocast

A hydrocast was undertaken using 20 litre Niskin bottles to collect seawater for incubation experiments. Details of the hydrocast are shown in Table 2.6, Figure 2.6 and Enclosure 2.6.

Navigation

Navigation was provided by *Rig Seismic's* on-board navigation system consisting of a Racal-based differential Global Positioning System (dGPS). During the survey the differential corrections were usually obtained using the Sydney shore station. dGPS navigation was provided for 99.2% of this portion of the survey. The noise levels were in the vicinity of 2-3 metres during sampling and 5.8 metres while the vessel was underway. All navigation details contained in this document are derived using the WGS84 system, unless otherwise specified.

Table 2.1.Seafloor sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
28	GS001	260	16:33	34 11.00	151 05.19	41.7	10	mud and sampled for LHC,HHC
28	BC001	260	18:37	34 11.01	151 05.18	40.3	<5	No sample
28	BC002	260	19:02	34 11.01	151 05.21	39.2	< 8	1 subcore for geochem - SWB was it archived?
28	BC003	260	19:36	34 11.00	151 05.19	40.3	0	Shell in jaws no sample
28	BC004	260	19:53	34 11.00	151 05.16	39.1	0	no sample
28	VC001	260	20:47	34 11.00	151 05.15	40.1	65	logged SWB,mud,fine muddy quartz sand
28	VC002	260	22:07	34 10.99	151 05.16	40.6	250 est	bent barrel and core broken - coretop lost - not logged whole sample AGSO
28	VC003	260	22:44	34 11.00	151 05.19	39.2	56	logged SWB,well sorted medium quartz sand
28	VC004	260	23:20	34 10.96	151 05.24	41.1	21	Whole core AGSO
28	VC005	260	23:58	34 11.04	151 05.15	40.2	175	logged SWB,mud drape,fine/medium muddy quartz sand
27	GS002	261	1:13	34 11.00	151 09.88	95	3/4 grab	mud - sampled for LHC. HHC, 1 SWB microbiology
27	BC005	261	1:50	34 11.03	151 09.87	101	< 1	1small bag
27	BC006	261	3:27	34 10.98	151 09.88	99.3	est 15	2 subcores SWB geochem, 3 archive bags
27	BC007	261	4:15	34 10.96	151 09.90	100	est 20	3 SWB subcores, 3 archive bags, 1 SWB subcore for interfacial contaminants
27	BC008	261	5:14	34 10.99	151 09.87	98.2	No sample	May have triggered in water
27	BC009	261	5:32	34 11.00	151 09.86	99.1	est 20	sample washed, 2 archive bags AGSO
27	BC010	261	6:09	34 10.96	151 09.89	99	est 20	4 subcores - 3 SWB geochem, 1 interfacial contaminants and sedimentology 3 archive bags
27	BC011	261	6:57	34 11.00	151 09.89	99.8	0	No sample wire broke on B/C
27	BC012	261	7:19	34 11.01	151 09.89	99.1	est 20	4 subcores - 3 SWB geochem, 1 sedimentology, 3 archive bags
26	GS003	261	8:32	34 11.06	151 13.29	123	0	No recovery
26	GS004	261	8:39	34 11.05	151 13.25	123	0	No recovery
26	BC013	261	9:07	34 11.05	151 13.28	123	0	suspect hard bottom
26	BC014	261	9:32	34 11.04	151 13.27	123	0	No recovery
26	BC015	261	10:56	34 11.07	151 13.28	123	est 25	3 sub cores - 1SWB, 2 AGSO, 2 archive bags
26	BC016	261	11:30	34 11.05	151 13.30	124	0	No recovery
25	GS005	261	12:42	34 11.05	151 16.66	136	0	No recovery
25	GS006	261	12:49	34 11.08	151 16.67	136	< 10	2 SWB geochem, 1 archive bag 1lhc,1chem

Table 2.1. Seafloor sampling sitesWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
25	BC017	261	13:10	34 11.05	151 16.67	135	0	No recovery
25	VC006	261	13:48	34 11.02	151 16.68	136	0	No recovery
25	VC007	261	14:27	34 11.02	151 16.66	136	196	Logged SWB medium/coarse shell hash
25	VC008	261	14:52	34 11.04	151 16.65	135	40	Logged SWB mud drape,medium calcareous sand
25	VC009	261	15:08	34 11.05	151 16.67	135	0	No recovery
24	GS007	261	16:23	34 11.02	151 20.07	143	0	No recovery
24	GS008	261	16:33	34 11.04	151 20.06	143	<10 gm	small amount of sand
24	GS009	261	16:44	34 11.04	151 20.10	143	<10	LHC,HHC, 1 archive bag, 1 SWB microbiology
24	VC010	261	17:20	34 11.05	151 20.09	142	20	Logged SWB,mud drape,med/coarse calcareous sand
24	VC011	261	17:50	34 11.03	151 20.09	141	168	Logged SWB,fine/med calcareous sand
23	GS010	261	18:55	34 11.04	151 23.49	150	15	sample for LHC, HHC, 2 archive bags, 1 SWB microbiology
23	BC018	261	19:37	34 11.06	151 23.46	150	<50gm sand	1Bag archive
23	VC012	261	20:08	34 11.06	151 23.46	150	122	logged SWB,mud drape,medium/coarse calcareous sand
23	VC013	261	20:46	34 11.05	151 23.48	151	<10 gms	sandy sediment 1bag no core
23	VC014	261	21:29	34 11.05	151 23.47	150	32	logged SWB,mud drape,medium/coarse calcareous sand
23	VC015	261	22:17	34 11.04	151 23.48	150	140	logged SWB,mud drape,medium calcareous sand
22	GS011	261	23:40	34 11.03	151 26.88	237	0	No recovery
22	BC019	262	0:06	34 11.03	151 26.87	237	0	No recovery
22	VC016	262	0:32	34 11.04	151 26.88	238	58	logged SWB,fine calcareous sand
22	VC017	262	1:24	34 11.04	151 26.87	238	180	logged SWB,fine silty calcareous sand
21	GS012	262	3:46	33 59.87	151 33.85	207	0	No recovery
21	BC020	262	4:09	33 59.85	151 33.85	205	<5	One small archive bag
21	BC021	262	4:38	33 59.85	151 33.85	205	<5	One small archive bag, , SWB microbiology
21	VC018	262	5:13	33 59.83	151 33.85	205	26	logged SWB,mud drape,fine/medium calcareous sand
21	VC019	262	5:44	33 59.86	151 33.85	205	280	logged SWB,fine quartz/carbonate sand
20	GS013	262	6:51	33 59.85	151 32.00	160	0	No recovery
20	BC022	262	7:12	33 59.87	151 31.98	159	< 5	1 archive bag, 1 SWB microbiology
20	VC020	262	7:44	33 59.84	151 31.98	160	0	No recovery
20	VC021	262	8:05	33 59.85	151 31 98	160	261	logged SWB,mud drape,fine/medium calcareous sand
20	VC022	262	8:24	33 59.86	151 31.99	160	140	logged SWB,fine quartz/carbonate sand
19	BC023	262	9:40	33 58.48	151 29.27	158	0	No recovery
19	BC024	262	10:07	33 58.49	151 29.28	148	0	No recovery

Table 2.1 Seafloor sampling sites WB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
19	VC023	262	10:38	33 58.49	151 29.28	148	42	logged SWB,mud drape,medium calcareous sand
19	VC024	262	11:09	33 58.50	151 29.29	148	145	logged SWB,mud drape,fine calcareous sand
18	BC025	262	12:49	34 00.96	151 24.37	133	0	Seaweed,sponge bottom growth
18	BC026	262	13:17	34 00.94	151 24.38	133	<10	1 SWB microbiology 1bag mud ,fern,rock fragments,shells
17	BC027	262	14:41	33 59.85	151 20.96	103	>10	1 chem,1lhc,1bag mud
17	BC028	262	15:21	33 59.88	151 20.97	103	15	1 SWB microbioology,1sub-core,
17	VC025	262	15:57	33 59.87	151 21.03	103	268	logged SWB,mud drape,medium quartz sand
17	VC026	262	16:27	33 59.87	151 20.99	103	176	AGSO have all the core,bent barrel
17	VC 027	262	16:48	33 59.86	151 20.99	102	118	logged SWB,mud drape,fine/medium quartz sand
16	GS014	262	17:59	33 59.82	151 17.08	81.2	10	SWB microbiology,
16	BC029	262	18:43	33 59.79	151 17.13	81.8	15	2 SWB subcores geochem,2bags 2gas samples
16	BC030	262	19:35	33 59.83	151 17.08	80.8	15	3 SWB subcores geochem,2bags,2gas samples, 1sub-core
16	BC031	262	20:17	33 59.81	151 17.07	80.4	15	1 SWB subcore1chem,1lhc,2bags mud,1sub-core
16	BC032	262	21:03	33 59.82	151 17.06	81	15	2 SWB subcores2bags,2gas samples,1sub-core
16	BC033	262	21:47	33 59.82	151 17.07	81.7	13	2 SWB subcores,2gas samples,1bag
16	VC028	262	22:34	33 59.80	151 17.08	81.2	281	whole core AGSO
16	VC029	262	22:54	33 59.83	151 17.08	81.2	0	No recovery
16	VC030	262	23:05	33 59.81	151 17.06	80.8	142	logged SWB,fine/medium quartz sand
16	VC031	262	23:32	33 59.82	151 17.07	81	0	No recovery gates failed to close
16	VC032	262	23:51	33 59.80	151 17.10	81.3	155	logged SWB,fine/medium quartz
29	GS015	263	1:36	33 52.19	151 18.56	59.1	13	SWB microbiology, LHC,HHC, 2 archive bags
30	GS016	263	2:05	33 52.26	151 19.97	65.4	12	silty sand, 3 archive bags,LHC,HHC
31	GS017	263	3:18	33 52.21	151 22.92	85	13	2bags mud for sampling
15	GS018	263	4:09	33 48.66	151 21.08	67.5	9	silty sand,SWB microbiology, 2 bags,LHC,HHC
15	VC033	263	4:28	33 48.65	151 21.07	66.7	0	No recovery core catcher washed out
15	VC034	263	4:41	33 48.66	151 21.08	66.1	63	logged SWB fine calcareous sand
15	VC035	263	4:58	33 48.66	151 21.07	65.5	14	logged SWB fine calcareous sand
15	VC036	263	5:26	33 48.66	151 21.10	66.7	0	No recovery, frame bent
14	GS019	263	6:28	33 48.65	151 25.09	110	9	2 archive bags, 1 SWB microbiology
14	BC034	263	6:46	33 48.65	151 25.08	110	35	1 SWB subcore, AGSO archive core, 1 archive bag
14	BC035	263	7:14	33 48.67	151 25.09	110	0	2 seaweed fronds,jaws open, box washed, reef sample
14	BC036	263	7:38	33 48.64	151 25.13	111	28	4 SWB geochem subcores, archive bag sample

Table 2.1 Seafloor sampling sites WB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
14	BC037	263	8:39	33 48.65	151 25.08	109	0	No recovery
14	BC038	263	9:00	33 48.66	151 25.08	109	25	3 SWB subcores,1archive bag sample
14	BC039	263	9:57	33 48.67	151 25.09	110	0	No recovery
14	VC037	263	10:26	33 48.66	151 25.08	110	58	logged SWB,mud drape,fine muddy calcareous sand
14	VC038	263	10:46	33 48.64	151 25.08	110	162	logged SWB,mud drape,fine muddy quartz sand
								Rough weather recovery, Argos transmitter decapitated
13	GS020	263	12:31	33 48.66	151 28.47	127	3/4 grab	SWB microbiological 1sub-tube, 2 archive bags LHC,HHC,
13	VC039	263	12:47	33 48.65	151 28.46	125	108	logged SWB,fine carbonate/ quartz sand
13	VC040	263	13:06	33 48.66	151 28.47	124	136	incomplete - vibrator stopped during penetration
								logged SWB fine/coarse calcareous sand
12	GS021	263	14:00	33 48.68	151 31 85	129	10	LHC, 2 archive bags
12	VC041	263	14:18	33 48.66	151 31.85	128	0	vibration stopped on seafloor no recovery
12	BC040	263	14:38	33 48.65	151 31.83	128	0	bridle and box tangled on recovery
12	BC041	263	15:02	33 48.66	151 31.86	128	8	SWB subcores,LHC,HHC,archive subcore,1 bag
12	BC042	263	15:30	33 48.66	151 31.81	130	10	1 archive bag,1 SWB subcore, LHC,HHC
11	GS022	263	16:26	33 48.65	151 35.25	140	25	SWB microbiological, SWB sedimentology,1 archive bag
11	BC043	263	16:44	33 48.65	151 35.26	140	5	1SWB microbiological, 1SWB sedimentological LHC,HHC, 1 bag archive
11	BC044	263	17:11	33 48.65	151 35.25	141	8	1SWB microbiological, 1SWB sedimentological LHC,HHC, 1 bag archive
10	GS023	263	18:12	33 48.64	151 38.59	148	<8	fine sand and silty mud, LHC,HHC,1 archive bag
10	BC045	263	18:22	33 48.66	151 38.60	149	0	No recovery
10	BC046	263	19:00	33 48.66	151 38.61	147	0	No recovery
10	BC047	263	19:22	33 48.65	151 38.61	148	25	SWB subcores contaminants and sedimentology, LHC, HHC, 1 archive bag
9	GS024	263	20:24	33 48.66	151 41.99	182	11	1SWB microbiology, LHC,HC,2 archive bags
9	BC048	263	20:53	33 48.66	151 42.00	182	0	No recovery
9	BC049	263	21:120	33 48.65	151 41.99	180	14	2 archive bags coarse sand and shell grit, 1microbioloical SWB,LHC,HHC
9	BC050	263	21:51	33 48.65	151 41.99	180	10	1 SWB microbiological
8	GS025	264	0:22	33 37.42	151 47.09	146	15	2 SWB samples microbiology , 2 archive bags,LHC.HHC
7	GS026	264	1:16	33 37.41	151 43.81	140	12	sandy sediment, 1 SWBsample, 2 archive bags, LHC,HHC
6	GS027	264	2:01	33 37.45	151 40.49	135	22	1 SWB microbiology ,2 archive bags1 s/sample R.J.
5	GS028	264	2:55	33 37.45	151 37.20	129	13	silty sand, 1 SWB microbiology, 2 archive bags LHC,HHC
5	BC051	264	3:14	33 37.45	151 37.19	128	~5	sediment washed, 1 archive bag sample
5	BC052	264	3:37	33 37.46	151 37.20	128	15	2 sub cores SWB geochem, 1 small sub core AGSO, archive bag sample

Table 2.1 Seafloor sampling sites WB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
4	GS029	264	4:48	33 37.45	151 33.88	118	30	1 SWB microbiological, 2 archive bags LHC,HHC.
4	BC053	264	5:00	33 37.45	151 33.89	118	full pen	3 SWB geochem sub-cores, 1 bag AGSO
4	BC054	264	5:44	33 37.44	151 33.87	118	full pen	3 SWB geochem, 1archive bag AGSO
4	BC055	264	6:36	33 37.45	151 33.88	119	~5	1 bag SWB, 1 bag archive
4	BC 056	264	6:59	33 37.44	151 33.87	117	22	4 SWB sub cores, 1 archive bag
3	GS030	264	8:26	33 37.45	151 30.58	88.4	full grab	2 archive bags
3	BC057	264	8:57	33 37.45	151 30.59	87.9	30	4 sub cores AGSO, 1 SWB microbiology, 2 archive bags AGSO
3	BC058	264	9:43	33 37.46	151 30.59	87.8	23	3 sub cores SWB, 1 bag AGSO
32	GS031	264	12:06	33 37.50	151 33.88	119	full grab	2 samples SWB, 2 bags AGSO
32	GC001	264	12:33	33 37.51	151 33.92	118	~120	1 core AGSO
32	GC002	264	13:19	33 37.50	151 33.97	120	~120	1 core AGSO
10	VC042	264	15:39	33 48.65	151 38.60	148	69	logged SWB,mud drape,medium calcareous sand
10	VC043	264	15:56	33 48.66	151 38.60	149	37	logged SWB,mud drape fine calcareous sand
10	VC044	264	16:10	33 48.66	151 38.60	148	131	AGSO core for geochemistry 0-31 missing
9	VC045	264	17:05	33 48.67	151 41.98	182	202	logged SWB,mud drape,medium /coarse calcareous sand
9	VC046	264	17:25	33 48.66	151 41.98	182	174	logged SWB,mud drape,fine/medium calcareous sand
8	VC047	264	19:22	33 37.45	151 47.16	146	100	logged SWB,fine/medium calcareous sand
8	VC048	264	19:41	33 37.45	151 47.19	146	110	logged SWB,mud drape,fine/medium calcareous sand
7	VC049	264	20:38	33 37.45	151 43.80	140	34.5	logged SWB,fine calcareous sand/core catcher & tube deformed due to hard base
7	VC050	264	20:58	33 37.45	151 43.80	140	45	logged SWB mud drape,fine calc. sand, core catcher & tube deformed due to hard base
6	VC051	264	21:51	33 37.43	151 40.48	134	26	logged SWB,mud drape,medium calcareous sand
6	VC052	264	22:11	33 37.42	151 40.48	134	127	logged SWB,mud drape,fine muddy calcareous sand
6	VC053	264	22:31	33 37.43	151 40.49	134	15	AGSO geochem 15 cms recovery
5	VC054	264	23:26	33 37.46	151 37.17	128	100	logged SWB,fine muddy quartz sand
5	VC055	264	23:45	33 37.47	151 37.18	128	148	logged SWB,fine muddy sand
4	VC056	265	0:36	33 37.48	151 33.86	118	129	logged SWB,fine silty mud
4	VC057	265	0:53	33 37.46	151 33.89	118	212	logged SWB, muddy fine/medium quartz sand
32	BC059	265	2:10	33 37.53	151 33.83	118	18	2 archive bags/ AGSO core/2 SWB sedimentology
32	BC060	265	2:38	33 37.51	151 33.81	118	16	2 archive bags/2 SWB sedimentary samples
32	VC058	265	3:05	33 37.52	151 33.80	118	245	AGSO all the core for geochemistry samples
33	GS032	265	4:03	33 37.53	151 31.72	87.9	3/4 grab	LHC,HHC, 2 archive bags
33	BC061	265	4:22	33 37.51	151 31.69	87.8	18	2 archive bags, LHC, HHC,1 AGSO archive core, 2 sedimentary SWB

Table 2.1 Seafloor sampling sites WB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
33	BC062	265	4:50	33 37.51	151 31.71	97.8	15	2 archive bags LHC,HHC
3	VC059	265	5:37	33 37.46	151 30.57	89.3	126	logged SWB,fine muddy quartz sand
3	VC060	265	5:54	33 37.46	151 30.59	89.5	78	logged SWB,fine fluidised mud,fine calcareous sand
2	GS033	265	6:54	33 37.45	151 26.29	58.8	10	2 archive bags AGSO/1 microbiology SWB.LHC,HHC.
2	VC061	265	7:08	33 37.47	151 26.28	47.4	220	logged SWB,mud drape, medium quartz sand
2	VC062	265	7:20	33 37.47	151 26.28	57.8	80	logged SWB,mud drape, fine/medium quartz sand
1	GS034	265	8:15	33 37.47	151 22.60	46.3	12	1 archive bag AGSO, 1 microbiology SWB
1	VC063	265	8:24	33 37.47	151 22.60	46.7	198	logged SWB,mud drape, medium quartz sand bent core barrel
1	VC064	265	8:50	33 37.45	151 22.62	46	202	logged SWB,mud drape, medium quartz sand bent core barrel
31	GS035	265	11:18	33 52.22	151 22.90	92.6	10	1 archive bag AGSO. LHC,HHC
31	BC063	265	11:38	33 52.21	151 22.89	90.8	40	4 sub cores SWB, 1 archive bag AGSO
31	BC064	265	12:25	33 52.18	151 22.90	90.9	40	4 sub cores SWB / 1 archive bag AGSO
31	BC065	265	13:18	33 52.19	151 22.93	92.2	45	2 sub cores SWB/1 sub core 1 archive bag AGSO
34	GS036	265	14:51	33 52.21	151 23.00	94	112	2 archive bags AGSO
34	BC066	265	15:13	33 52.21	151 23.00	93.6	38	1 archive bag, LHC, HHC, 1 archive sub core AGSO
34	BC067	265	15:46	33 52.22	151 23.00	94	40	1 archive bag, LHC, HHC, 1 archive sub core AGSO
34	VC065	265	16:18	33 52.21	151 23.0	94.1	190	core subsampled for geochem AGSO ,LHC,HHC.
35	GS037	265	17:05	33 52.22	151 21.5	75.3	1/2 grab	muddy sand,LHC,HHC,1bag
35	BC068	265	17:22	33 52.21	151 21.5	75	35	geochem LHC,HHC and bag of sediment AGSO
35	BC069	265	17:43	33 52.21	151 21.5	74	36	geochem LHC,HHC and bag of sediment AGSO
35	VC066	265	18:02	33 52.19	151 21.49	73.8	92	barrel bent on recovery, wire angle acute
36	GS038	265	19:30	33 58.90	151 17.43	80.1	13	near Malabar outfall, 1 archive bag, LHC,HHC
36	BC070	265	19:47	33 58.89	151 17.44	79.7	40	2 archive bags, LHC, HHC(4tins)
36	BC071	265	20:32	34 00.20	151 17.08	84	40	2 archive bags, 2LHC,2HHC,1 subcore
38	BC072	265	21:08	33 59.91	151 17.069	82.4	44	1 subcore, 2 archive bags, 2LHC,2HHC
39	BC073	265	21:47	33 59.20	151 17.97	83.3	42	2 archive bags, 2LHC,2HHC
37	VC067	265	22:18	33 59.23	151 17.96	84.2	26	core for hydrocarbon geochemistry (1 sample only)
14	VC068	267	0:19	33 48.67	151 25.09	110	0	No recovery
14	VC069	267	0:37	33 48.63	151 25.08	110	150	all core at AGSO
36	BC074	267	4:17	33 58.91	151 17.98	84.1	40	4 sub cores SWB, 2 archive bags AGSO
36	BC075	267	5:08	33 58.91	151 17.98	83.9	40	4 sub cores SWB, 1 archive bag AGSO
36	BC076	267	5:51	33 58.92	151 17.97	83.1	38	2 sub cores SWB, 1 sub core and 2 archive bags AGSO

Table 2.1 Seafloor sampling sites WB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
16	BC077	267	7:06	33 59.84	151 17.00	81.6	44	2 sub cores SWB, 2 archive bags AGSO
9	HC001	267	10:58	33 51.80	151 18.17	61	yes	water sample at 20 m and 30 m

Table 2.1 Seafloor sampling sites `WB/AGSO program

Table 2.2 Grab sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
28	GS001	260	16:33	34 11.00	151 05.19	41.7	10	mud and sampled for LHC,HHC
27	GS002	261	1:13	34 11.00	151 09.88	95	3/4 grab	mud - sampled for LHC. HHC, 1 SWB microbiology
26	GS003	261	8:32	34 11.06	151 13.29	123	0	No recovery
26	GS004	261	8:39	34 11.05	151 13.25	123	0	No recovery
25	GS005	261	12:42	34 11.05	151 16.66	136	0	No recovery
25	GS006	261	12:49	34 11.08	151 16.67	136	< 10	2 SWB geochem, 1 archive bag 1lhc,1chem
24	GS007	261	16:23	34 11.02	151 20.07	143	0	No recovery
24	GS008	261	16:33	34 11.04	151 20.06	143	<10 gm	small amount of sand
24	GS009	261	16:44	34 11.04	151 20.10	143	<10	LHC,HHC, 1 archive bag, 1 SWB microbiology
23	GS010	261	18:55	34 11.04	151 23.49	150	15	sample for LHC, HHC, 2 archive bags, 1 SWB microbiology
22	GS011	261	23:40	34 11.03	151 26.88	237	0	No recovery
21	GS012	262	3:46	33 59.87	151 33.85	207	0	No recovery
20	GS013	262	6:51	33 59.85	151 32.00	160	0	No recovery
16	GS014	262	17:59	33 59.82	151 17.08	81.2	10	SWB microbiology,
29	GS015	263	1:36	33 52.19	151 18.56	59.1	13	SWB microbiology, LHC,HHC, 2 archive bags
30	GS016	263	2:05	33 52.26	151 19.97	65.4	12	silty sand, 3 archive bags,LHC,HHC
31	GS017	263	3:18	33 52.21	151 22.92	85	13	2bags mud for sampling
15	GS018	263	4:09	33 48.66	151 21.08	67.5	9	silty sand,SWB microbiology, 2 bags,LHC,HHC
14	GS019	263	6:28	33 48.65	151 25.09	110	9	2 archive bags, 1 SWB microbiology
13	GS020	263	12:31	33 48.66	151 28.47	127	3/4 grab	SWB microbiological 1sub-tube, 2 archive bags LHC,HHC,
12	GS021	263	14:00	33 48.68	151 31 85	129	10	LHC, 2 archive bags
11	GS022	263	16:26	33 48.65	151 35.25	140	25	SWB microbiological, SWB sedimentology,1 archive bag
10	GS023	263	18:12	33 48.64	151 38.59	148	<8	fine sand and silty mud, LHC,HHC,1 archive bag
9	GS024	263	20:24	33 48.66	151 41.99	182	11	1SWB microbiology, LHC,HC,2 archive bags
8	GS025	264	0:22	33 37.42	151 47.09	146	15	2 SWB samples microbiology , 2 archive bags,LHC.HHC
7	GS026	264	1:16	33 37.41	151 43.81	140	12	sandy sediment, 1 SWBsample, 2 archive bags, LHC,HHC
6	GS027	264	2:01	33 37.45	151 40.49	135	22	1 SWB microbiology ,2 archive bags1 s/sample R.J.
5	GS028	264	2:55	33 37.45	151 37.20	129	13	silty sand, 1 SWB microbiology, 2 archive bags LHC,HHC
4	GS029	264	4:48	33 37.45	151 33.88	118	30	1 SWB microbiological, 2 archive bags LHC,HHC.
3	GS030	264	8:26	33 37.45	151 30.58	88.4	full grab	2 archive bags
32	GS031	264	12:06	33 37.50	151 33.88	119	full grab	2 samples SWB, 2 bags AGSO

Table 2.2 Grab sample sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD	Recovery	Comment
						(m)	(cm)	
33	GS032	265	4:03	33 37.53	151 31.72	87.9	3/4 grab	LHC,HHC, 2 archive bags
2	GS033	265	6:54	33 37.45	151 26.29	58.8	10	2 archive bags AGSO/1 microbiology SWB.LHC,HHC.
1	GS034	265	8:15	33 37.47	151 22.60	46.3	12	1 archive bag AGSO, 1 microbiology SWB
31	GS035	265	11:18	33 52.22	151 22.90	92.6	10	1 archive bag AGSO. LHC,HHC
34	GS036	265	14:51	33 52.21	151 23.00	94	112	2 archive bags AGSO
35	GS037	265	17:05	33 52.22	151 21.5	75.3	1/2 grab	muddy sand,LHC,HHC,1bag
36	GS038	265	19:30	33 58.90	151 17.43	80.1	13	near Malabar outfall, 1 archive bag, LHC,HHC

Table 2.2 Grab sample sites SWB/AGSO program

Table 2.3 Vibrocore sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
28	VC001	260	20:47	34 11.00	151 05.15	40.1	65	logged SWB,mud,fine muddy quartz sand
28	VC002	260	22:07	34 10.99	151 05.16	40.6	250 est	bent barrel and core broken - coretop lost - not logged whole sample AGSO
28	VC003	260	22:44	34 11.00	151 05.19	39.2	56	logged SWB,well sorted medium quartz sand
28	VC004	260	23:20	34 10.96	151 05.24	41.1	21	Whole core AGSO
28	VC005	260	23:58	34 11.04	151 05.15	40.2	175	logged SWB,mud drape,fine/medium muddy quartz sand
25	VC006	261	13:48	34 11.02	151 16.68	136	0	No recovery
25	VC007	261	14:27	34 11.02	151 16.66	136	196	Logged SWB medium/coarse shell hash
25	VC008	261	14:52	34 11.04	151 16.65	135	40	Logged SWB mud drape,medium calcareous sand
25	VC009	261	15:08	34 11.05	151 16.67	135	0	No recovery
24	VC010	261	17:20	34 11.05	151 20.09	142	20	Logged SWB,mud drape,med/coarse calcareous sand
24	VC011	261	17:50	34 11.03	151 20.09	141	168	Logged SWB,fine/med calcareous sand
23	VC012	261	20:08	34 11.06	151 23.46	150	122	logged SWB,mud drape,medium/coarse calcareous sand
23	VC013	261	20:46	34 11.05	151 23.48	151	<10 gms	sandy sediment 1bag no core
23	VC014	261	21:29	34 11.05	151 23.47	150	32	logged SWB,mud drape,medium/coarse calcareous sand
23	VC015	261	22:17	34 11.04	151 23.48	150	140	logged SWB,mud drape,medium calcareous sand
22	VC016	262	0:32	34 11.04	151 26.88	238	58	logged SWB,fine calcareous sand
22	VC017	262	1:24	34 11.04	151 26.87	238	180	logged SWB,fine silty calcareous sand
21	VC018	262	5:13	33 59.83	151 33.85	205	26	logged SWB,mud drape,fine/medium calcareous sand
21	VC019	262	5:44	33 59.86	151 33.85	205	280	logged SWB,fine quartz/carbonate sand
20	VC020	262	7:44	33 59.84	151 31.98	160	0	No recovery
20	VC021	262	8:05	33 59.85	151 31 98	160	261	logged SWB,mud drape,fine/medium calcareous sand
20	VC022	262	8:24	33 59.86	151 31.99	160	140	logged SWB,fine quartz/carbonate sand
19	VC023	262	10:38	33 58.49	151 29.28	148	42	logged SWB,mud drape,medium calcareous sand
19	VC024	262	11:09	33 58.50	151 29.29	148	145	logged SWB,mud drape,fine calcareous sand
17	VC025	262	15:57	33 59.87	151 21.03	103	268	logged SWB,mud drape,medium quartz sand
17	VC026	262	16:27	33 59.87	151 20.99	103	176	AGSO have all the core,bent barrel
17	VC027	262	16:48	33 59.86	151 20.99	102	118	logged SWB,mud drape,fine/medium quartz sand
16	VC028	262	22:34	33 59.80	151 17.08	81.2	281	whole core AGSO
16	VC029	262	22:54	33 59.83	151 17.08	81.2	0	No recovery
16	VC030	262	23:05	33 59.81	151 17.06	80.8	142	logged SWB,fine/medium quartz sand
16	VC031	262	23:32	33 59.82	151 17.07	81	0	No recovery gates failed to close

Table 2.3 Vibrocore sampling sites SWB/AGSO program

16	VC032	262	23:51	33 59.80	151 17.10	81.3	155	logged SWB,fine/medium quartz
15	VC033	263	4:28	33 48.65	151 21.07	66.7	0	No recovery core catcher washed out
15	VC034	263	4:41	33 48.66	151 21.08	66.1	63	logged SWB fine calcareous sand
15	VC035	263	4:58	33 48.66	151 21.07	65.5	14	logged SWB fine calcareous sand
15	VC036	263	5:26	33 48.66	151 21.10	66.7	0	No recovery, frame bent
14	VC037	263	10:26	33 48.66	151 25.08	110	58	logged SWB,mud drape,fine muddy calcareous sand
14	VC038	263	10:46	33 48.64	151 25.08	110	162	logged SWB,mud drape,fine muddy quartz sand
								Rough weather recovery, Argos transmitter decapitated
13	VC039	263	12:47	33 48.65	151 28.46	125	108	logged SWB,fine carbonate/ quartz sand
13	VC040	263	13:06	33 48.66	151 28.47	124	136	incomplete - vibrator stopped during penetration
								logged SWB fine/coarse calcareous sand
12	VC041	263	14:18	33 48.66	151 31.85	128	0	vibration stopped on seafloor no recovery
10	VC042	264	15:39	33 48.65	151 38.60	148	69	logged SWB,mud drape,medium calcareous sand
10	VC043	264	15:56	33 48.66	151 38.60	149	37	logged SWB,mud drape fine calcareous sand
10	VC044	264	16:10	33 48.66	151 38.60	148	131	AGSO core for geochemistry 0-31 missing
9	VC045	264	17:05	33 48.67	151 41.98	182	202	logged SWB,mud drape,medium /coarse calcareous sand
9	VC046	264	17:25	33 48.66	151 41.98	182	174	logged SWB,mud drape,fine/medium calcareous sand
8	VC047	264	19:22	33 37.45	151 47.16	146	100	logged SWB,fine/medium calcareous sand
8	VC048	264	19:41	33 37.45	151 47.19	146	110	logged SWB,mud drape,fine/medium calcareous sand
7	VC049	264	20:38	33 37.45	151 43.80	140	34.5	logged SWB,fine calcareous sand/core catcher & tube deformed due to hard base
7	VC050	264	20:58	33 37.45	151 43.80	140	45	logged SWB mud drape,fine calc. sand, core catcher & tube deformed due to hard bas
6	VC051	264	21:51	33 37.43	151 40.48	134	26	logged SWB,mud drape,medium calcareous sand
6	VC052	264	22:11	33 37.42	151 40.48	134	127	logged SWB,mud drape,fine muddy calcareous sand
6	VC053	264	22:31	33 37.43	151 40.49	134	15	AGSO geochem 15 cms recovery
5	VC054	264	23:26	33 37.46	151 37.17	128	100	logged SWB,fine muddy quartz sand
5	VC055	264	23:45	33 37.47	151 37.18	128	148	logged SWB,fine muddy sand
4	VC056	265	0:36	33 37.48	151 33.86	118	129	logged SWB,fine silty mud
4	VC057	265	0:53	33 37.46	151 33.89	118	212	logged SWB, muddy fine/medium quartz sand
32	VC058	265	3:05	33 37.52	151 33.80	118	245	AGSO all the core for geochemistry samples
3	VC059	265	5:37	33 37.46	151 30.57	89.3	126	logged SWB,fine muddy quartz sand
3	VC060	265	5:54	33 37.46	151 30.59	89.5	78	logged SWB,fine fluidised mud,fine calcareous sand
2	VC061	265	7:08	33 37.47	151 26.28	47.4	220	logged SWB,mud drape, medium quartz sand
2	VC062	265	7:20	33 37.47	151 26.28	57.8	80	logged SWB,mud drape, fine/medium quartz sand
1	VC063	265	8:24	33 37.47	151 22.60	46.7	198	logged SWB,mud drape, medium quartz sand bent core barrel

Table 2.3 Vibrocore sampling sites SWB/AGSO program

1	VC064	265	8:50	33 37.45	151 22.62	46	202	logged SWB,mud drape, medium quartz sand bent core barrel
34	VC065	265	16:18	33 52.21	151 23.0	94.1	190	core subsampled for geochem AGSO ,LHC,HHC.
35	VC066	265	18:02	33 52.19	151 21.49	73.8	92	barrel bent on recovery, wire angle acute
37	VC067	265	22:18	33 59.23	151 17.96	84.2	26	core for hydrocarbon geochemistry (1 sample only)
14	VC068	267	0:19	33 48.67	151 25.09	110	0	No recovery
14	VC069	267	0:37	33 48.63	151 25.08	110	150	all core at AGSO

Table 2.3 Vibrocore sampling sites SWB/AGSO program

Table 2.4 Boxcore sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
28	BC001	260	18:37	34 11.01	151 05.18	40.3	<5	No sample
28	BC002	260	19:02	34 11.01	151 05.21	39.2	< 8	1 subcore for geochem - SWB was it archived?
28	BC003	260	19:36	34 11.00	151 05.19	40.3	0	Shell in jaws no sample
28	BC004	260	19:53	34 11.00	151 05.16	39.1	0	no sample
27	BC005	261	1:50	34 11.03	151 09.87	101	< 1	1small bag
27	BC006	261	3:27	34 10.98	151 09.88	99.3	est 15	2 subcores SWB geochem, 3 archive bags
27	BC007	261	4:15	34 10.96	151 09.90	100	est 20	3 SWB subcores, 3 archive bags, 1 SWB subcore for interfacial contaminants
27	BC008	261	5:14	34 10.99	151 09.87	98.2	No sample	May have triggered in water
27	BC009	261	5:32	34 11.00	151 09.86	99.1	est 20	sample washed, 2 archive bags AGSO
27	BC010	261	6:09	34 10.96	151 09.89	99	est 20	4 subcores - 3 SWB geochem, 1 interfacial contaminants and sedimentology
								3 archive bags
27	BC011	261	6:57	34 11.00	151 09.89	99.8	0	No sample wire broke on B/C
27	BC012	261	7:19	34 11.01	151 09.89	99.1	est 20	4 subcores - 3 SWB geochem, 1 sedimentology, 3 archive bags
26	BC013	261	9:07	34 11.05	151 13.28	123	0	suspect hard bottom
26	BC014	261	9:32	34 11.04	151 13.27	123	0	No recovery
26	BC015	261	10:56	34 11.07	151 13.28	123	est 25	3 sub cores - 1SWB, 2 AGSO, 2 archive bags
26	BC016	261	11:30	34 11.05	151 13.30	124	0	No recovery
25	BC017	261	13:10	34 11.05	151 16.67	135	0	No recovery
23	BC018	261	19:37	34 11.06	151 23.46	150	<50gm sand	1Bag archive
22	BC019	262	0:06	34 11.03	151 26.87	237	0	No recovery
21	BC020	262	4:09	33 59.85	151 33.85	205	<5	One small archive bag
21	BC021	262	4:38	33 59.85	151 33.85	205	<5	One small archive bag, , SWB microbiology
20	BC022	262	7:12	33 59.87	151 31.98	159	< 5	1 archive bag, 1 SWB microbiology
19	BC023	262	9:40	33 58.48	151 29.27	158	0	No recovery
19	BC024	262	10:07	33 58.49	151 29.28	148	0	No recovery
18	BC025	262	12:49	34 00.96	151 24.37	133	0	Seaweed,sponge bottom growth
18	BC026	262	13:17	34 00.94	151 24.38	133	<10	1 SWB microbiology 1bag mud ,fern,rock fragments,shells
17	BC027	262	14:41	33 59.85	151 20.96	103	>10	1 chem,1lhc,1bag mud
17	BC028	262	15:21	33 59.88	151 20.97	103	15	1 SWB microbioology,1sub-core,
16	BC029	262	18:43	33 59.79	151 17.13	81.8	15	2 SWB subcores geochem,2bags 2gas samples
16	BC030	262	19:35	33 59.83	151 17.08	80.8	15	3 SWB subcores geochem,2bags,2gas samples, 1sub-core

Table 2.4 Boxcore sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD	Recovery	Comment
						(m)	(cm)	
16	BC031	262	20:17	33 59.81	151 17.07	80.4	15	1 SWB subcore1chem,1lhc,2bags mud,1sub-core
16	BC032	262	21:03	33 59.82	151 17.06	81	15	2 SWB subcores2bags,2gas samples,1sub-core
16	BC033	262	21:47	33 59.82	151 17.07	81.7	13	2 SWB subcores,2gas samples,1bag
14	BC034	263	6:46	33 48.65	151 25.08	110	35	1 SWB subcore, AGSO archive core, 1 archive bag
14	BC035	263	7:14	33 48.67	151 25.09	110	0	2 seaweed fronds,jaws open, box washed, reef sample
14	BC036	263	7:38	33 48.64	151 25.13	111	28	4 SWB geochem subcores, archive bag sample
14	BC037	263	8:39	33 48.65	151 25.08	109	0	No recovery
14	BC038	263	9:00	33 48.66	151 25.08	109	25	3 SWB subcores,1archive bag sample
14	BC039	263	9:57	33 48.67	151 25.09	110	0	No recovery
12	BC040	263	14:38	33 48.65	151 31.83	128	0	bridle and box tangled on recovery
12	BC041	263	15:02	33 48.66	151 31.86	128	8	SWB subcores,LHC,HHC,archive subcore,1 bag
12	BC042	263	15:30	33 48.66	151 31.81	130	10	1 archive bag,1 SWB subcore, LHC,HHC
11	BC043	263	16:44	33 48.65	151 35.26	140	5	1SWB microbiological, 1SWB sedimentological LHC,HHC, 1 bag archive
11	BC044	263	17:11	33 48.65	151 35.25	141	8	1SWB microbiological, 1SWB sedimentological LHC,HHC, 1 bag archive
10	BC045	263	18:22	33 48.66	151 38.60	149	0	No recovery
10	BC046	263	19:00	33 48.66	151 38.61	147	0	No recovery
10	BC047	263	19:22	33 48.65	151 38.61	148	25	SWB subcores contaminants and sedimentology, LHC, HHC, 1 archive bag
9	BC048	263	20:53	33 48.66	151 42.00	182	0	No recovery
9	BC049	263	21:120	33 48.65	151 41.99	180	14	2 archive bags coarse sand and shell grit, 1microbioloical SWB,LHC,HHC
9	BC050	263	21:51	33 48.65	151 41.99	180	10	1 SWB microbiological
5	BC051	264	3:14	33 37.45	151 37.19	128	~5	sediment washed, 1 archive bag sample
5	BC052	264	3:37	33 37.46	151 37.20	128	15	2 sub cores SWB geochem, 1 small sub core AGSO, archive bag sample
4	BC053	264	5:00	33 37.45	151 33.89	118	full pen	3 SWB geochem sub-cores, 1 bag AGSO
4	BC054	264	5:44	33 37.44	151 33.87	118	full pen	3 SWB geochem, 1archive bag AGSO
4	BC055	264	6:36	33 37.45	151 33.88	119	~5	1 bag SWB, 1 bag archive
4	BC056	264	6:59	33 37.44	151 33.87	117	22	4 SWB sub cores, 1 archive bag
3	BC057	264	8:57	33 37.45	151 30.59	87.9	30	4 sub cores AGSO, 1 SWB microbiology, 2 archive bags AGSO
3	BC058	264	9:43	33 37.46	151 30.59	87.8	23	3 sub cores SWB, 1 bag AGSO
32	BC059	265	2:10	33 37.53	151 33.83	118	18	2 archive bags/ AGSO core/2 SWB sedimentology
32	BC060	265	2:38	33 37.51	151 33.81	118	16	2 archive bags/2 SWB sedimentary samples
33	BC061	265	4:22	33 37.51	151 31.69	87.8	18	2 archive bags, LHC, HHC,1 AGSO archive core, 2 sedimentary SWB
33	BC062	265	4:50	33 37.51	151 31.71	97.8	15	2 archive bags LHC,HHC

Table 2.4 Boxcore sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
31	BC063	265	11:38	33 52.21	151 22.89	90.8	40	4 sub cores SWB, 1 archive bag AGSO
31	BC064	265	12:25	33 52.18	151 22.90	90.9	40	4 sub cores SWB / 1 archive bag AGSO
31	BC065	265	13:18	33 52.19	151 22.93	92.2	45	2 sub cores SWB/1 sub core 1 archive bag AGSO
34	BC066	265	15:13	33 52.21	151 23.00	93.6	38	1 archive bag, LHC, HHC, 1 archive sub core AGSO
34	BC067	265	15:46	33 52.22	151 23.00	94	40	1 archive bag, LHC, HHC, 1 archive sub core AGSO
35	BC068	265	17:22	33 52.21	151 21.5	75	35	geochem LHC,HHC and bag of sediment AGSO
35	BC069	265	17:43	33 52.21	151 21.5	74	36	geochem LHC,HHC and bag of sediment AGSO
36	BC070	265	19:47	33 58.89	151 17.44	79.7	40	2 archive bags, LHC, HHC(4tins)
36	BC071	265	20:32	34 00.20	151 17.08	84	40	2 archive bags, 2LHC,2HHC,1 subcore
38	BC072	265	21:08	33 59.91	151 17.069	82.4	44	1 subcore, 2 archive bags, 2LHC,2HHC
39	BC073	265	21:47	33 59.20	151 17.97	83.3	42	2 archive bags, 2LHC,2HHC
36	BC074	267	4:17	33 58.91	151 17.98	84.1	40	4 sub cores SWB, 2 archive bags AGSO
36	BC075	267	5:08	33 58.91	151 17.98	83.9	40	4 sub cores SWB, 1 archive bag AGSO
36	BC076	267	5:51	33 58.92	151 17.97	83.1	38	2 sub cores SWB, 1 sub core and 2 archive bags AGSO
16	BC077	267	7:06	33 59.84	151 17.00	81.6	44	2 sub cores SWB, 2 archive bags AGSO

Table 2.4 Boxcore sampling sites SWB/AGSO program

Table 2.5 Gravity core sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD (m)	Recovery (cm)	Comment
32	GC001	264	12:33	33 37.51	151 33.92	118	~120	1 core AGSO
32	GC002	264	13:19	33 37.50	151 33.97	120	~120	1 core AGSO

Table 2.5 Gravity core sampling sites

Table 2.6 Hydrocast sampling sites SWB/AGSO program

Site	Sample	J'day	GMT	Lat.	Long.	WD	Recovery	Comment		
						(m)	(cm)			
9	HC001	267	10:58	33 51.80	151 18.17	61	yes	water sample at 20 m and 30 m		

Table 2.6 Hydrocast sampling site

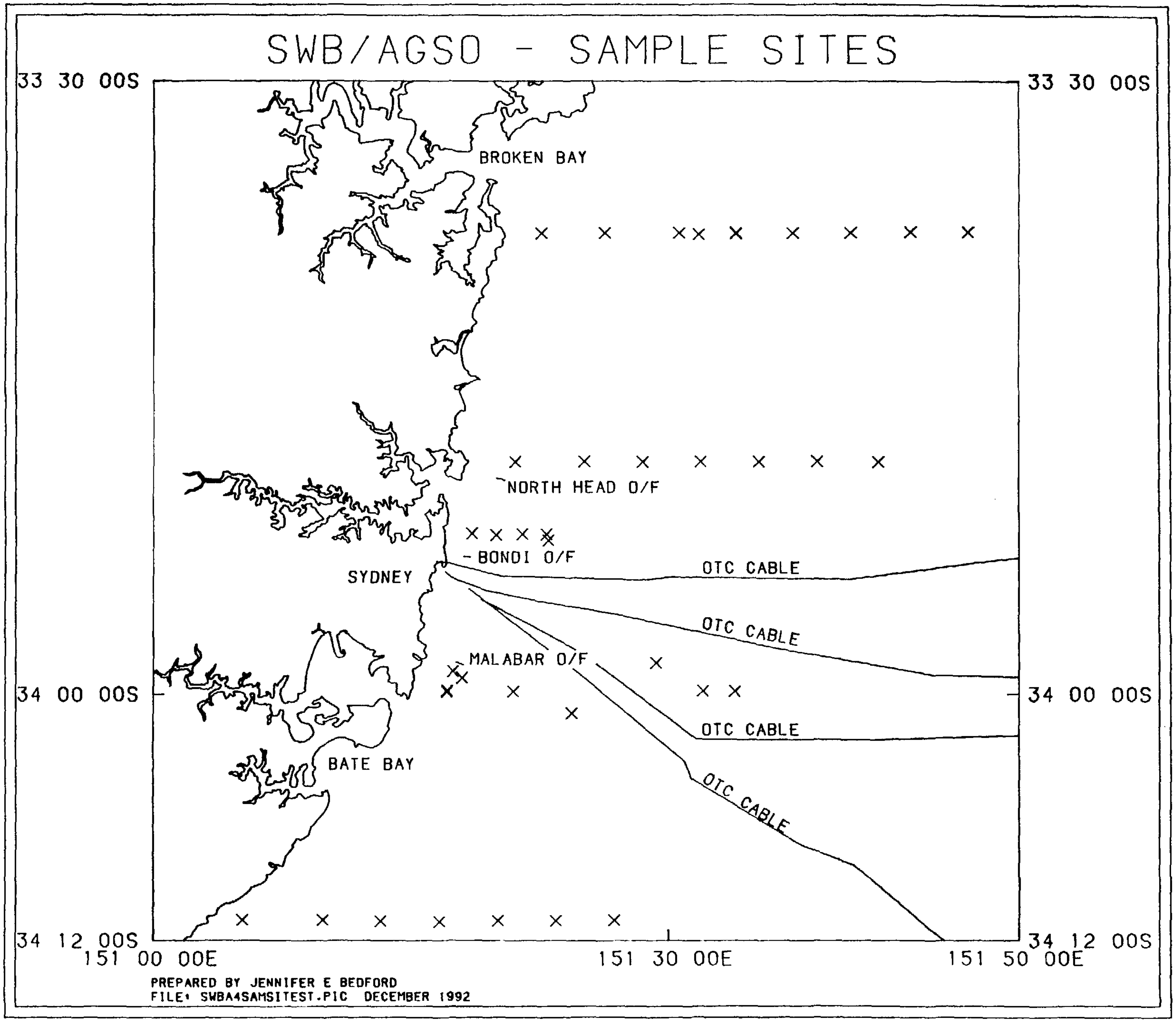


Figure 2.1 Map of all seafloor sampling sites AGSO/WB project.

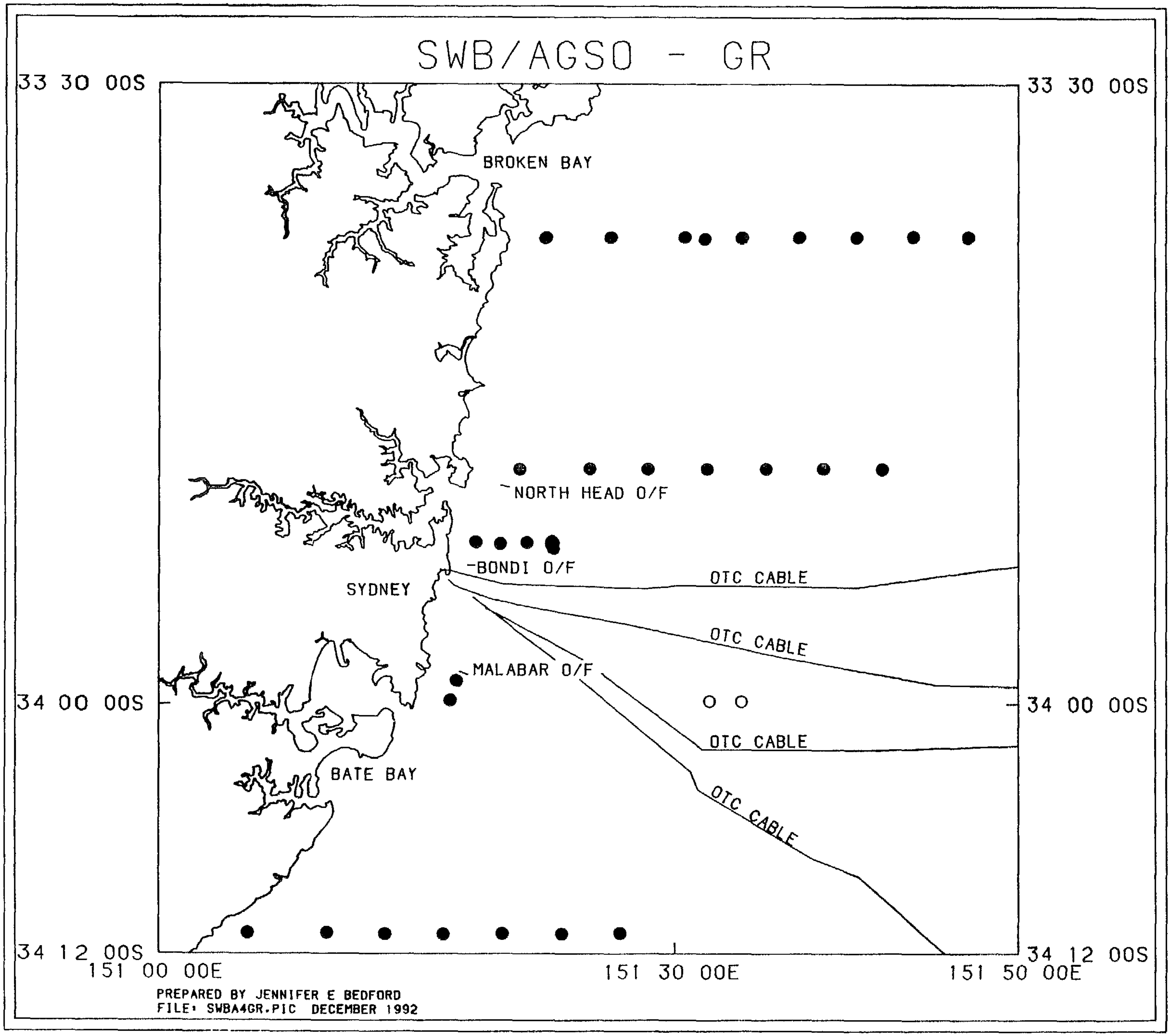


Figure 2.2 Map of all grab sample locations AGSO/WB project.

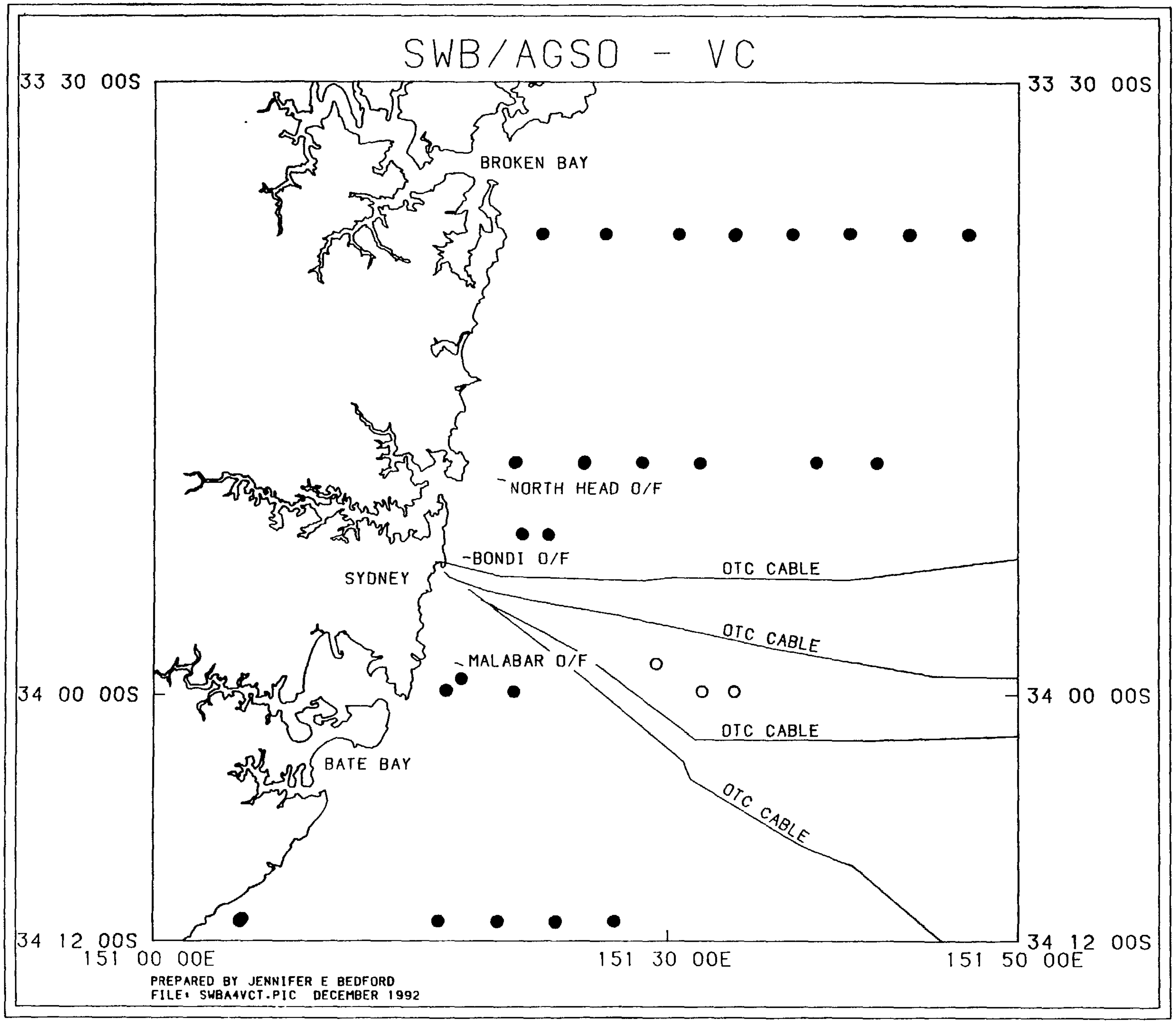


Figure 2.3. Map of all vibrocore locations AGSO/WB project.

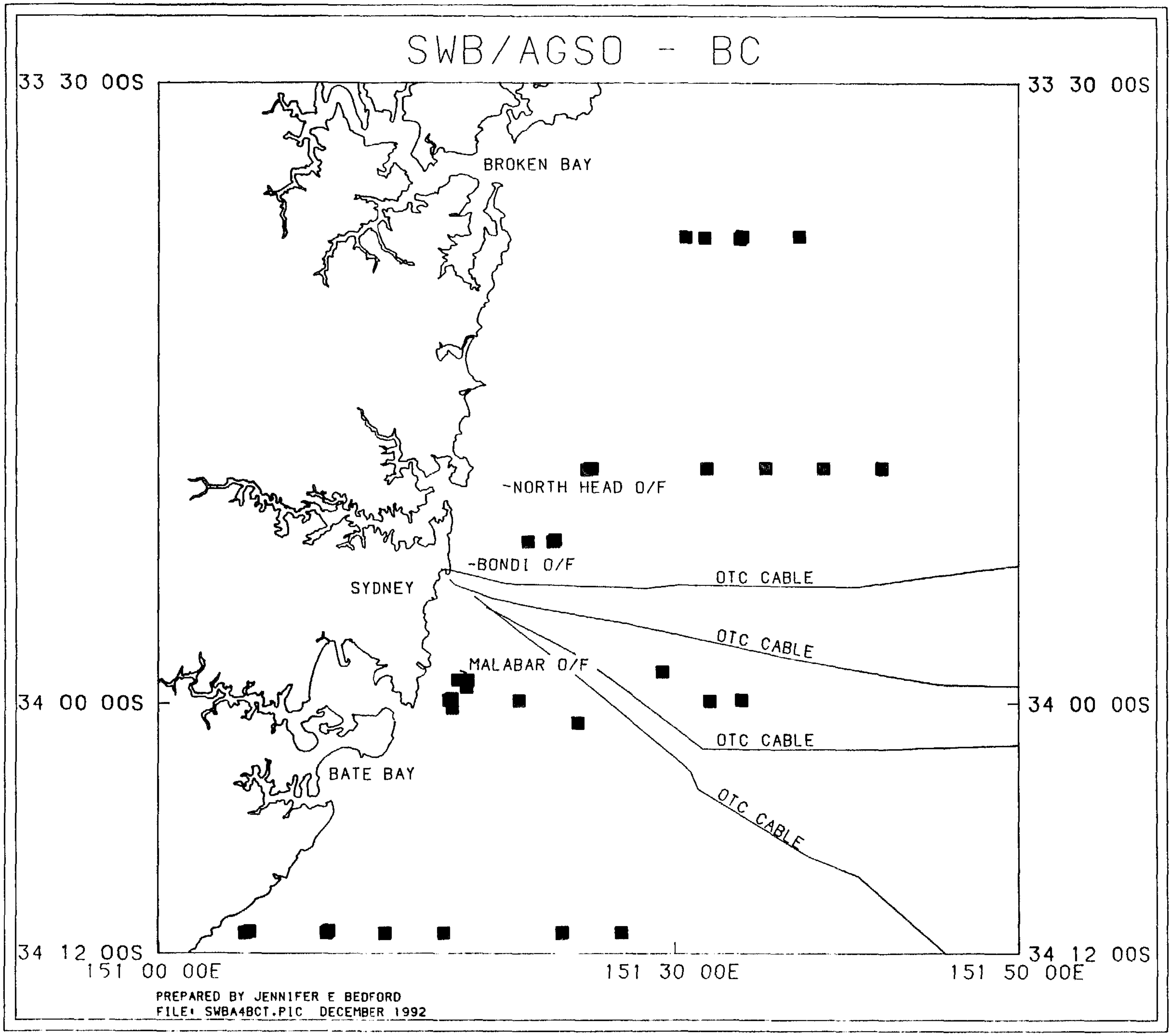


Figure 2.4. Map of all box core locations AGSO/WB project.

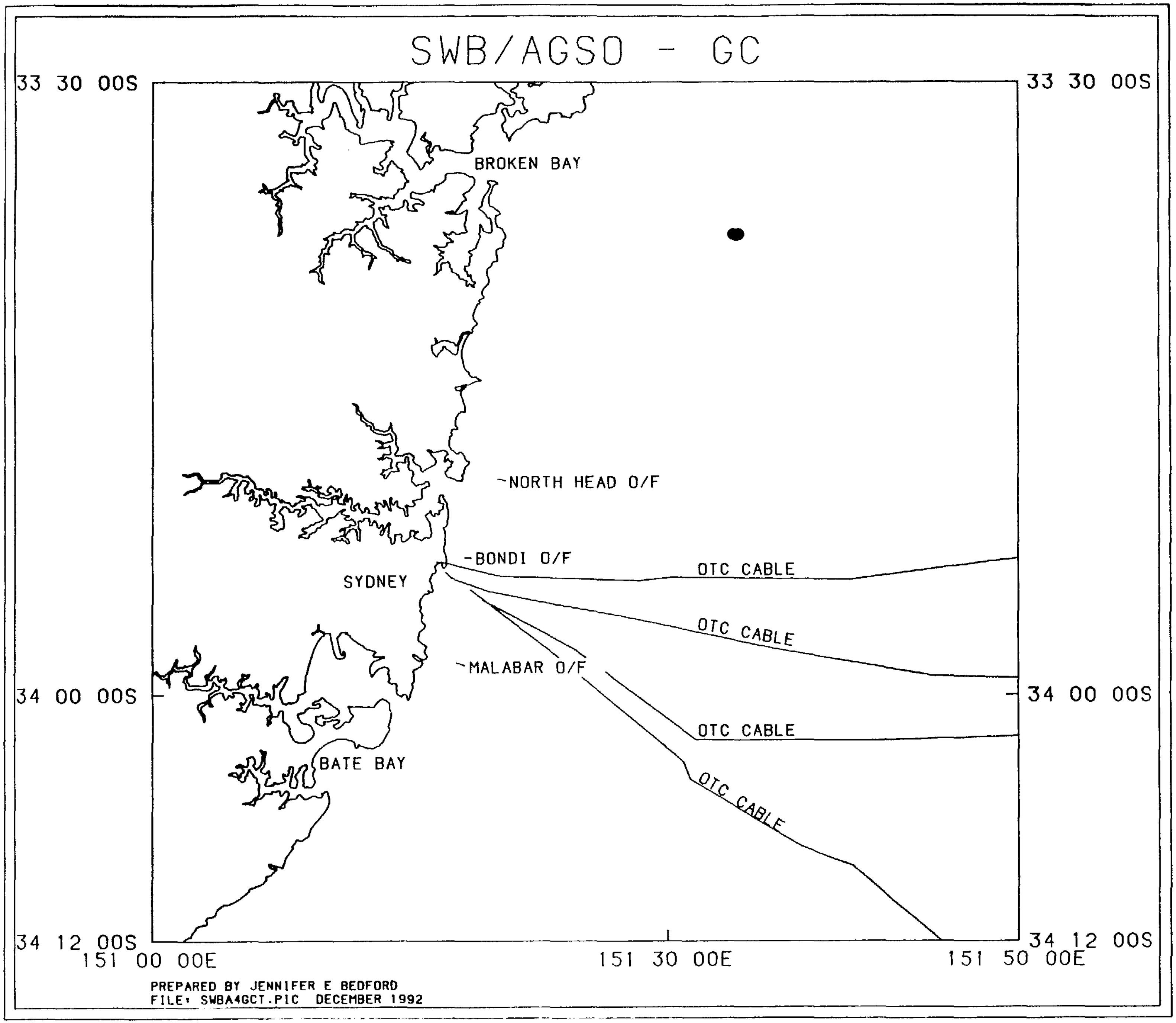


Figure 2.5 Map of gravity core locations AGSO/WB project

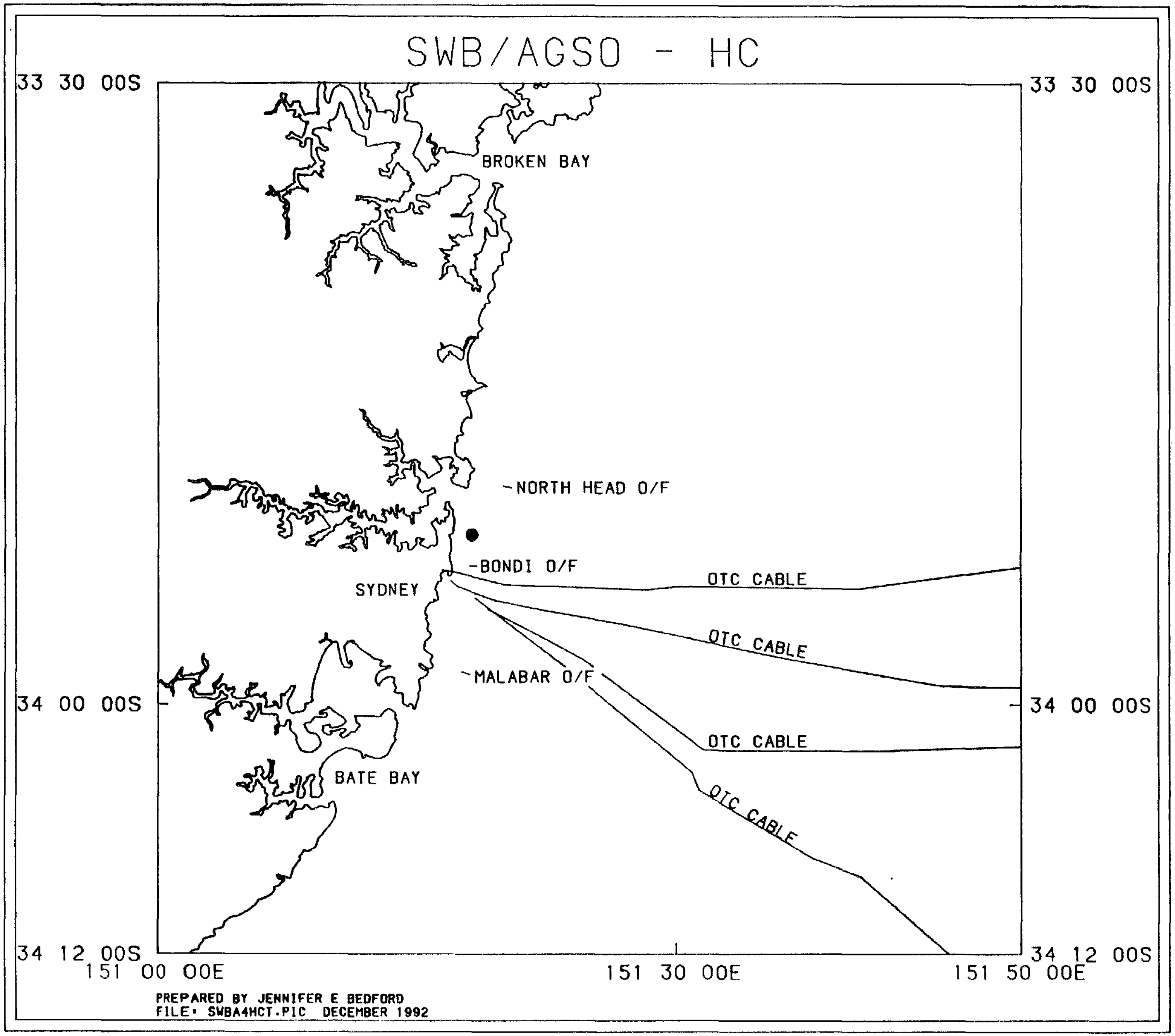


Figure 2.6 Map of the hydrocast location AGSO/WB project.

3. Sedimentology and Contaminant Sampling.

The Water Board (WB) has been undertaking investigations along the local N.S.W. inner and middle shelves in order to determine both the spatial distribution and source of terrestrially derived contaminants to the marine environment. This work concerning sedimentary loadings of contaminants in the coastal zone stems from the recognition that sediments are both a long term sink (Hites and Lopez-Avila, 1980; Ginn 1989) and source (Burgess and Scott, 1992; Baudo and Muntau, 1990) for many organic and inorganic contaminants. The effect of many of these contaminants on both humans and other organisms is well documented (Merian, 1991; Howard, 1991) so assessment of their concentrations and distributions in the environment are both pertinent and essential.

With the commissioning of the Sydney deepwater sewage outfalls between 1990 and 1991 it was desirable to place the results of intense WB nearshore outfall-focussed studies within a greater regional context and to look at possible effects on the outer-shelf and further seawards. The WB undertook, together with AGSO, to sample the sediments along specified transects which would extend across the entire continental shelf. For the joint AGSO/WB sediment contaminant program 62 sediment samples (Table 3.1) from 30 sites along four transects (Figure 3.1) were collected for contaminant and grain-size analysis.

Objectives

The primary objective of this study was to document the concentrations and spatial distribution of selected organic and inorganic trace pollutants on the continental shelf adjacent Sydney. The distribution of these contaminants will relate to possible source, dispersion pathways, and fate of these pollutants. Grain-size and organic carbon analyses will enable any relationships between pollutants and physical parameters to be identified.

Sampling Methods

Three types of sediment samplers were deployed during the cruise. These were a vibro corer, box corer and Van Veen grab.

Van Veen Grab

The Van Veen Grab was used for preliminary determination of substrate character at sampling sites prior to box coring or vibro coring. Sediments were retained in the sampler in approximately 75% of deployments, however the suitability of some samples for subsequent analysis of contaminants was limited. For example, if the jaws of the grab did not close completely, water flushed through the sample with an apparent loss of the finer grain-size fractions. Recoveries were lowest during rough sea conditions with the grab triggering early either because of swell conditions or strong tides and currents which caused the grab to hit the bottom at an extreme angle.

Vibro corer

The vibro corer was used as the primary sampling device in collection of sediments for contaminant analysis and analysis of surficial structure. Its use was based on previous analysis of sampling devices (Schneider and Wyllie, 1991) in generally coarse grained shelf sediments. Recovery rates with the vibro corer were approximately 85%. Recoveries varied from full penetration of 3m to minimal recoveries of 15 cm on very coarse material (Table 3.2), with an average core length of 1.2 metres.

Mud caps were a predominant feature of many cores (Appendix 1). These occurred as a result of transient re-suspension of fine-grained sediments within the core barrel during sampling. Significant mud caps (> 4-5 mm) occurred in cores which were:

(i) collected during rough weather when onboard retrieval of the vibro core resulted in disturbance of the in-core sediments,

(ii) collected at sites where penetration of the corer was restricted by hard substrate (ie reef or impenetrable facies), and

(iii) collected at sites where sediment mud content was greater than 30%.

In cores with significant mud caps it is apparent that the percentage mud content of the top few centimetres will be elevated through the disturbance and selective redeposition of the finer particle component from the upper few centimetres of the core. Since only the top 5 cm was subsampled for chemical/geological analysis, should the mud drape be compositionally derived from deeper than 5cm it is likely that contaminant concentrations higher, or lower than those in-situ on the shelf may result. Care must therefore be exercised when interpreting chemical results from those cores with significant mud caps.

Protocols for handling and subsampling vibro cores are schematically represented in Figure 3.2.

Box corer

The box corer was used for all nutrient geochemistry sampling and for geo-contaminant sampling when the vibro corer was in-operable or where the substrate was fine, porous and predominantly muddy. Across a variety of sediment types, the box corer was not as efficient in sample recovery as the vibro corer. Use of the box corer was restricted to areas where sediments were predominantly muddy.

Use of the box corer was advantageous when large sample sizes were required. Multiple subcores were collected from a single box core and such cores were relatively undisturbed. The box corer was deployed successfully during rough weather. Subcores from box cores sampled for contaminants and sedimentology are summarised in Table 3.2

Protocols for handling and subcoring box cores are schematically represented in Figure 3.3.

Sedimentological Observations

Duplicate sediment samples were collected at 30 sites, (Figure 3.1; Table 3.1). Gross sediment characteristics and structure of the cores were described onboard. The gross sediment characteristics are detailed in Appendix 1.

Three broad lithofacies, generally corresponding to similar zones described by previous authors (Bembrick, 1973; Boyd, 1974; Davies, 1979; Marshall, 1979), were identified in the study area. These are inner-shelf sands, mid-shelf muddy sands, and outer-shelf calcareous sands. On at least three of the four transects, each of these three lithofacies could be identified from onboard descriptions of surficial sediment character (Appendix 1). On the transect adjacent Botany Bay the mud component of sediments from sites within the mid-shelf did not exceed 10% (on average) of the overall sediment particle composition, hence the muddy sands were not delineated on this transect.

Inner-shelf Sands

Near-shore surficial sediments were characterised by well sorted fine to medium, generally quartzose sands with little or no mud component (Appendix 1). The biogenic carbonate component was pronounced at Sites 14 and 15, which was adjacent to a large reef system. Minor iron staining and a variable lithic (rock fragments plus feldspar) component of up to 10% were common. The carbonate fraction was generally angular and comprised mainly of mollusc remains. Some southern sites had abundant foraminiferal populations. The quartz component was well sorted, subround to subangular, generally non iron-stained, and fine to medium grained.

Vibro cores showed little structure except at Sites 15 and 2 where coarse material impeded core barrel penetration. In both cases large rounded river pebbles and coarse shell material were caught in the core catcher. As both these sites are off major estuaries it is possible that paleo-channels were intersected. The structureless profiles, and mature sediment character of the other cores are consistent with previous descriptions (Roy, 1985) of these deposits as reworked Holocene sands.

Mid-shelf Muddy Sands

At five sites from three transects and water depths of between 90 and 128m olive mid-shelf muddy sands were collected, as described in vibro core logs (Appendix 1). This lithofacies is characterised by at least 30% olive, terrigenous mud and by fine, quite angular non iron-stained quartz. Variable carbonate components of up to 40% consisting of shell fragments and worm tubes occurred. Foraminifera were only a minor component and at some sites were altogether absent. The lithic component, while generally high, was variable ranging from 5% to 75%. The mud content appeared organic rich, and it was quite noticeable that in sub-cores removed from box cores a fine 'flocculant' overlying the sediment was present.

At Site 6, the two duplicate vibro cores collected within 100m of each other showed differing, yet distinct features of both the mid-shelf and outer-shelf facies. This may indicate that the break between the muddy sands and the outer-shelf calcareous sands is either a well delineated boundary, or may represent small scale spatial variation.

Variations in the down-core compositions of the mid-shelf vibro cores indicate interesting processes during their Quaternary development. Cores from Sites 6, 13, and to a lesser extent 5 contain re-cemented shelly bands at 50 to 80 cm depth. The coarse biogenic carbonate is predominantly pectin shell, with bivalve and gastropods also occurring. The carbonate cementation post-dates the shell deposition and may have occurred during a Pleistocene lowstand as supersaturated ground water percolated through these shelly lenses resulting in re-cementation. At the base of some cores from Sites 3 and 4, large, well rounded river cobbles comprising sandstones, quartzites and basalts to a diameter of 50 mm occur. These are coated with milky white carbonate coatings indicating re-precipitation and are most likely to be Hawkesbury river palaeo-channels.

The muddy unit overlying these structures is a consistent, relatively homogenous unit with abundant scaphopods, worm tubes, foraminifera, and spicules. The terrigenous nature, and the fine flocculant material indicate that this facies is an actively accumulating unit, and thus a possible sink for anthropogenic contaminants.

Outer-shelf Calcareous Sands

The largest area sampled during the survey was the outer-shelf plain from a depth of 140m to the edge of the shelf. Here, sediments are characterised by coarse to medium, iron-stained biogenic carbonate. The quartz component is minor (less than 20%), generally fine to medium and either fine, non iron-stained and angular, or coarser, iron-stained and rounded. Mud content for most outer-shelf sites is generally low and consists of a white carbonate rich mud, with a notable absence (<5%) of modern terrigenous, olive muds. The lithic component is minor, up to 10%, but generally only a trace. Abundant and diverse populations of foraminifera are common, as are authigenic glauconite infilling of foraminifera tests.

Many of the longest cores were from this region and the structure of these cores show features typical of a relict, sediment-starved region. Commonly occurring characteristics of the cores collected on the outer-shelf include fining up sequences and coarse shelly, pectin rich layers. Most of the cores from the outer-shelf contain single, and in one instance (112/VC/043) two complete fining upward sequences in the top 10 to 60 cm. What processes controll these features and when did these processes occur? It is accepted that the sediments are relict in character, as demonstrated by the iron-staining, the lack of significant terrigenous material and radiocarbon dating of pre-Holocene shelly material (Roy, 1983). If the fining upward features are controlled by modern processes, the outer-shelf sediments are "palimpsest" (Swift et.al., 1971) in nature, that is they display petrographic characteristics of the relict facies overprinted by characteristics of a later depositional environment. Alternatively, the upward fining upward sequences may be relict structures from the last marine transgression which have not been significantly altered in the recent development of the shelf.

A common feature of many of the cores collected on the outer-shelf is the presence of large shell fragments, bivalves and, in particular, pectin shells (Pectinidae). These are generally shallow water molluscs that would have lived in this region at times of lower sea level. In some cores (112/VC/052) they are dispersed within the sediment over a down-core interval, while in others (112/VC/024) they are a single unit of packed shells, up to one metre thick, with no significant amount of interspersed sediment. It is possible that the latter sequence may represent a lag bank or storm bank deposited as a result of erosional processes during the last marine transgression.

Boomer Survey

The way points for the boomer survey around the ocean outfalls between Botany Bay and Port Hacking are summarised in Table 3.3, and the track map of the survey is shown in Figure 3.4. A total of 80 line-km of data were obtained.

Approximately ten hours of seismic data were generated from two shore-parallel lines. These lines extend from Sydney Harbour to Botany Bay over the inner and mid shelves between water depths of 40-110 metres.

Inner-shelf lines are characterised by a rough exposed basement topography containing interspersed pockets of sediment. Parts of the survey which fall into this category include the reef complex which extends up to 4.5 kilometres east of North Head. A similar topography from mid-shelf depths of 60-80 metres further south are related to the reef complex off Malabar and Bondi. The remaining tracklines show a generally continuous but thin (< 10 metres) sediment cover over a basement topography similar to the reefal areas adjacent North Head and Malabar.

Bathymetric and sub-bottom profiling (12 and 3.5 KhZ) Surveys

The way points for the combined bathymetric and 3.5 Khz sub-bottom profiling survey are summarised in Table 3.4. Also shown are the line-km of data collected for each survey line. A total of 28 line-km of data were collected. The track map for the bathymetric survey is shown in Figure 3.5

A reef system between 90 metres and 120 metres water depth and 18 kilometres ESE of the mouth of the Hawkesbury River was surveyed using both 12 and 3.5 kHz sounders. Bathymetry (Fig. 3.6) was contoured from the 12 kHz Trace. Contours are for the most part shore parallel to 90 metres water depth. From 110 to 120 metres depth a distinct break is often clearly identifiable where the reef adjoins the coastal plain. This break most likely represents Pleistocene sea level stands although it has been argued in the past that modern processes may be responsible. The 3.5 kHz record was sufficiently good to allow some interpretation of the shallow sediment distribution adjacent the surveyed reef area (Fig. 3.7). This record identifies a wide spectrum of features including lobes, irregular hummocks and scour channels. Sediments adjacent to the reef are generally shallow, rarely exceeding 5 metres depth. Coring in the vicinity of the reef often resulted in short cores, bent barrels and damaged nose cones. Along both the eastern and western perimeters of the reef, shallow ponded sediments could be identified. Both vibro cores and box cores in these sediments retrieved extremely muddy/flocculent surface sediments with a high water content (>50% w/v). Eastward of the ponded sediments on the seaward edge of the reef, sediment depth rapidly increased to in excess of 10 metres depth after which the 3.5 kHz record was no longer able to distinguish basement. Sediment thickness on the western edge of the reef, shoreward of the ponded sediment, was markedly different. While sediment depth rarely exceeded 10-15 metres, it was extremely variable. Depth of sediment in this mid-shelf area ranged from 0-15 metres with often no apparent trend other than a partial shoreward increase along some lines.

Contaminant Core Collection and Subsampling

On retrieval all Water Board vibro cores were labelled and, where required, sectioned into lengths no greater than 1 metre in length (Fig. 3.2). All sections were then capped with tightly fitting teflon caps. Throughout the retrieval, sectioning and capping process cores were kept upright so as to minimise disturbance of the sediments. Cores were cut on board using two opposed circular saws and split using a prepared length of stainless steel wire. The top 5 cm of all vibro cores was subsampled for contaminant analysis. Sediment adjacent the aluminium tube was not subsampled to avoid metal shavings from cutting and entrainment effects from coring. Prior to subsampling cores were photographed and logged (Appendix 1). Once subsampled, cores were wrapped in aluminium foil (to restrict movement of sediment during transport), sealed in polyethylene tubing and refrigerated at 4° Celsius. Subsamples were packed into teflon bags, sealed and frozen (-18° Celsius) for later analysis.

Proposed Post-Survey Analyses

Geological Analysis

Geological analysis will involve determination of gravel:sand:mud ratios by wet sieving using 2 mm and 63μm mesh sizes. Dried samples will then be weighed and the relevant percentages calculated. Grain-size analysis of the sand fraction will be carried out using a settling tube. Data will be provided in the form of hard copy showing the cumulative frequency curve plus statistical parameters derived using Folk's graphical method. The grain-size analysis of the mud fraction (i.e. size < 63μm) will be carried out using a modified Malvern laser particle sizer. Data will be provided in hard copy form giving the cumulative frequency curve and relevant grain-size statistics.

The carbonate component of the sand and mud fractions will be determined using a standard "acid bomb" technique. The precision of this method is proportional to the carbonate content and mass of sample available for analysis. Precision of ± 5% is normal, but increased precision occurs with greater sample mass and carbonate content.

Organic Carbon Analysis

Analysis of organic carbon will be carried out on a total carbon analyser to the method of Sandstrom & others (1986).

Organochlorine Analysis

Organochlorine analysis will be for DDT, DDD, DDE, BHC, HCB, heptachlor, heptachlor epoxide, chlordane, dieldrin, aldrein and PCB's. Samples will be sonicated three times with dichloromethane and acetone, concentrated to 5 ml and solvent exchanged to n-hexane. Cleanup will be carried out on a fluorisil column, eluting the first fraction (I) with n-hexane and the second (II) with 2% acetone in n-hexane. Both fractions will be concentrated to 2 ml. Gas chromatography will be on 30 metre capillary columns using an electron capture detector. Estimates of detection limits will be based on a minimum peak height/area of three times background. Results will be reported on a dry weight basis back-calculated off a separately dried subsample. Detection limits for all compounds except PCB's will be 5ppb. For PCB's detection limits will be 10ppb.

Trace Metal Analysis

Heavy metal analysis will be carried out for Cadmium, Nickel, Chromium, Manganese, Copper, Lead. Zinc, Iron, Mercury, Arsenic and Selenium. Acid oxidative digestion (HNO_3/HCL) of wet sediment will be followed by Flame Atomic Absorption Spectrometry (AAS) for all metals except Mercury, Arsenic and Selenium which will be derived via cold vapour, AAS and hydride generation AAS respectively. Results will be reported on a dry weight basis back-calculated off a separately dried subsample. Detection limits are 0.5 ppm for Copper, Nickel, Arsenic and Manganese; 1.0 ppm for Lead, Zinc and Chromium; 0.05 ppm for Mercury, Selenium and Cadmium. Iron will be quoted in percentage values.

Discussion: Synthesis of shipboard results, sedimentology and implications for contaminants.

The lack of recently derived terrigenous material on the outer shelf has a number of implications with respect to anthropogenic contaminant buildup in this region, and the potential source of these contaminants.

Terrigenous muds are generally restricted to water depths less than 140 metres. Between depths of 140 and 240 metres sediment character is coarse and reflects features indicating that it is a relict deposit, significantly older than the last 200 years and since anthropogenic inputs have occurred. The lack of a significant fine fraction in sediments of this region as well as the absence of any indication that there is seaward, shore-normal transport at depths greater than 140 metres means it is likely that there would be little or no water-derived contaminant buildup in these sediments. Waterborne transport is specified here because where sediment concentrations of some elements/compounds are very low (as indicated by recent W.B. work on inner/mid shelf), atmospheric contributions from nearby urban and industrial complexes may prove significant (Denton and Burdon-Jones, 1986). The inner and mid shelves, however do have significant quantities of terrestrially derived material. Contaminant transport and buildup in these areas is therefore likely, and has been observed in previous W.B. studies of the inner and mid shelf areas between Port Jackson and Botany Bay. In those studies it was also observed that reef distribution in depths of 60-100 metres was associated with adjacent mud deposits and poorly sorted sediments. Further afield of these reefs (both seawards and shorewards) sorting increased and mud content decreased.

Gordon and Hoffman (1986) analysed current meter and sediment trap data from three sites off Sydney showing that sediment transport within the mid shelf was possible to depths of at least 80 metres. Radiocarbon dating of whole shell material retrieved by the W.B. from similar depths and 60cm below the sediment surface indicate modern origins for such material (< 200 years) suggesting that recent sediment transport may be responsible for this burial. Water flow related to such transport would be expected to be turbulent over and adjacent any reefs of significant relief. It might be expected that sorting of sediments would be poorer adjacent these reefs and would improve with distance from the reef as turbulance decreases. In previous Water Board studies along the inner/mid shelves at depths of 60-100 metres and in the current AGSO/WB survey of deeper reefs (100-120m water depths), such reef related sorting was apparent. Peirson & others (1992) concluded that turbulent flows along the inner mid-shelf off Sydney occurred over periods of the order of several hours and that subsurface shore normal velocity components under stratified conditions had significant intensities and bore little or no relationship to surface direction and velocity. Gordon and Hoffman (pers. comm.) found in some instances, that flow velocity and direction of bedforms were related to storm fronts - events often of several hours duration or less.

The oceanographic and hydraulic characteristics of the modern processes on the inner, mid and outer shelves are poorly understood. It has been suggested that the East Australian Current may be strong along the outer shelf, actively winnowing this region and that near-bottom flows on the outer shelf might be dominated by interactions between contrasting oceanic and shelfal water masses (Huyer & others, 1988), whereas the local wind and wave climate may be more important on the inner shelf. While there is little data to indicate whether offshore currents alone are enough to initiate sediment disturbance, the vertical component of both long period waves and turbulent flow from boundary effects may overcome some of the perceived problems of shear inertia at low velocities. Outer shelf sediments are generally a medium grained platy carbonate with little cohesive mud/organic content while the bulk of the inner and mid shelf sediments are composed of medium grained quartz and carbonate particles. Drag and inertia forces restraining movement are less in these sediments than in those with higher mud and organic content (McLaren, 1981). As a result vertical energy components of long period waves could lift these particles into the water column after which they are easily transported by ambient water flow.

Both the observed upward fining sequences in many shelf sediments and the decrease in particle size and sorting with increasing proximity to reefs may be considered as modern reworking. It is also likely that not only long period waves and ambient currents are implicated in this reworking but that storm fronts and storms influence transport patterns at least to the outer shelf. If reworking is significant as suggested, resident times for both contaminants and nutrients would be expected to be low (less than 2-3 years). A range of organic contaminants have been recently identified in the inner/mid shelf sediments by the Water Board. The presence of compounds with a half life or several weeks and the total absence of their known breakdown products (with extended half lives of 3 years) in sediments between depths of 80-100 metres would strongly support short residence times and significant sediment transport within the mid shelf. Both the compounds and their breakdown products are strongly absorbed to sediments, hence it is unlikely the absence of breakdown products are related to volatilisation or dissolution into overlying waters.

Samples for shore based contaminant analysis

SITE	CORE	DATE	TIME	LAT	LONG	WD	LENGTH	COMMENTS
28	VC 003	17/9	0844:30	34 11.00	151.0519	39.2	55.5 cm	logged,well sorted medium quartz sand
28	VC 005	17/9	0958:00	34 11.04	151.0515	40.2	175 cm	logged, mud drape, fine/medium muddy quartz sand
27	BC 007	17/9	1415:10	34 10.96	151 09.90	100		used for geo-contaminant analysis
27	BC 010	17/9	1609:40	34 10.31	151 09.87	99		used for geo-contaminant analysis
26	BC 015	17/9	2044:10	34 11.07	151 13.28	123		only sample at this site due to poor recoveries
25	VC 007	18/9	0027:10	34 11.02	151 16.66	136	196 cm	logged, medium/coarse shell hash
25	VC 008	18/9	0052:00	34 11.04	151 16.65	135	40 cm	logged, mud drape, medium calcareous sand
24	VC 010	18/9	0320:00	34 11.05	151 20.09	142	15 cm	logged, mud drape, med/coarse calcareous sand
24	VC 011	18/9	0350:00	34 11.03	151 20.09	141	168 cms	logged, fine/medium calcareous sand
23	VC 012	18/9	0608:00	34 11.06	151 23.46	150	122 cms	logged, mud drape, medium/coarse calcareous sand
23	VC 014	18/9	0729:00	34 11.00	151 23.47	150	32 cms	logged, mud drape, medium/coarse calcareous sand
23	VC 015	18/9	0817:00	34 11.04	151 23.48	150	140 cms	logged, mud drape, medium calcareous sand
22	VC 016	18/9	1041:00	34 11.04	151 26.88	238	58 cms	logged, fine calcareous sand
22	VC 017	18/9	1124:00	34 11.04	151 26.87	238	180 cms	logged, fine silty calcareous sand
21	BC020	18/9	1409:00	33 59.85	151 33.85	205		fine/medium calcareous sand
21	VC 018	18/9	1513:50	33 59.83	151 33.80	205	26 cms	logged, mud drape, fine/medium calcareous sand
21	VC 019	18/9	1544:00	33 59.86	151 33.85	205	280 cm	logged, fine quartz/carbonate sand
20	VC 021	18/9	1805:00	33 59.85	151 31 98	160	261 cm	logged, mud drape, fine/medium calcareous sand
20	VC 022	18/9	1824:00	33 59.86	151 31.99	160	140 cm	logged, fine quartz/carbonate sand
19	VC 023	18/9	2038:00	33 58.49	151 29.28	148	42 cm	logged, mud drape, medium calcareous sand
19	VC 024	18/9	2109:00	33 58.50	151 29.29	148	145 cm	logged, mud drape, fine calcareous sand
	Site 18 abandoned due to reef							

Table 3.1 Inventory of samples for shore-based contaminant analyses.

Samples for shore based contaminant analysis

17	VC 025	19/9	0157:00	33 59.87	151 21.03	103	268 cm	logged, mud drape, medium quartz sand
17	VC 027	19/9	0246:00	33 59.86	151 20.99	102	118 cm	logged, mud drape, fine/medium quartz sand
16	VC 030	19/9	0905:00	33 59.81	151 17.06	80.8	142 cm	logged, fine/medium quartz sand
16	VC 032	19/9	0951:00	33 59.80	151 17.10	81.3	155 cm	logged, fine/medium quartz
15	VC 034	19/9	1441:00	33 48.66	151 21.08	66.1	63 cm	logged, fine calcareous sand
15	VC 035	19/9	1458:00	33 48.66	151 21.07	65.5	14 cm	logged, fine calcareous sand
14	VC 037	19/9	2026:00	33 48.66	151 25.08	110	58 cm	logged, mud drape, fine muddy calcareous sand
14	VC 038	19/9	2046:00	33 48.64	151 25.08	110	162 cm	logged, mud drape, fine muddy quartz sand
13	VC 039	19/9	2247:00	33 48.65	151 28.46	125	107.5 cm	logged, fine carbonate/quartz sand
13	VC 040	19/9	2306:00	33 48.66	151 28.47	124	136 cm	logged, fine/coarse calcareous sand
12	BC 041	20/9	0057:00	33 48.66	151 31.86	128		2 sub-cores homogenised
12	BC 042	20/9	0130:00	33 48.66	151 31.81	130		2 sub-cores homogenised
11	BC 043	20/9	0244:00	33 48.65	151 35.26	140		2 sub-cores homogenised
11	BC 044	20/9	0311:00	33 48.65	151 35.25	141		2 sub-cores homogenised
10	BC 047	20/9	0516:00	33 48.65	151 38.61	148		2 sub-cores homogenised, dry well packed sand
9	BC 049	20/9	0620:00	33 48.65	151 41.99	180		2 sub-cores homogenised
9	BC 050	20/9	0751:00	33 48.65	151 41.99	180		2 sub-cores homogenised
10	VC 042	21/9	0134:00	33 48.65	151 38.60	148	69 cm	logged, mud drape, medium calcareous sand
10	VC 043	21/9	0156:00	33 48.66	151 38.60	149	36.5 cm	logged, mud drape, fine calcareous sand
9	VC 045	21/9	0205:00	33 48.67	151 41.98	182	202 cm	logged, mud drape, medium/coarse calcareous sand
9	VC 046	21/9	0225:00	33 48.66	151 41.98	182	174 cm	logged, mud drape, fine/medium calcareous sand
8	VC 047	21/9	0522:00	33 37.45	151 47.16	146	100 cm	logged, fine/medium calcareous sand
8	VC 048	21/9	0541:00	33 37.45	151 47.19	146	109.5 cm	logged, mud drape, fine/medium calcareous sand
7	VC 049	21/9	0638:00	33 37.45	151 43.80	140	35 cm	logged, fine calcareous sand

Samples for shore based contaminant analysis

7	VC 050	21/9	0658:00	33 37.45	151 43.80	140	45 cm	logged, mud drape, fine calcareous sand
6	VC 051	21/9	0751:00	33 37.43	151 40.48	134	26 cm	logged, mud drape, medium calcareous sand
6	VC 052	21/9	0811:00	33 37.42	151 40.48	134	128 cm	logged, mud drape, fine muddy calcareous sand
5	VC 054	21/9	0926:40	33 37.46	151 37.17	128	100 cm	logged, fine muddy quartz sand
5	VC 055	21/9	0945:10	33 37.47	151 37.18	128	148 cm	logged, mud drape, fine muddy sand
4	VC 056	21/9	1032:00	33 37.48	151 33.86	118	129 cm	logged, fine silty mud
4	VC 057	21/9	1053:00	33 37.46	151 33.89	118	211.5 cm	logged, muddy fine/medium quartz sand
32	BC 059	21/9	1210:50	33 37.53	151 33.83	118		2 sub-cores homogenised
32	BC 060	21/9	1238:00	33 37.51	151 33.81	118		2 sub-cores homogenised
33	BC 061	21/9	1422:00	33 37.51	151 31.69	87.8		2 sub-cores homogenised
33	BC 062	21/9	1450:00	33 37.51	151 31.71	97.8		2 sub-cores homogenised
3	VC 059	21/9	1520:00	33 37.46	151 30.57	89.3	118.5 cm	logged, fine muddy quartz sand
3	VC 060	21/9	1554:00	33 37.46	151 30.57	89.5	78 cm	logged, fine fluidised mud, fine calcareous muddy sand
2	VC 061	21/9	1708:00	33 37.47	151 26.28	47.4	220 cm	logged, mud drape, medium quartz sand
2	VC 062	21/9	1720:00	33 37.47	151 26.28	57.8	80 cm	logged, mud drape, fine/medium quartz sand
1	VC 063	21/9	1824:00	33 37.47	151 22.60	46.7	198 cm	logged, mud drape, medium quartz sand
1	VC 064	21/9	1850:00	33 37.45	151 22.62	46	202 cm	logged, mud drape, medium quartz sand

Vibrocores split and logged by SWB scientific crew

14	VC 037	19/9	2026:00	33 48.66	151 25.08	110	58 cm	logged, mud drape, fine muddy calcareous sand
14	VC 038	19/9	2046:00	33 48.64	151 25.08	110	162 cm	logged, mud drape, fine muddy quartz sand
13	VC 039	19/9	2247:00	33 48.65	151 28.46	125	107.5 cm	logged, fine carbonate/quartz sand
13	VC 040	19/9	2306:00	33 48.66	151 28.47	124	136 cm	logged, fine/coarse calcareous sand
10	VC 042	21/9	0134:00	33 48.65	151 38.60	148	69 cm	logged, mud drape, medium calcareous sand
10	VC 043	21/9	0156:00	33 48.66	151 38.60	149	36.5 cm	logged, mud drape, fine calcareous sand
9	VC 045	21/9	0205:0	33 48.67	151 41.98	182	202 cm	logged, mud drape, medium/coarse calcareous sand
9	VC 046	21/9	0225:00	33 48.66	151 41.98	182	174 cm	logged, mud drape, fine/medium calcareous sand
8	VC 047	21/9	0522:00	33 37.45	151 47.16	146	100 cm	logged, fine/medium calcareous sand
8	VC 048	21/9	0541:00	33 37.45	151 47.19	146	109.5 cm	logged, mud drape, fine/medium calcareous sand
7	VC 049	21/9	0638:00	33 37.45	151 43.80	140	35 cm	logged, fine calcareous sand
7	VC 050	21/9	0658:00	33 37.45	151 43.80	140	45 cm	logged, mud drape, fine calcareous sand
6	VC 051	21/9	0751:00	33 37.43	151 40.48	134	26 cm	logged, mud drape, medium calcareous sand
6	VC 052	21/9	0811:00	33 37.42	151 40.48	134	128 cm	logged, mud drape, fine muddy calcareous sand
5	VC 054	21/9	0926:40	33 37.46	151 37.17	128	100 cm	logged, fine muddy quartz sand
5	VC 055	21/9	0945:10	33 37.47	151 37.18	128	148 cm	logged, mud drape, fine muddy sand
4	VC 056	21/9	1032:00	33 37.48	151 33.86	118	129 cm	logged, fine silty mud
4	VC 057	21/9	1053:00	33 37.46	151 33.89	118	211.5 cm	logged, muddy fine/medium quartz sand
3	VC 059	21/9	1520:00	33 37.46	151 30.57	89.3	118.5 cm	logged, fine muddy quartz sand
3	VC 060	21/9	1554:00	33 37.46	151 30.57	89.5	78 cm	logged, fine fluidised mud, fine calcareous muddy sand
2	VC 061	21/9	1708:00	33 37.47	151 26.28	47.4	220 cm	logged, mud drape, medium quartz sand
2	VC 062	21/9	1720:00	33 37.47	151 26.28	57.8	80 cm	logged, mud drape, fine/medium quartz sand
1	VC 063	21/9	1824:00	33 37.47	151 22.60	46.7	198 cm	logged, mud drape, medium quartz sand
1	VC 064	21/9	1850:00	33 37.45	151 22.62	46	202 cm	logged, mud drape, medium quartz sand

Table 3.2. Inventory of cores logged by WB scientists.

Vibrocores split and logged by SWB scientific crew

SITE	CORE	DATE	TIME	LAT	LONG	WD	LENGTH	COMMENTS
28	VC 001	17/9	0647:30	34 11.00	151. 0515	40.1	65 cm	logged, mud drape , fine muddy quartz sand
28	VC 003	17/9	0844:30	34 11.00	151.0519	39.2	55.5 cm	logged,well sorted medium quartz sand
28	VC 005	17/9	0958:00	34 11.04	151.0515	40.2	175 cm	logged, mud drape, fine/medium muddy quartz sand
25	VC 007	18/9	0027:10	34 11.02	151 16.66	136	196 cm	logged, medium/coarse shell hash
25	VC 008	18/9	0052:00	34 11.04	151 16.65	135	40 cm	logged, mud drape, medium calcareous sand
24	VC 010	18/9	0320:00	34 11.05	151 20.09	142	15 cm	logged, mud drape, med/coarse calcareous sand
24	VC 011	18/9	0350:00	34 11.03	151 20.09	141	168 cms	logged, fine/medium calcareous sand
23	VC 012	18/9	0608:00	34 11.06	151 23.46	150	122 cms	logged, mud drape, medium/coarse calcareous sand
23	VC 014	18/9	0729:00	34 11.00	151 23.47	150	32 cms	logged, mud drape, medium/coarse calcareous sand
23	VC 015	18/9	0817:00	34 11.04	151 23.48	150	140 cms	logged, mud drape, medium calcareous sand
22	VC 016	18/9	1041:00	34 11.04	151 26.88	238	58 cms	logged, fine calcareous sand
22	VC 017	18/9	1124:00	34 11.04	151 26.87	238	180 cms	logged, fine silty calcareous sand
21	VC 018	18/9	1513:50	33 59.83	151 33.80	205	26 cms	logged, mud drape, fine/medium calcareous sand
21	VC 019	18/9	1544:00	33 59.86	151 33.85	205	280 cm	logged, fine quartz/carbonate sand
20	VC 021	18/9	1805:00	33 59.85	151 31 98	160	261 cm	logged, mud drape, fine/medium calcareous sand
20	VC 022	18/9	1824:00	33 59.86	151 31.99	160	140 cm	logged, fine quartz/carbonate sand
19	VC 023	18/9	2038:00	33 58.49	151 29.28	148	42 cm	logged, mud drape, medium calcareous sand
19	VC 024	18/9	2109:00	33 58.50	151 29.29	148	145 cm	logged, mud drape, fine calcareous sand
17	VC 025	19/9	0157:00	33 59.87	151 21.03	103	268 cm	logged, mud drape, medium quartz sand
17	VC 027	19/9	0246:00	33 59.86	151 20.99	102	118 cm	logged, mud drape, fine/medium quartz sand
16	VC 030	19/9	0905:00	33 59.81	151 17.06	80.8	142 cm	logged, fine/medium quartz sand
16	VC 032	19/9	0951:00	33 59.80	151 17.10	81.3	155 cm	logged, fine/medium quartz
15	VC 034	19/9	1441:00	33 48.66	151 21.08	66.1	63 cm	logged, fine calcareous sand
15	VC 035	19/9	1458:00	33 48.66	151 21.07	65.5	14 cm	logged, fine calcareous sand

Table 3.3 Navigation data for the boomer survey conducted offshore Sydney

WAY POINT #	TIME SSS.DDD.HHMMSS	POSITION W.G.S.	DISTANCE LAST W.P.	COMMENTS
WP #20	112.269.032000	S33 58.433 E151 17.333		BOOMER LINE #1
WP #21	112.269.042400	S33 53.216 E151 17.637	9.41km.	
WP #22	112.269.054100	S33 47.321 E151 20.812	13.86 km.	E.O.L. LINE #1 + 1 n.m.
WP #23	112.269.060200	S33 48.425 E151 20.869		S.O.L. LINE #2
WP #24	112.269.070400	S33 53.201 E151 18.312	9.49 km.	
WP #25	112.269.080300	S33 58.383 E151 17.869	9.85 km.	
WP #26	112.269.092700	S34 04.509 E151 14.266	12.42 km.	E.O.L. LINE #2
WP #40	112.269.093800	S34 04.698 E151 14.713		S.O.L. LINE #3
WP #41	112.269.101200	S34 02.038 E151 16.351	5.62 km.	
WP #42	112.269.105500	S34 58.602 E151 18.490	7.05 km.	
WP #43	112.269.115400	S33 53.325 E151 18.924	9.79 km.	
WP #44	112.269.130500	S33 47.728 E151 21.881	13.04 km.	E.O.L. LINE #3 + 1 n.m.
WP #30	112.269.132500	S33 48.696 E151 21.894		S.O.L. LINE #4
WP #29	112.269.143000	S33 53.362 E151 19.581	9.29 km.	
	112.269.151400	S33 56.333 E151 19.330	2.98 km.	E.O.L. LINE #4 BOOMER LOST
		BOOMER TOTAL	79.53 km.	

Table 3.4. Way-points for the bathymetric survey conducted offshore Sydney.

TIME SSS.DDD.HHMMSS	POSITION W.G.S.	DISTANCE LAST W.P.	COMMENTS
112.266.031900	S33 39.405 E151 28.224		S.O.L. LINE #1 BATHYMETRY
112.266.041200	S33 39.405 E151 33.644	8.36 km.	E.O.L.
112.266.050700	S33 38.905 E151 34.065		S.O.L. LINE #2
112.266.055000	S33 38.905 E151 29.639	6.82 km.	E.O.L.
112.266.055800	S33 38.405 E151 29.456		S.O.L. LINE #3
112.266.064100	S33 38.405 E151 33.605	6.40 km.	E.O.L.
112.266.065100	S33 37.905 E151 33.636		S.O.L. LINE #4
112.266.073100	S33 37.905 E151 29.667	6.12 km.	E.O.L. BATHYMETRY
	BATHYMETRY TOTAL	27.70 km.	

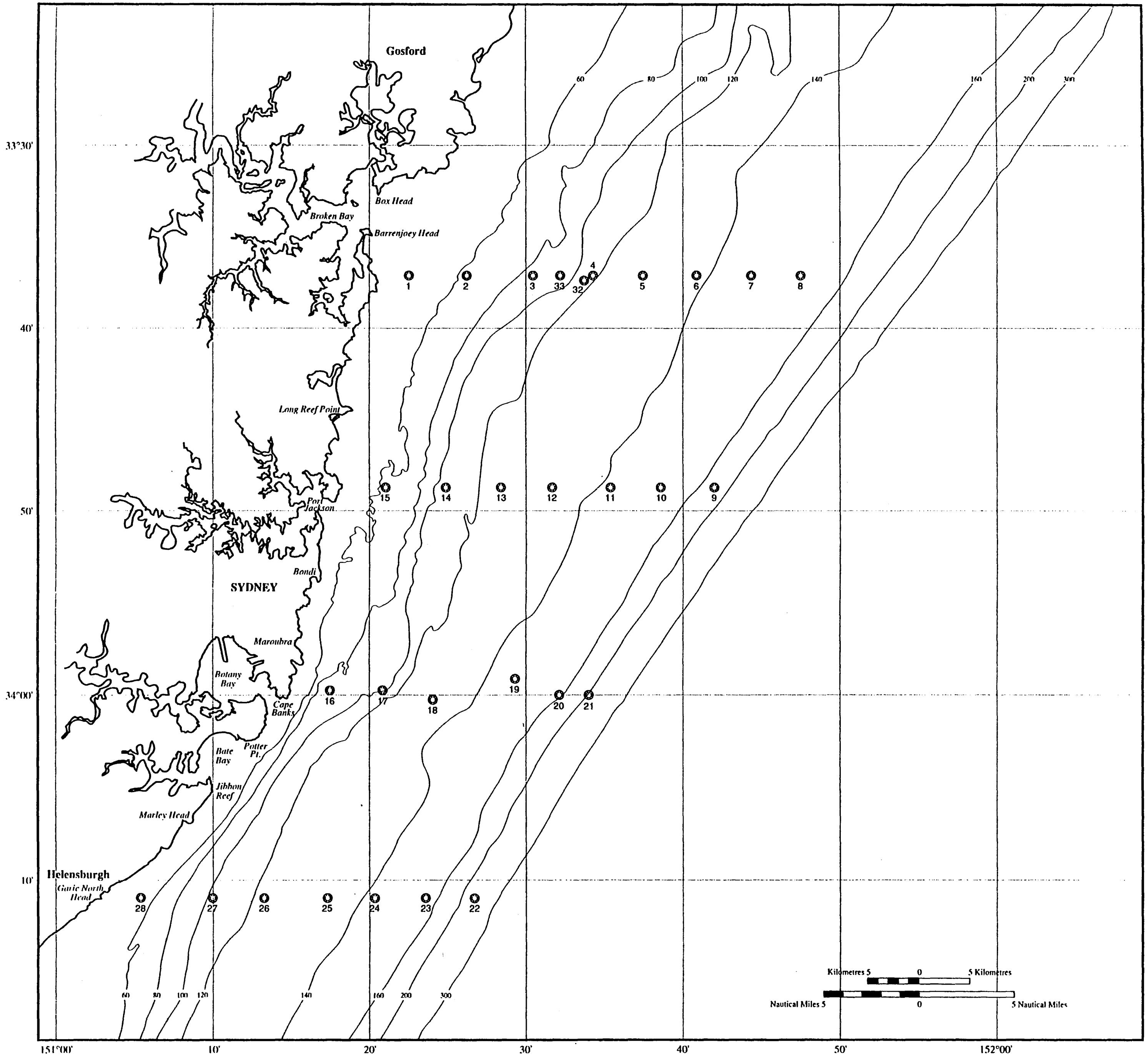


Figure 3.1 Map of samples sites occupied for contaminant and grain size analyses.

Vibrocore Handling & Subsampling Protocols

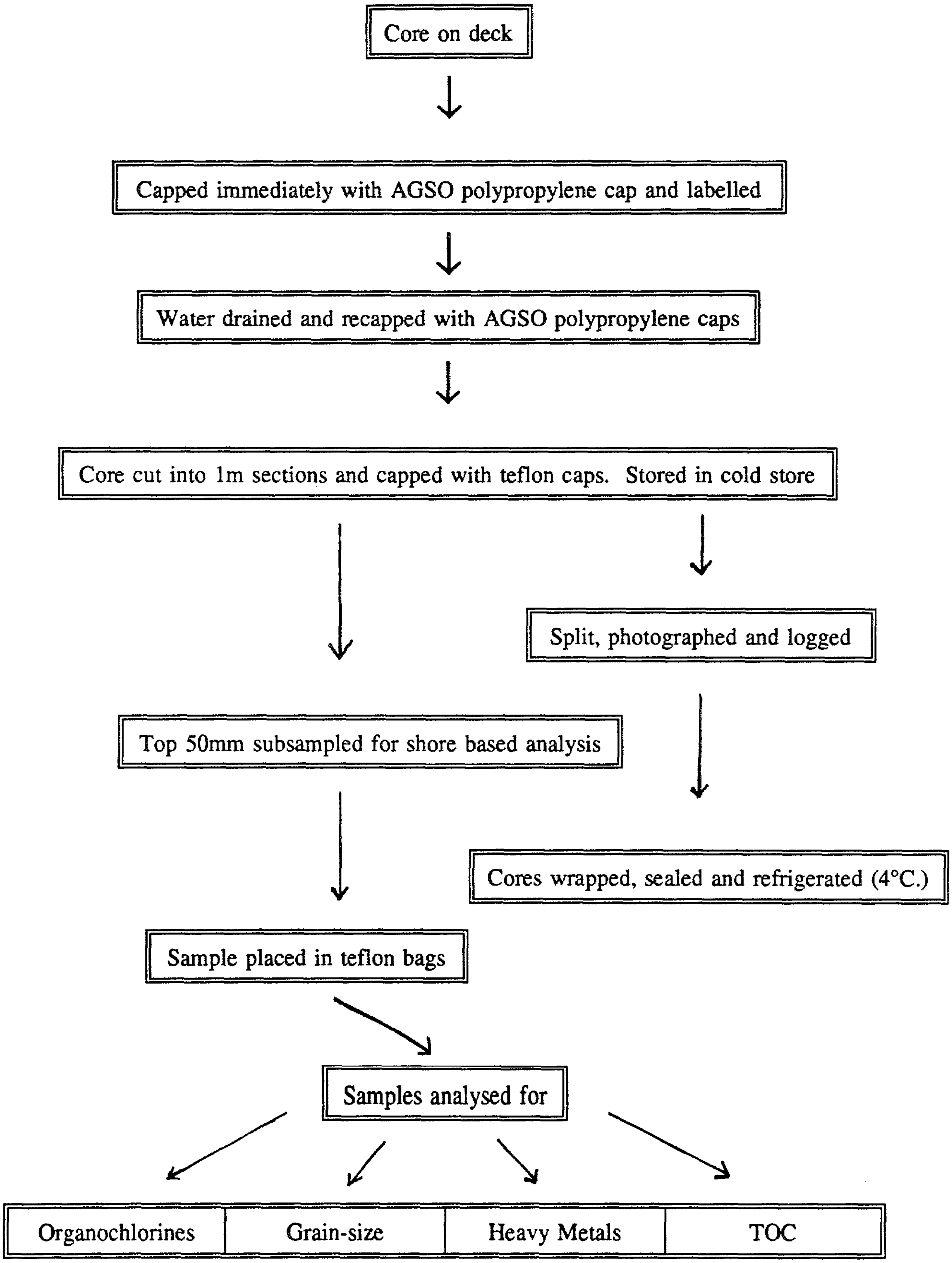


Figure 3.2 Schematic diagram of the protocol used for processing and sampling of vibro cores.

Box Core Handling & Subsampling Protocols

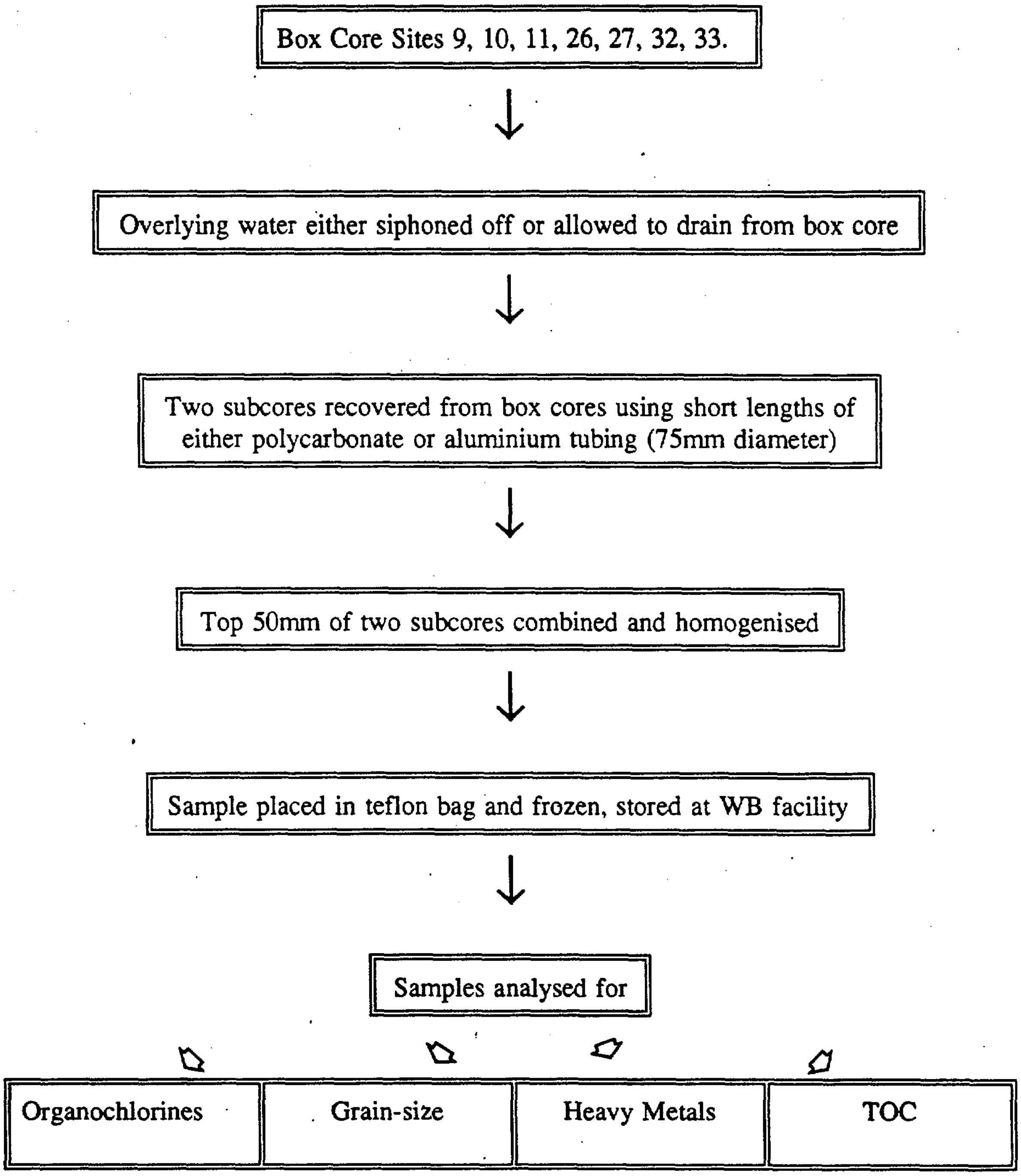


Figure 3.3 Schematic diagram of the protocol used for processing and sampling of box cores.

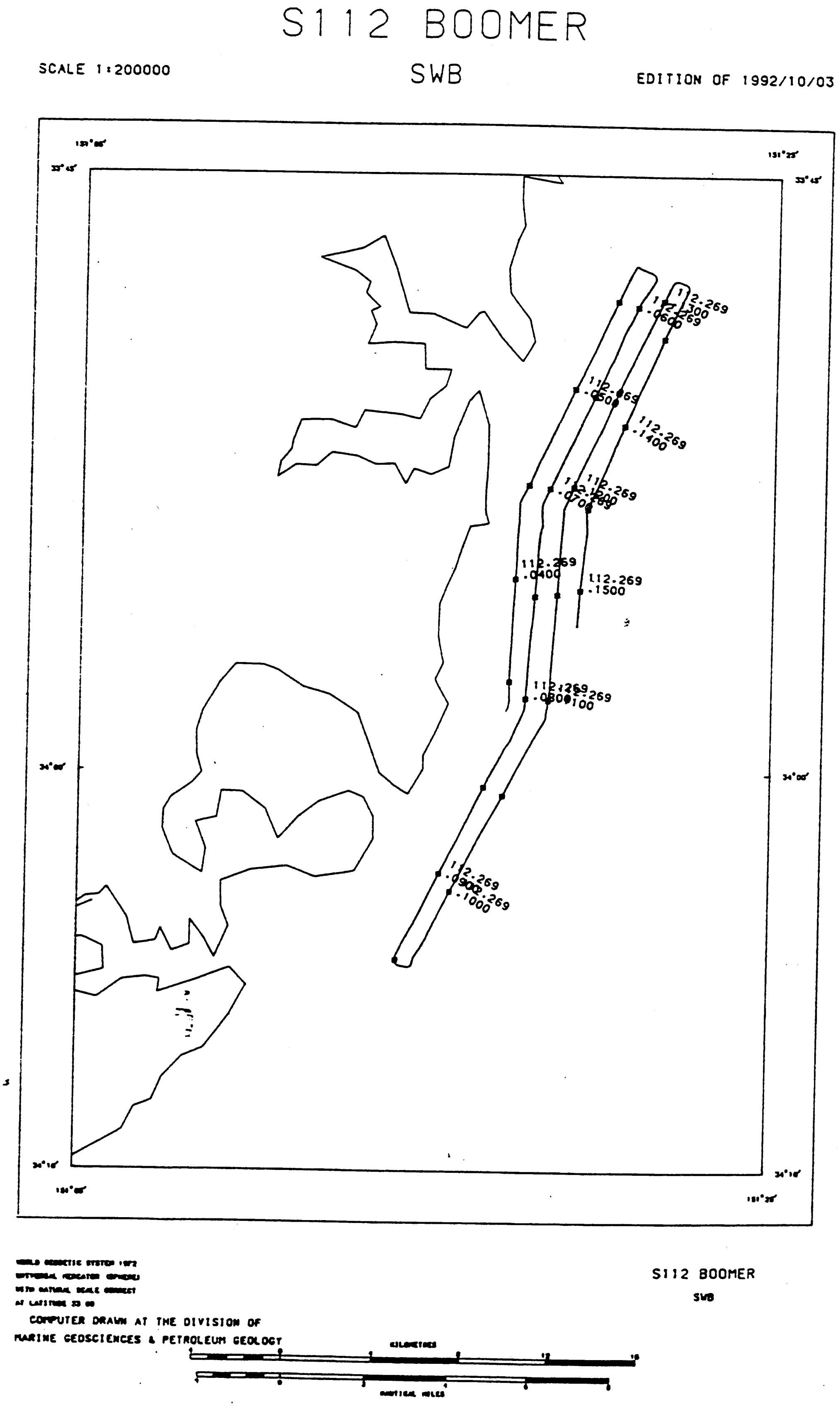


Figure 3.4. Track map of the boomer survey.

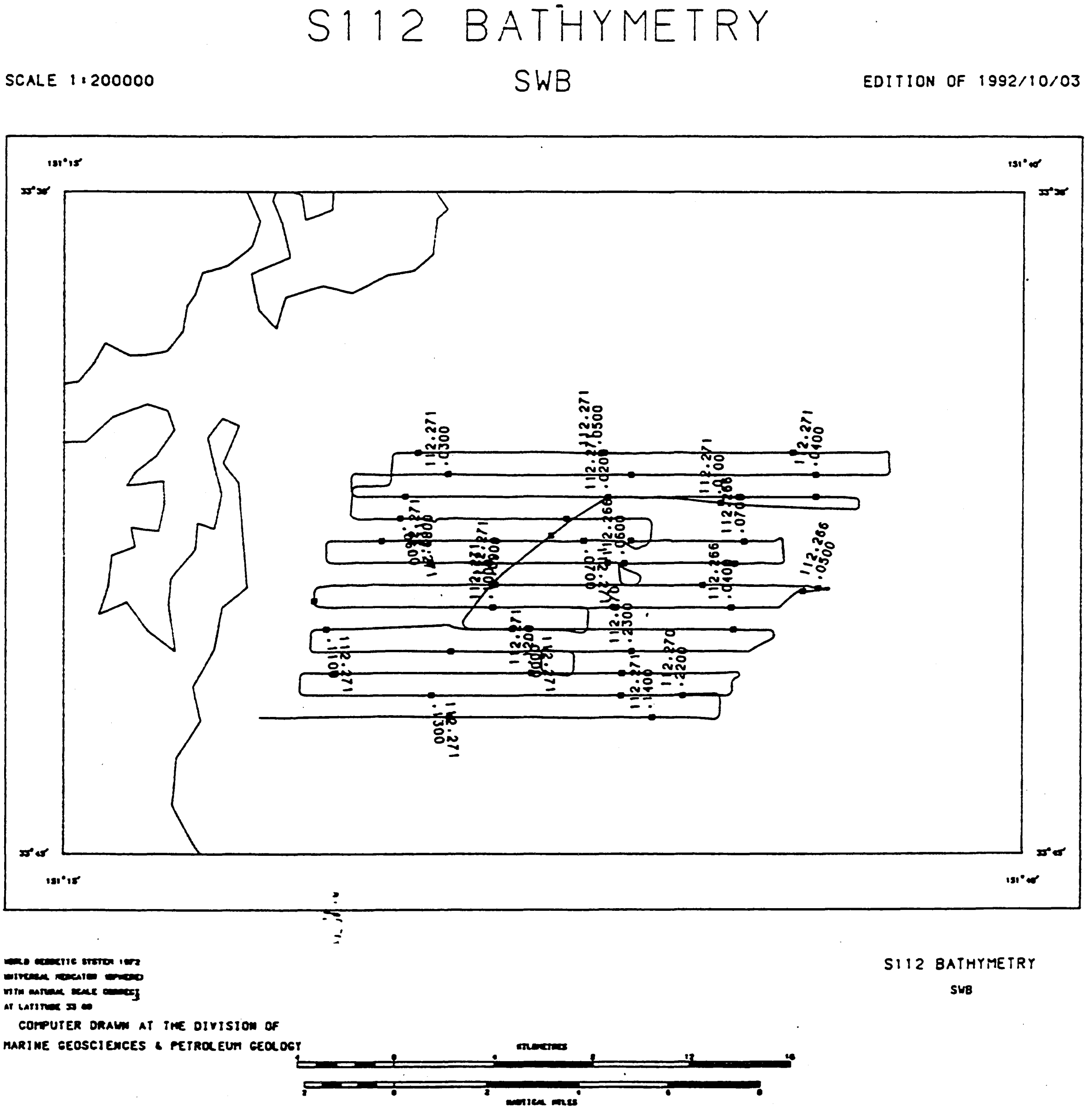


Figure 3.5 Track map of the bathymetric survey

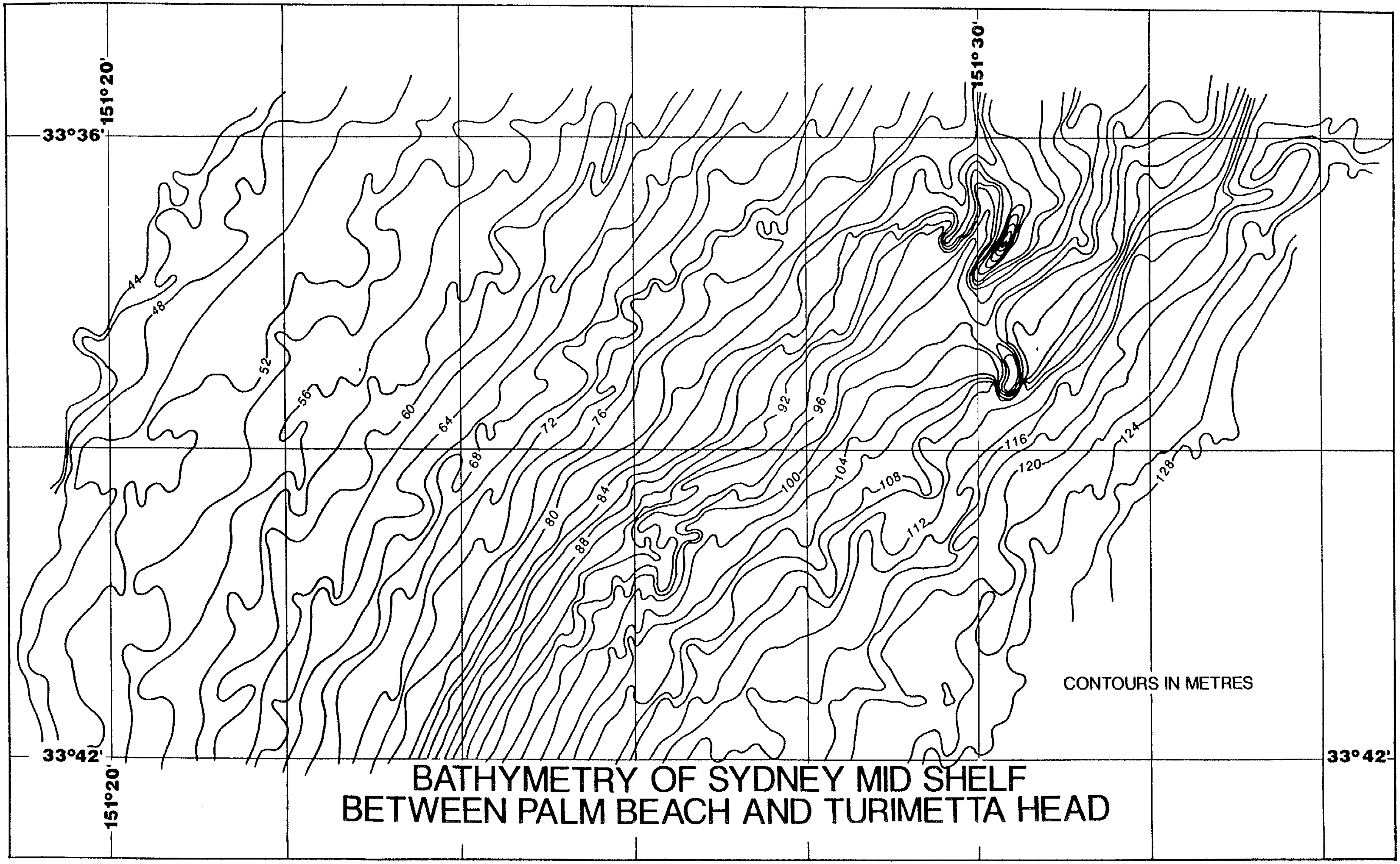

151°20'
151°30'
33°36'
33°42'
33°42'
151°20'
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
104
108
112
116
120
124
128
CONTOURS IN METRES
BATHYMETRY OF SYDNEY MID SHELF
BETWEEN PALM BEACH AND TURIMETTA HEAD

Figure 3.6

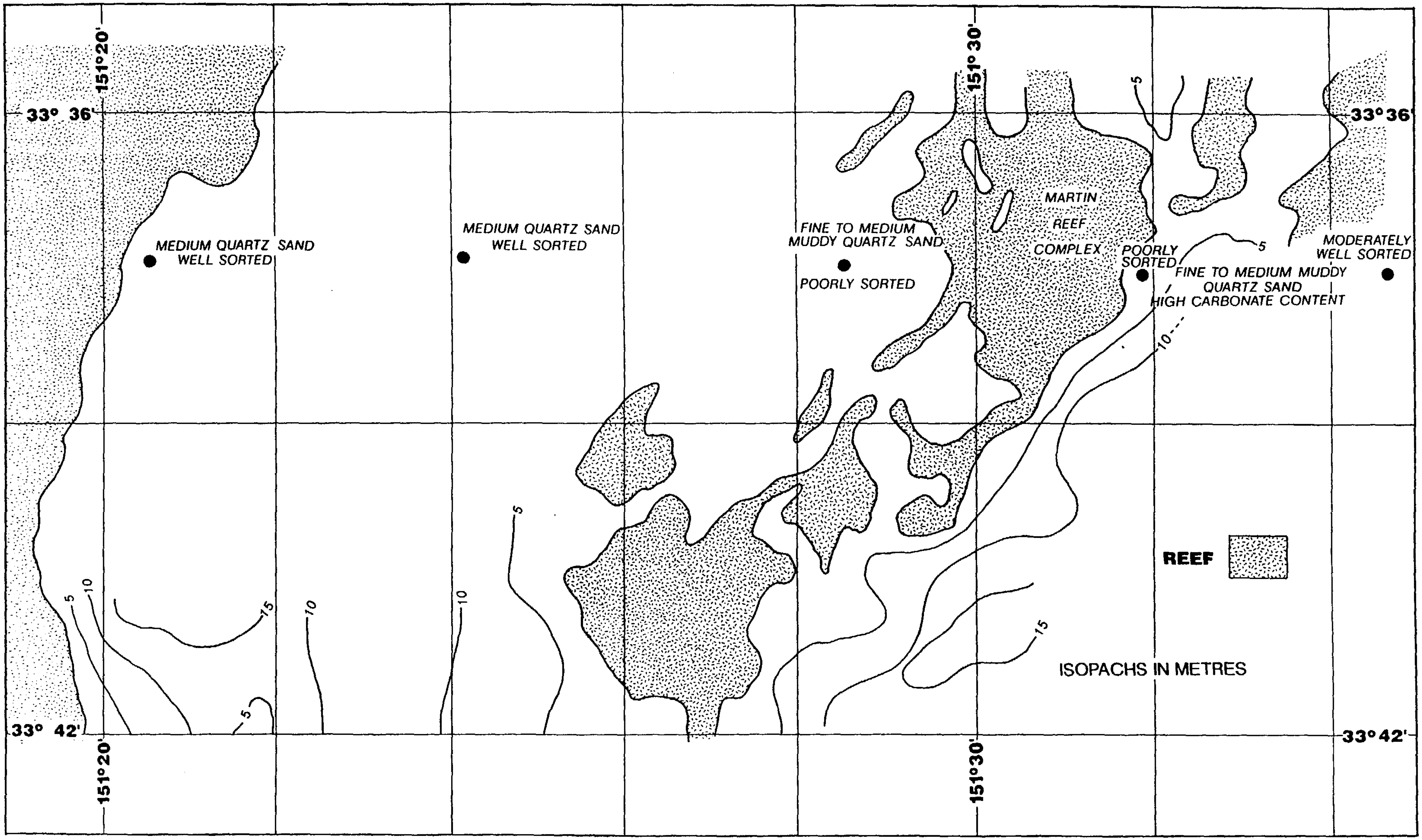


Figure 3.7 MID SHELF REEF DISPOSITION AND ADJACENT ISOPACHS BETWEEN PALM BEACH AND TURIMETTA HEAD

4. Geochemical characterisation of continental shelf sediments

The anthropogenic input of nutrients and organic material has been implicated in a number of large scale ecological effects in different marine and estuarine ecosystems. These include increased organic matter production (Nixon & others, 1984; Oviatt & others, 1987), changes in species composition among pelagic communities (e.g. Rudstam, 1988) and in some systems, the development of areas of bottom water with very low or zero dissolved oxygen concentrations (Leppdkoski, 1980; Officer & others, 1984; Launiainen & others, 1987). While it is clear that standing stock concentrations for the major nutrients (such as carbon, nitrogen and phosphate) are subject to atmospheric, topographical and hydrodynamic influences, anthropogenic inputs can greatly modify the existing nutrient dynamics of an ecosystem.

In many estuarine ecosystems, sediment oxygen and nutrient dynamics have been found to exert an important influence on conditions in overlying waters and in the sediments themselves. Benthic denitrification, for example, is one of the main controlling factors for water column primary production in Narragansett Bay (Seitzinger & others, 1980). Clearly, sediments can be important temporary sources for compounds, terminal sinks for others and an interface in the ecosystem where a diversity of biogeochemical transformations can occur (see Bolin and Cook, 1983).

There is little data currently available by which to predict the impact of anthropogenic inputs of nutrients and organic material to a coastal region such as that near Sydney. Much of the previous work in this field has been focused on enclosed waters or low-energy coastal zones. However, these may not adequately predict the effects of increased organic or inorganic nutrient input to the Sydney region given its open ocean, high-energy environment.

Objectives

To assess the impact of increased anthropogenic discharges of organic carbon and nutrients to the coastal zone it was necessary to collect baseline data on those parameters or processes that are likely to respond most rapidly to changing inorganic nutrient or carbon status. The objectives of this program were therefore:

1. To estimate rates of benthic metabolism from measured oxygen flux rates and micro-scale oxygen profiles in fine-grained coastal sediments.

2. To determine organic carbon and nutrient (nitrogen and phosphorus) concentrations in the sediments.

3. To measure flux rates of nutrients, NH_4^+, PO_4^-, NO_3^- and NO_2^-, across the sediment/water interface.

The sediment program includes assessment of ambient rates of benthic metabolism, organic carbon turnover (oxidation) rates, nutrient (nitrogen and phosphorus) fluxes, as well as physico-chemical features such as porewater and solid phase nutrient concentrations, grain-size distribution and porosity.

Sampling Sites

Sediment geochemistry. Sampling sites were located offshore of the Sydney metropolitan region between Broken Bay in the north to Port Hacking in the south in water depths between 80 and 120m (Figure 4.1). Samples were collected using a Soutar box core from which sub-cores were obtained using 8 cm diameter polycarbonate corer tubes. Details of sampling locations are summarised in Table 4.1. The protocol for the sampling and analyses of sediments in the nutrient geochemistry program is described below and summarised in Figure 4.2.

Sediment microbiology. Samples for microbiological analysis of pathogenic organisms were collected at 21 sites offshore of the Sydney metropolitan region (Figure 4.3). Samples were obtained using a grab sampler from which cores (5 cm depth, 8 cm diameter) were subsampled. Details of sampling locations are summarised in Table 4.2.

Sediment Oxygen Profiles

Duplicate cores (8 cm diameter x 20 cm depth) were collected for determination of dissolved oxygen concentrations in the sediments at each of six sites (Sites 3, 4, 14, 16, 36 and 27) using Clarke style microelectrodes (Diamond General Model 737GC and Microsensor MkII). Oxygen was measured at 1 mm intervals commencing 5 mm above the sediment surface and continued to 3 mm below the point of zero dissolved oxygen. Duplicate profiles were measured for each core. The electrode was calibrated against seawater of known oxygen concentrations at each site.

Oxygen profiles at each of the sites are shown in Figure 4.4. Oxygen concentrations reached zero within 2 to 6 mm of the sediment surface. Diffusive oxygen fluxes will be calculated once sediment porosity's have been determined.

Pore water nutrients

Sediments from four replicate cores at each of six sampling sites (Sites 4, 14, 16, 27, 31, 36) were extruded and sectioned in a glove bag under a nitrogen atmosphere. Each core was sub-sectioned at 1 cm intervals to 5 cm depth and at 9-10 cm depth. The length of subcores varied and cores were subsectioned to a depth of 10 cm if sufficient sample was recovered (see Table 4.3). Sediments were transferred to a centrifuge tube, sealed and porewaters extracted by centrifugation (15,000 rpm for 10 min) in a Sorvall RC5B refrigerated centrifuge. Ammonia and phosphate were determined at sea via colorimetric methods (Parsons & others, 1984). Porewater samples for nitrate and nitrite analysis were frozen for subsequent analysis. Following porewater extraction, remaining sediments were frozen for subsequent analysis of solid phase nutrients (see below).

The distributions of ammonia and phosphate in sediments at each of the sampling sites are shown in Figure 4.5. Ammonia concentrations in surface sediments ranged from 67 μgN/l at site 27 to 178 μgN/l at site 16. Concentrations in all cores increased with depth in the sediment reaching concentrations of up to 461 μgN/l.

Phosphate concentrations at the sediment surface ranged from 70 μgP/l at site 27 to 236 μgP/l at site 14. At some sites (Sites 14, 16, 27, 31) sediment profiles showed a phosphate maximum at 1 to 2 or 2 to 3 cm depth.

Data have not been fully analysed at this stage and nutrient profiles at each site will be analysed further. Nitrate and nitrite analyses will be completed. Diffusive nutrient flux rates will be calculated once sediment porosity data are available.

Solid phase nutrients

Replicate sediment cores were sectioned at 1 cm intervals to 5 cm depth and at 9-10 cm as described above. Following porewater extraction, sediments were stored in acid-washed vials and freeze dried. These samples will be homogenised and subsamples taken for analysis of total organic carbon, total nitrogen, and total phosphorous. Total organic carbon will be analysed by the method of Sandstrom &

others, (1986). Total nitrogen will be measured using an Heraus Elemental Analyser. Total organic phosphorus will be measured by persulfate oxidation followed by standard phosphate analysis.

Grain-size

Sediment samples for grain-size analysis were collected as part of the contaminants programme at Sites 3, 4, 14, 16 and 27 and will be analysed as described in Section 3 of this report. Duplicate subcores were collected from box cores at Sites 31 and 36 for grain-size analysis, as these sites were not sampled as part of the contaminants programme.

Benthic flux measurements

Four replicate cores were collected for determination of nutrient and oxygen fluxes at the sediment/water interface at Sites 4, 14, 16, 27, 31 and 36. After collection, the cores were equilibrated in the laboratory for up to 12 hours at *in situ* temperature with constant exchange of the overlying seawater. Overlying seawater was pumped from a reservoir of bottom water collected at the site of sediment collection. After equilibration, flow-through of bottom water was stopped and nutrient flux rates were determined by measuring nutrient accumulation in the overlying water. Following nutrient flux measurements, oxygen flux rates were determined for the same cores.

Nutrient fluxes. After flow-through of bottom water was stopped, water samples (50 mls) were withdrawn at 4 hour intervals over a period of twelve hours. The water was aerated during the period in which flux rates were measured by bubbling air into the overlying water. A total of three flux rate determinations were made for each core with a 6 to 12 hour equilibration period between each experiment. Fluxes were measured for NH_4^+, PO_4^-, NO_3^- and NO_2^-. Water samples were filtered through acid-washed, pre-rinsed GF/F glass fiber filters. Samples were analysed on ship-board for ammonia and phosphate as described above for porewaters. Samples collected for analysis of nitrite and nitrate were frozen for subsequent analysis.

Oxygen fluxes. To measure oxygen fluxes from the sediments, cores were sealed and oxygen concentrations were measured using a WTW polarographic electrode inserted through a port in the core caps. Oxygen concentrations were measured at two to four hour intervals over one 12 hour period.

Flux rates of ammonia and phosphate were calculated as the mean (± standard error) of up to 12 flux measurements at each site (i.e. 4 cores/site and 3 rate measurements/core; Fig. 4-6). There was generally a net release of nutrients at the sediment-water interface with the exception of a net uptake of ammonia at Site 31 (-0.14 (±1.08) mgN $m^{-2}d^{-1}$) and of phosphate at Site 27 (-1.90 (±2.19) mgP $m^{-2}d^{-1}$.) Ammonia release rates ranged from 0.71 (±1.05) at Site 4, to 16.14 (±10.40) mgN $m^{-2}d^{-1}$at Site 16 (Fig. 4-5). Phosphate release rates ranged from 1.55 (±1.54) at Site 31 to 6.84 (±2.19) mgP $m^{-2}d^{-1}$at Site 16 (Fig. 4-5). Flux rates at sites located offshore from the North Head outfall/Port Jackson (Site 14) and Botany Bay/Malabar outfall (Sites 16, 36) appeared to be greater than those offshore from the Bondi outfall, Broken Bay and the Royal National Park. However, these trends have not yet been analysed for statistical significance. Such differences could be related to a number of factors such as grain-size or total organic carbon content of the sediments (which may in turn be related to proximity to point sources of anthropogenic compounds) or to factors such as numbers or types of macrofauna in the sediments.

Oxygen consumption rates in sediments ranged from 400 to 2180 $mg0_2$ m^{-2} d^{-1} (Fig. 4-7). Assuming a Redfield ratio (106:138), these rates are equivalent to carbon utilisation rates of 307 to 1674mgC m^{-2} d^{-1}.

Distribution of pathogenic bacteria

Samples collected for microbiological analysis were subsampled from the grab sampler and stored in sterile containers at 4°C for subsequent analyses of numbers of *Clostridium perfringens* spores. These samples are being analysed by Dr. N. Ashbold at AWTT Science and Environment at the Water Board.

Macrofauna Analysis

Subcores from Sites 4, 14, 16, 31 and 36 were sieved through 2 mm and 63 µm screens on board ship and stored in 90% ethanol for subsequent identification of macrofauna in the laboratory. A limited number of cores (Table 4.3) were analysed following observations of varying numbers of worm tubes, burrows and biota between sampling sites. Quantitative analysis of macrofaunal numbers was not possible as cores had been held in the lab for up to ten days before extraction and the number of cores available for analysis were not great enough for meaningful enumeration. Initial observations showed that Sites 36 and 16 had largest numbers of worm tubes at the surface compared to other sites.

Table 4-1. Summary of sampling locations and cores collected for sediment geochemistry analysis.

Site	Sample	Julian Day	GMT	Latitude	Longitude	Depth (m)	Sub-cores (1)
27	BC 006	261	3:27	34 10.98	151.09.88	99	7
27	BC007	261	4:15	34 10.96	151 09.90	100	
27	BC 010	261	6:09	34 11.00	151 09.89	99	
27	BC 012	261	7:19	34 11.01	151 09.89	99	
16	BC029	262	18:43	33 59.79	151 17.13	82	14
16	BC030	262	19:35	33 59.83	151 17.08	81	
16	BC031	262	20:17	33 59.81	151 17.07	80	
16	BC032	262	21:03	33 59.82	151 17.06	81	
16	BC 033	262	21:47	33 59.82	151 17.07	82	
14	BC034	263	6:46	33 48.65	151 25.08	110	8
14	BC036	263	7:38	33 48.64	151 25.13	111	
14	BC038	263	9:00	33 48.66	151 25.08	109	
4	BC053	264	5:00	33 37.45	151 33.88	118	9
4	BC054	264	5:44	33 37.44	151 33.87	118	
4	BC 056	264	6:59	33 37.44	151 33.87	117	
3	BC058	264	9:43	33 37.46	151 30.59	88	3
31	BC063	265	11:38	33 52.21	151 22.89	91	11
31	BC064	265	12:25	33 52.18	151 22.90	91	
31	BC065	265	13:18	33 52.19	151 22.93	92	
36	BC074	267	4:17	33 58.91	151 17.98	84	12
36	BC075	267	5:08	33 58.91	151 17.98	84	
36	BC076	267	5:51	33 58.92	151 17.97	83	

(1) Total number of subcores collected from each site. No record was kept of individual subcores collected from each box core.

Table 4.2 Summary of sampling locations and cores collected for analysis of numbers of *Clostridium perfingrens* spores.

Site	Sample	Julian Day	GMT	Latitude	Longitude	Depth (m)
1	GS034	265	8:15	33 37.47	151 22.60	46.3
2	GS 033	265	6:54	33 37.45	151 26.29	58.8
3	BC057	264	8:57	33 37.45	151 30.59	87.9
4	GS029	264	4:48	33 37.45	151 33.88	118
5	GS028	264	2:55	33 37.45	151 37.20	129
6	GS027	264	2:01	33 37.45	151 40.49	135
8	GS025	264	0:22	33 37.42	151 47.09	146
9	BC050	263	21:51	33 48.65	151 41.99	180
10	BC047	263	19:22	33 48.65	151 38.61	148
12	BC041	263	15:02	33 48.66	151 31.86	128
13	GS020	263	12:31	33 48.66	151 28.47	127
14	GS019	263	6:28	33 48.65	151 25.09	110
15	GS018	263	4:09	33 48.66	151 21.07	67.5
16	GS014	262	17:59	33 59.82	151 17.08	81.2
17	BC 028	262	15:21	33 59.88	151 20.97	103
18	BC026	262	13:17	34 00.94	151 24.38	133
20	BC0 22	262	7:12	33 59.87	151 31.98	159
21	BC 021	262	4:38	33 59.85	151 33.85	205
23	GS010	261	18:55	34 11.04	151 23.49	150
24	GS 009	261	16:44	34 11.04	151 20.10	143
27	GS002	261	1:13	34 11.00	151. 0988	95

Table 4.3 Summary of sub-cores collected at each site, analyses and storage.

Site	Total Subcores	Porewater Analysis	Solid Phase(1)	Oxygen Profiles	Benthic Fluxes	Sectioned and frozen (2)	Archived (3)	Macrofauna (4)	Grain Size (5)	
27	7	4	4	2	4	2	1			
16	14	4	8	2	4	5		1		Solid phase: One subcore sectioned at 1 cm intervals to 5 cm depth One subcore sectioned at 1 cm intervals to 6 cm depth One subcore sectioned at 1 cm intervals to 5 cm depth and at 7-8 cm depth Sectioned and frozen: 2 subcores have several depth intervals missing - check this
14	8	3	3	2	4	3	1	1		
4	9	4	4	2	4	2	1	2		
3	3		3	2						
31	11	4	4		4	2	1	2	2	
36	12	4	2	2	4	5	1	2	2	Grain size: One subcore 0-5cm depth only

1) Samples for analysis of solid phase chemistry consist of the sediment remaining after centrifuging of sediments for porewater extraction. Sediments were sectioned at 1 cm intervals to 5 cm depth and at 9-10 cm depth unless otherwise noted.

2) Sediment cores were sectioned as above and frozen. These samples will be subsampled for analysis of sediment porosity and wet weght to dry weight ratios. These cores had been held in the laboratory for up to ten days.

3) Archived subcores are held at AGSO. These cores had been held in the laboratory for up to 10 days from collection.

4) Cores were sieved on board ship for qualitiative analysis of macrofauna.

5) Sediment samples were collected at sites 31 and 36 for grain size analysis of the 0-5 cm and 6-10 cm depth intervals. At other sites, grain size samples were collected as part of the contaminants programme.

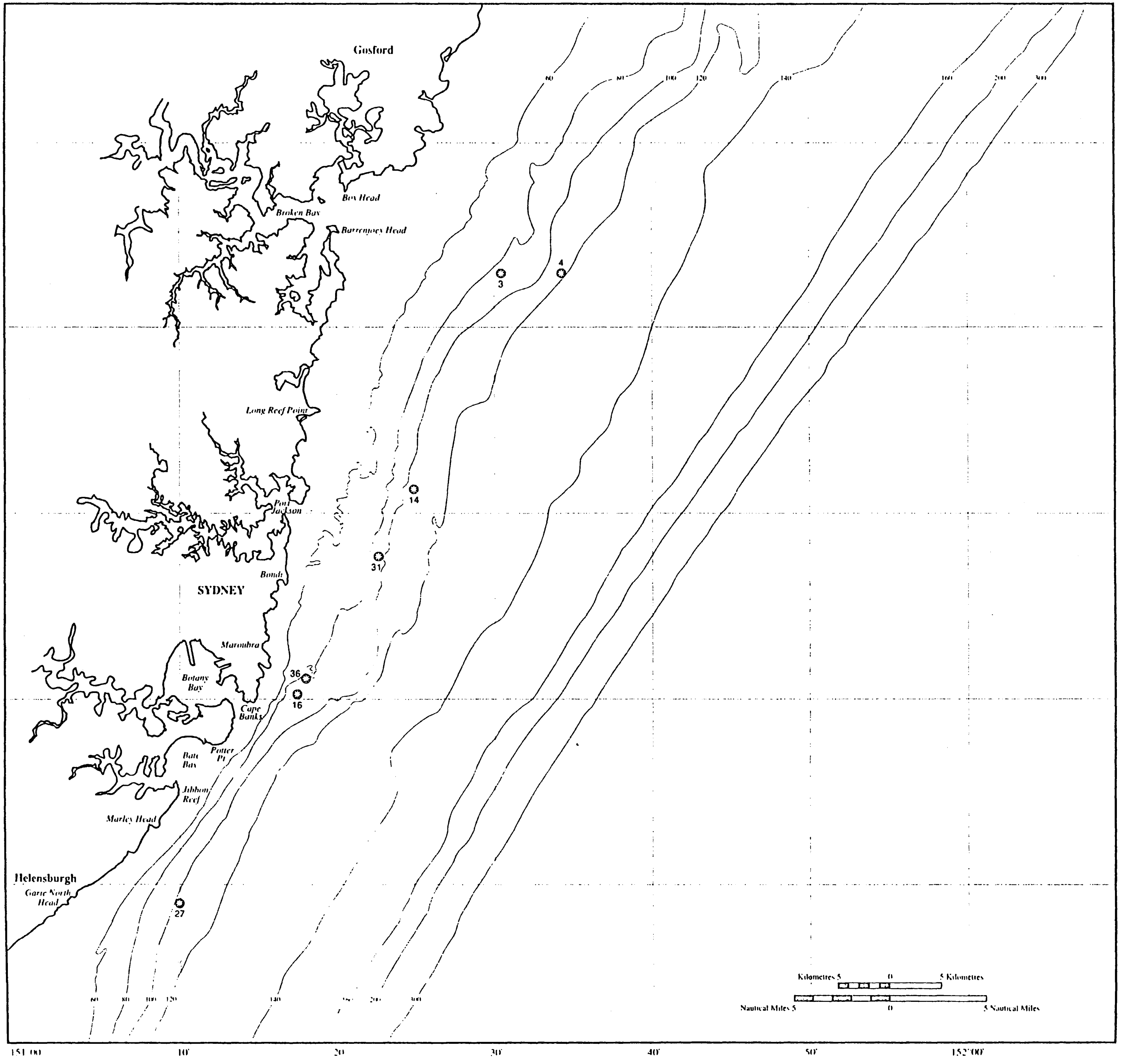


Figure 4.1. Map of box core sampling locations for sediment (nutrient) geochemistry.

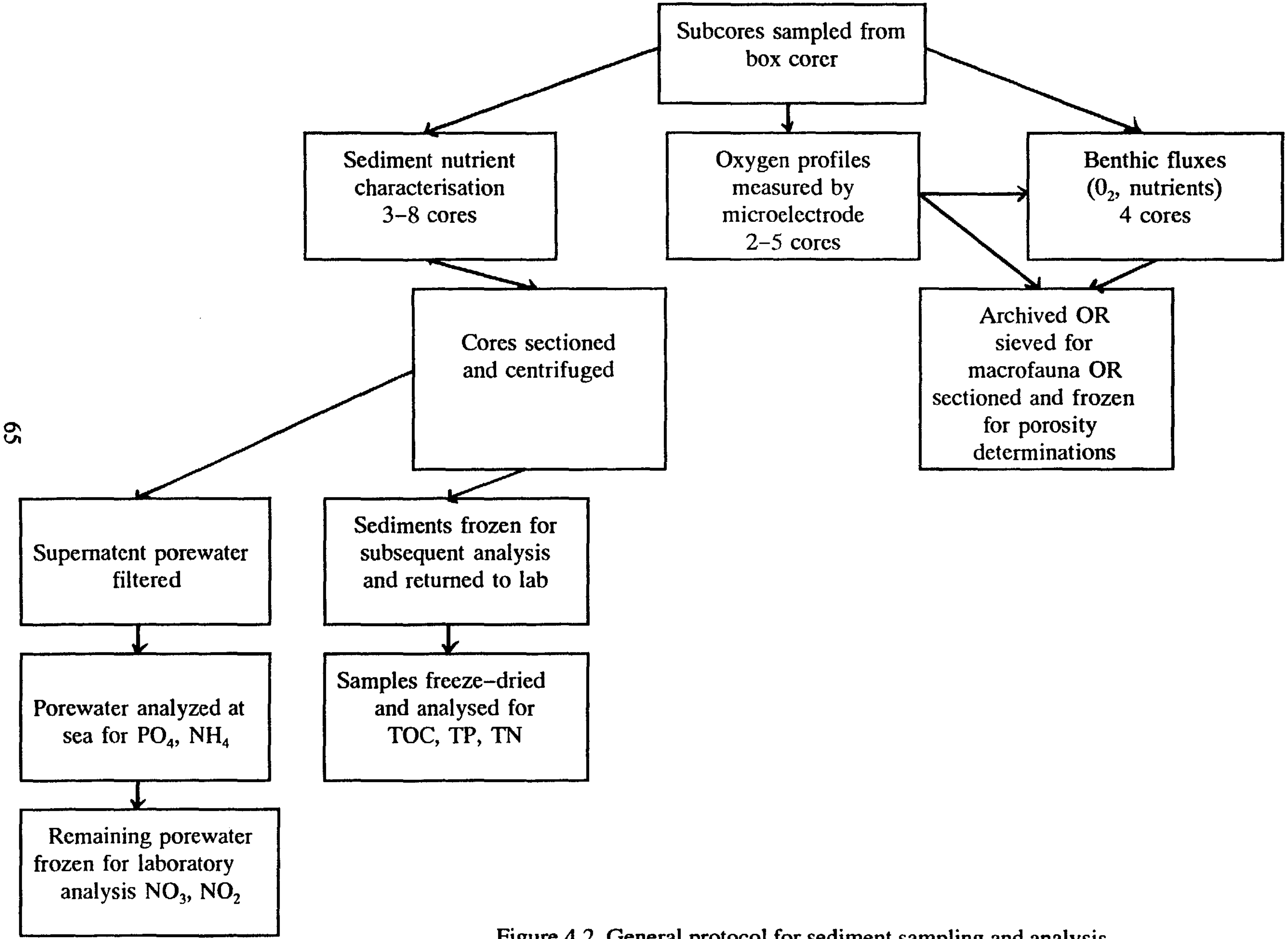


Figure 4.2. General protocol for sediment sampling and analysis.

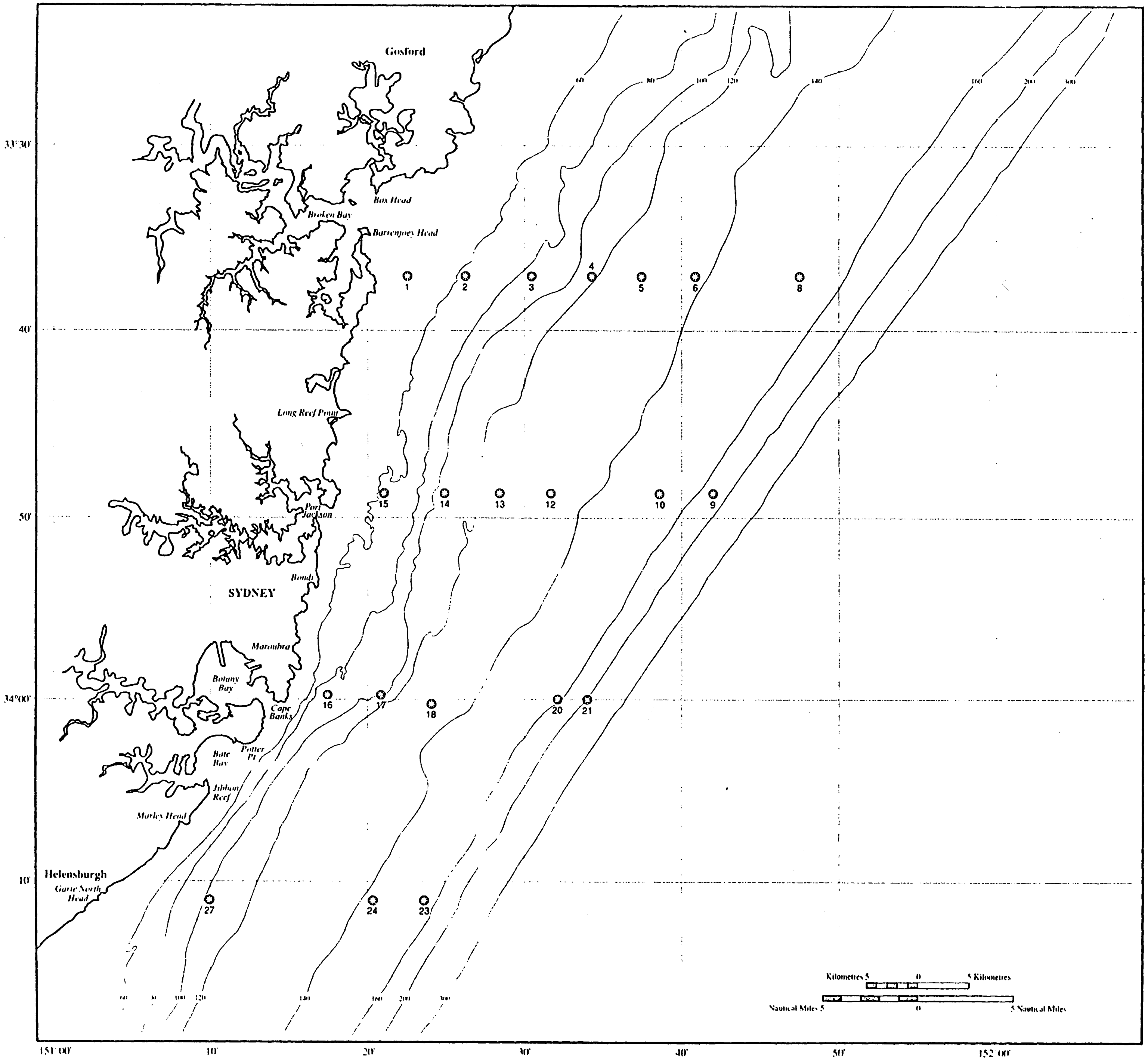
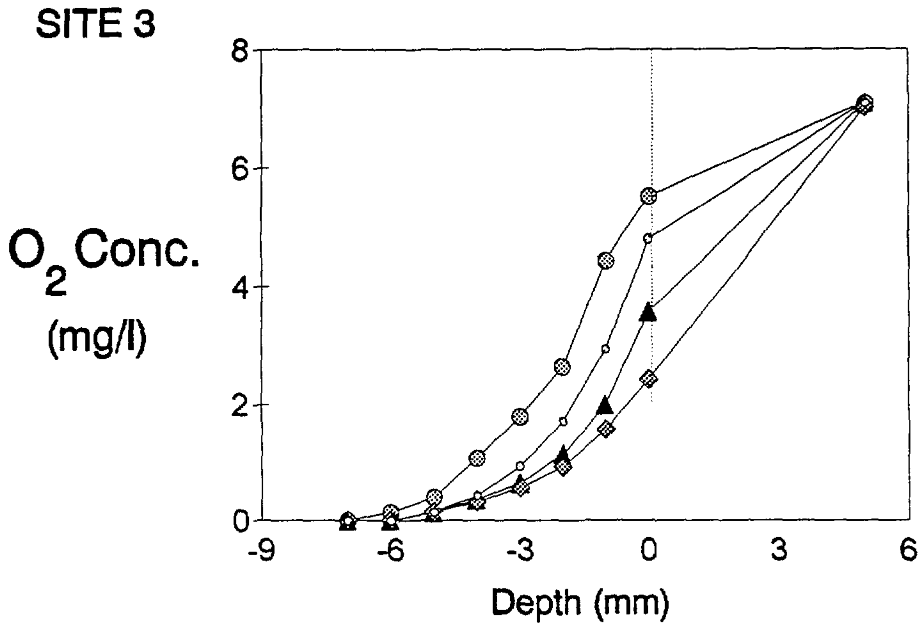


Figure 4.3 Locations of sampling sites for sediment microbiology sampling.



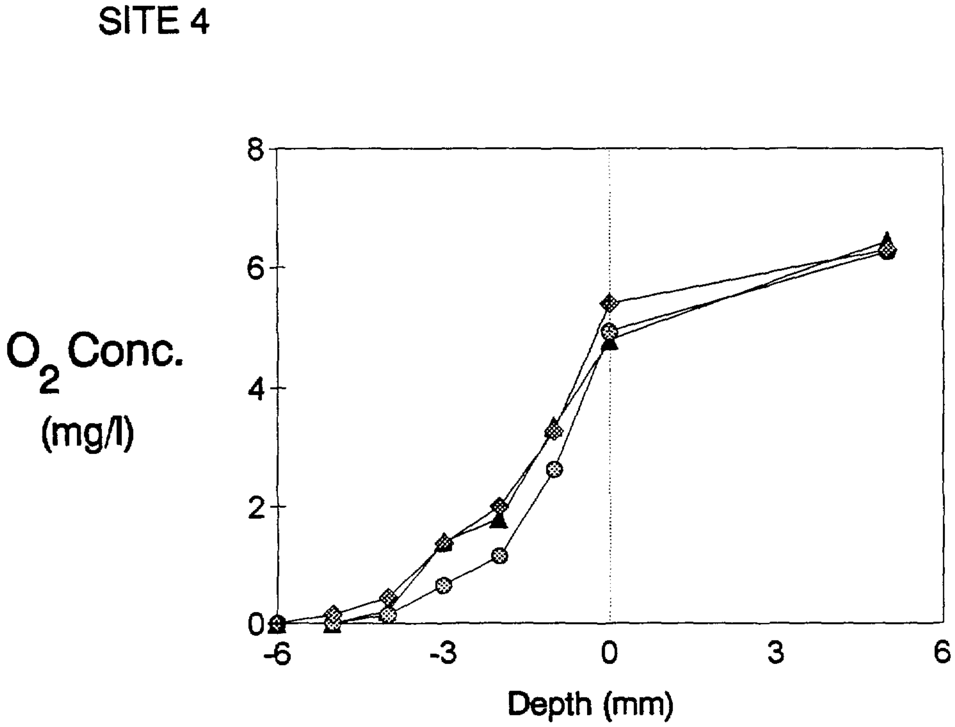


Figure 4.4 Oxygen profiles in fine grained coastal sediments.

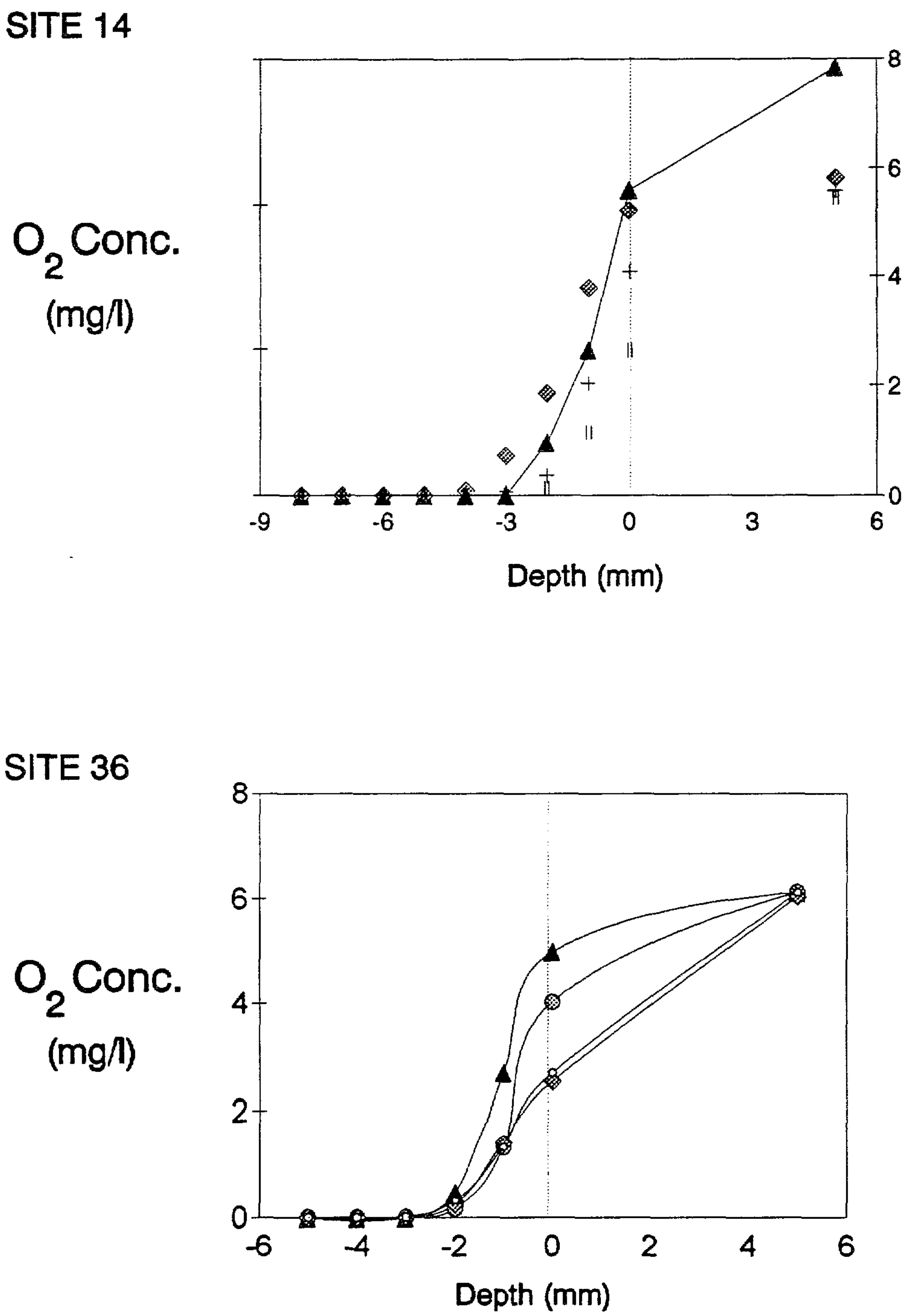
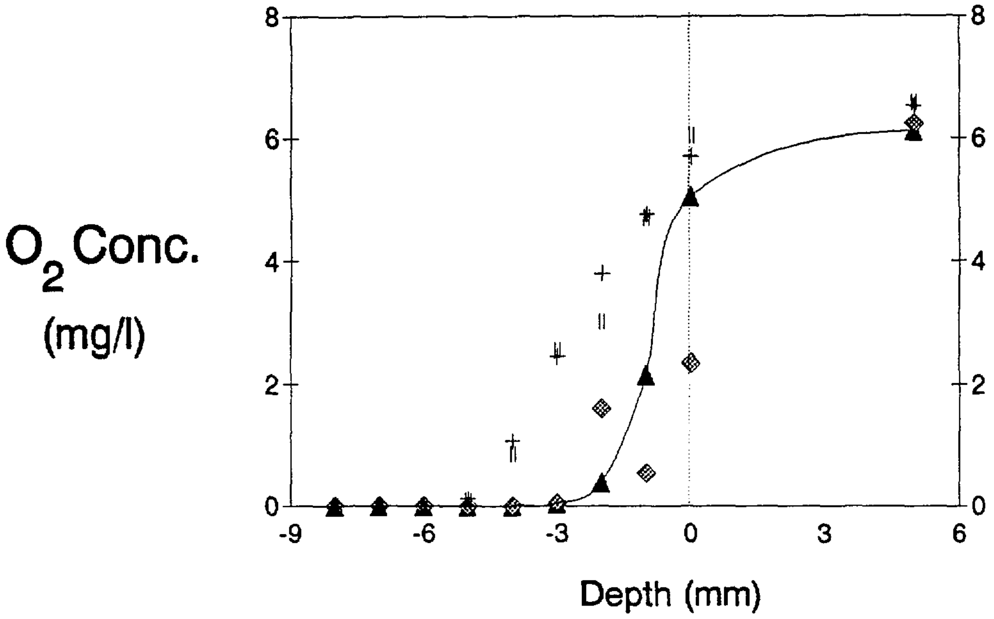


Figure 4.4 (cont.) Oxygen profiles in fine grained coastal sediments.

SITE 16



SITE 27

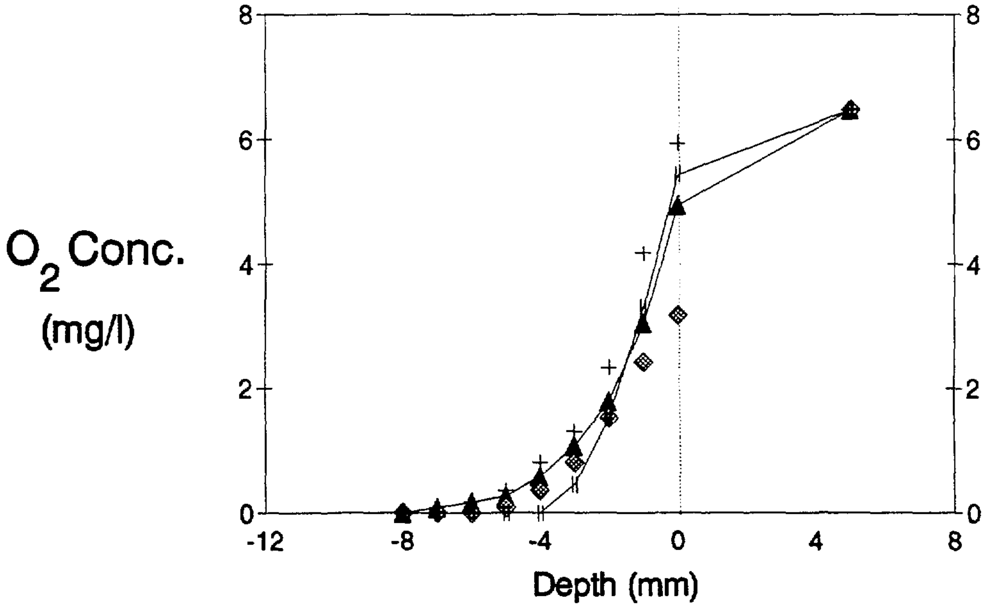
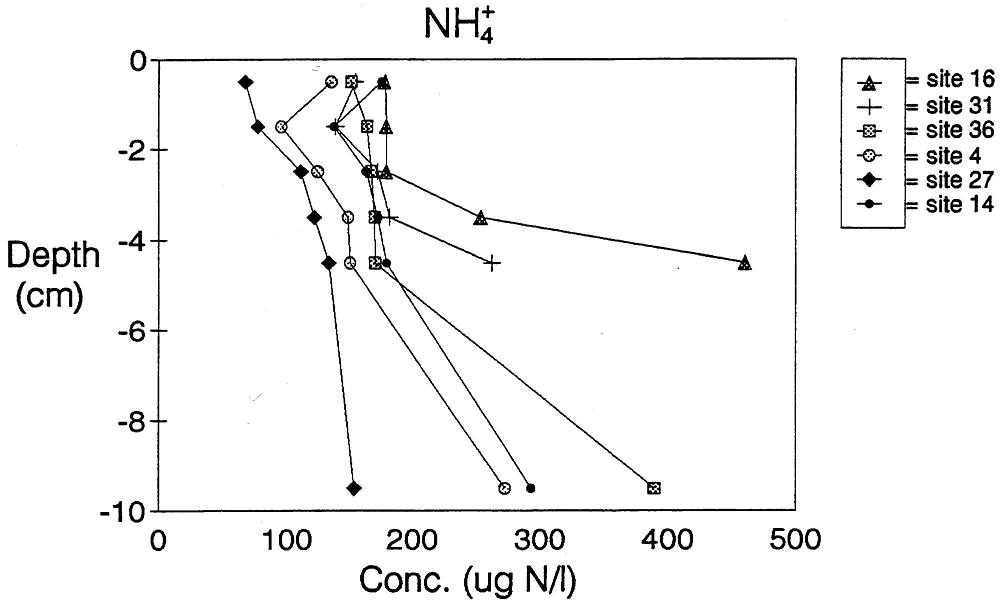


Figure 4.4 (cont.). Oxygen profiles in fine grained coastal sediments.

Nutrient concentrations in sediment porewaters



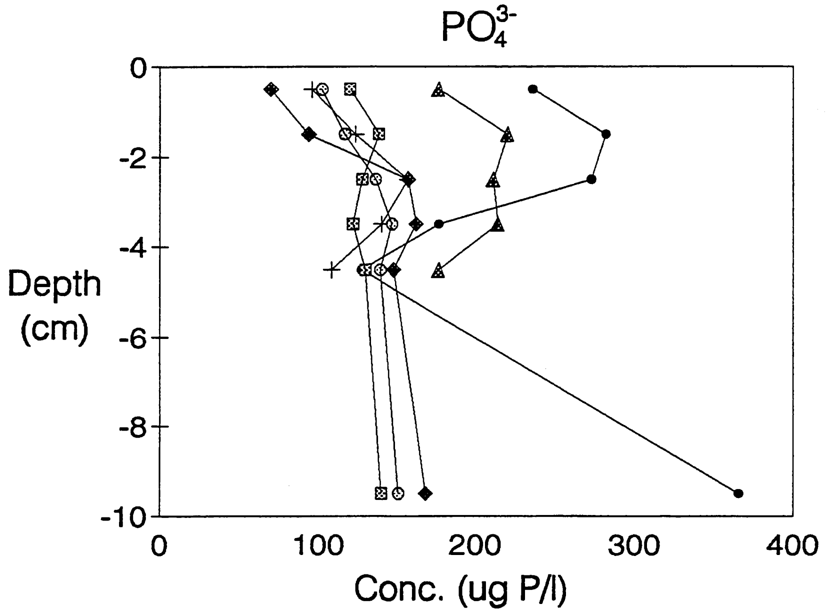


Figure 4.5. Porewater nutrient concentrations in fine grained coastal sediments.

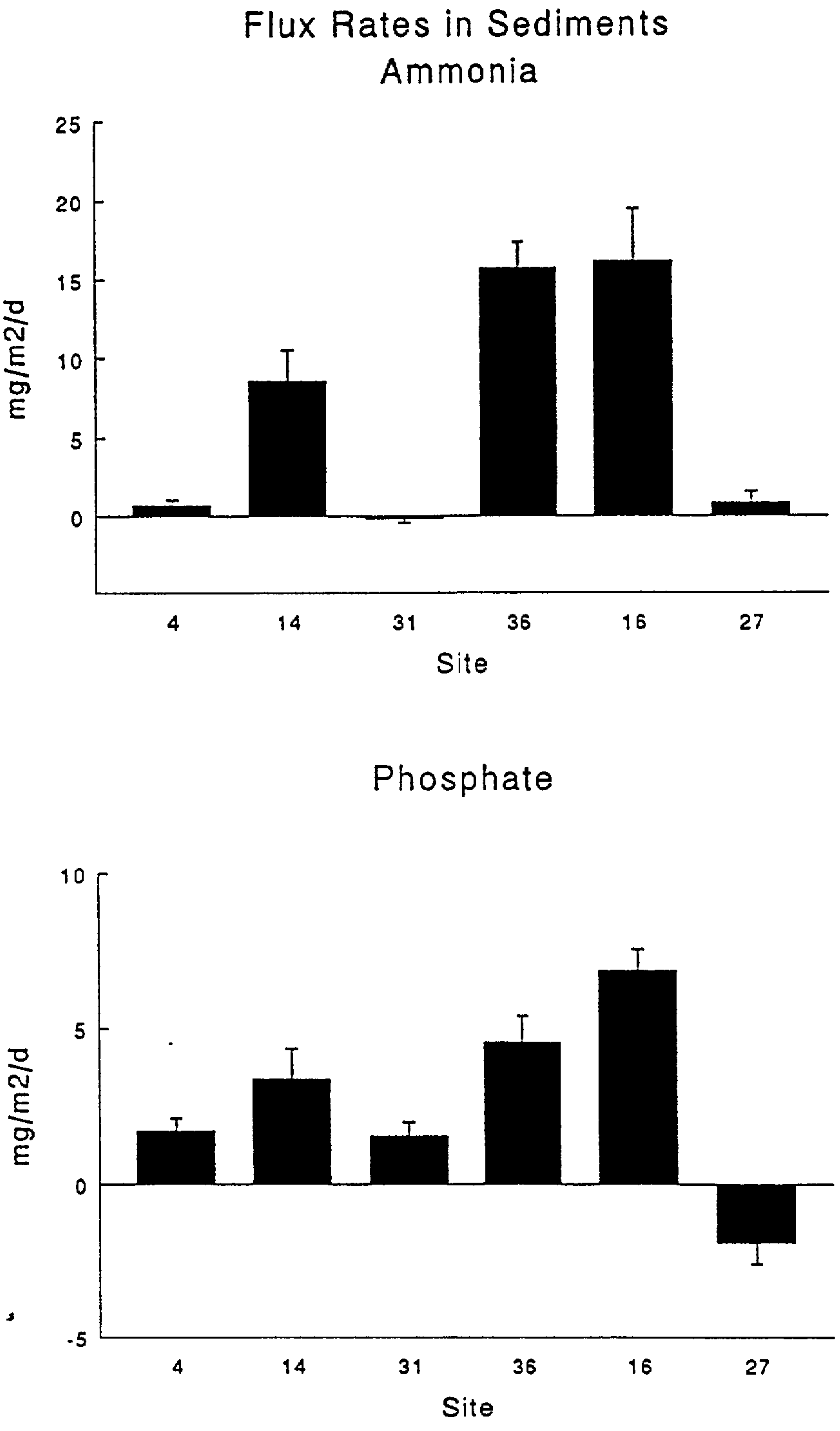
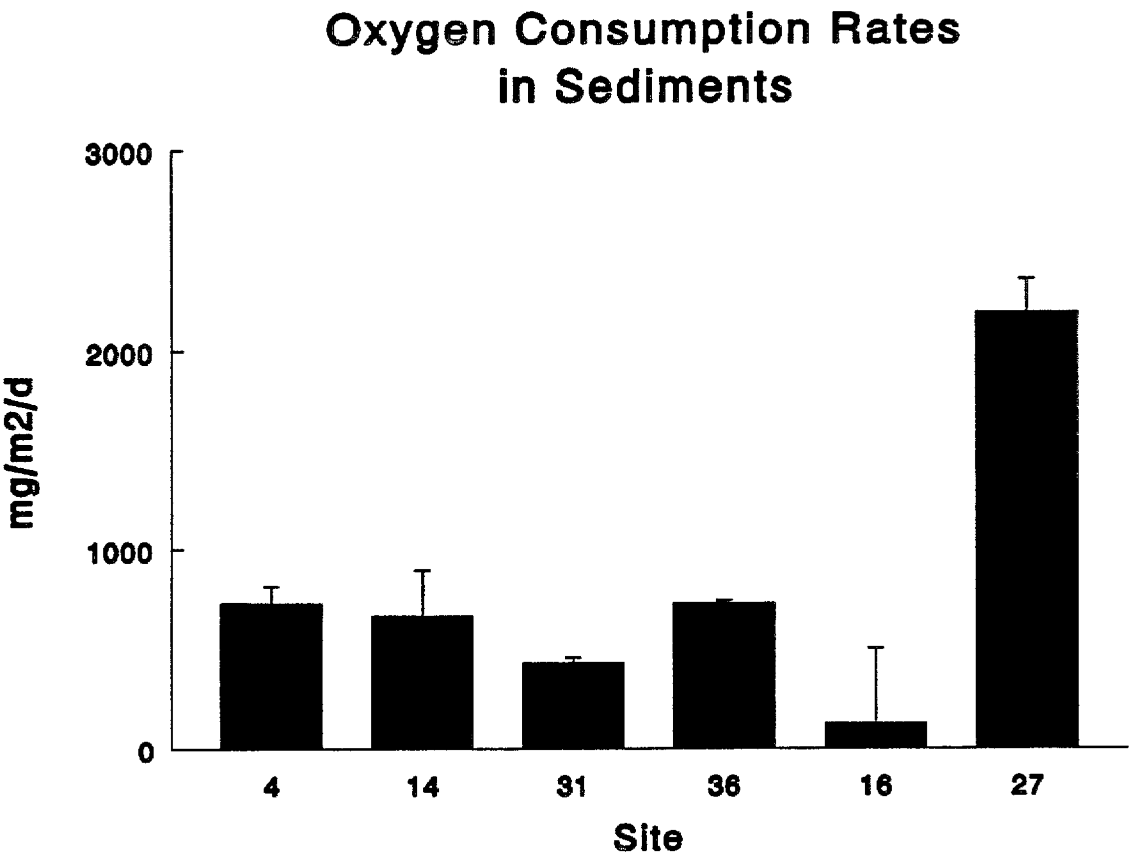
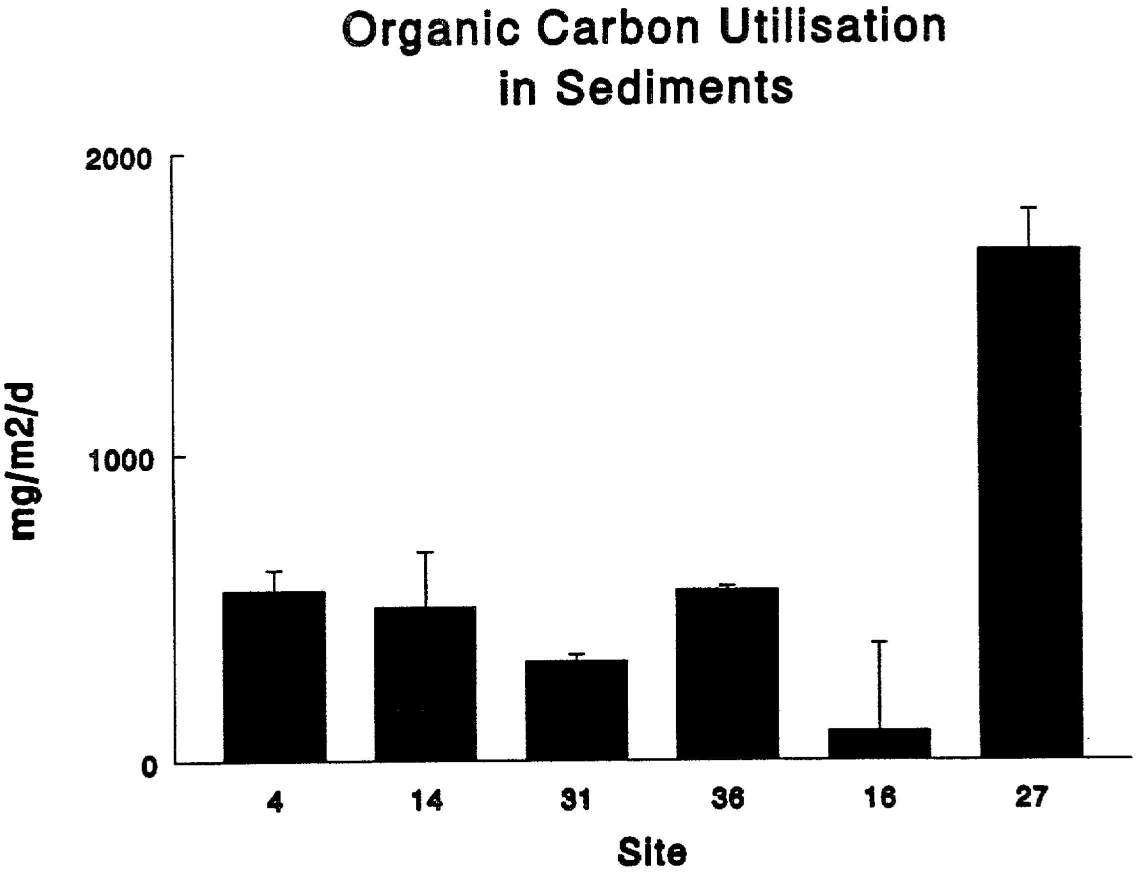


Figure 4.6. Flux rates of ammonia and phosphate from fine grained coastal sediments.



Oxygen Consumption Rates in Sediments



Organic Carbon Utilisation in Sediments

Figure 4.7. Oxygen and carbon utilisation in fine grained coastal sediments.

5. Continuous geochemical tracers (CGT); light hydrocarbons, dissolved oxygen, pH, temperature and salinity in seawater.

The pilot project conducted in 1991 (see Fig. 1.1), suggested that light hydrocarbon anomalies in seawater may be potential tracers of anthropogenic inputs to the coastal zone. These data potentially provided a new tool which could be used to (i) document the dispersion of anthropogenic plumes of materials injected into the coastal zone (ii) develop an understanding of oceanographic and geochemical processes controlling the dispersion of these materials, and hence (iii) assist in the development of environmental monitoring strategies.

The continuous geochemical tracer (CGT) component of this new program (Survey 112) was expanded beyond the scope of the pilot survey (Fig. 1.1) and attempted to identify and characterise the hydrocarbon signals from a number of possible pollutant 'sources' along the coastline offshore Sydney. The CGT component included the Direct Hydrocarbon Detection (DHD), and a submersible data logger (SDL - Yeo-Kal instruments), installed into the CGT tow-fish to provide additional measurements (seawater temperature, salinity, dissolved oxygen and pH), that may also be useful tracers of anthropogenic inputs. Schematics of the CGT capability aboard *Rig Seismic* are shown in Figure 5.1.

The distributions of light hydrocarbons in seawater and sediments (see below) provide sets of both 'baseline' and geochemical/oceanographic processes data that complement the other components of the program - contaminants in sediments, and the nutrient (nitrogen and phosphorus) status of sediments.

Objectives

The objectives of this part of the program were therefore:

1. To determine the concentrations and distributions of light hydrocarbons entering the coastal zone from the ocean outfalls located at Malabar, North Head and Bondi.

2. To determine the concentrations and distributions of light hydrocarbons entering the coastal zone from major estuaries including, Port Jackson, Botany Bay, Broken Bay and Port Hacking.

3. To characterise the molecular and isotopic compositions of light hydrocarbons entering the coastal zone - hence, test if these data are potential tracers of hydrocarbon 'source'

4. To determine the distributions of dissolved oxygen, pH, temperature and salinity in the coastal zone, and test if these parameters may be useful tracers of potential anthropogenic inputs (particularly around the ocean outfalls).

To achieve these objectives approximately 500 line-km of continuous geochemical profiling (CGT) was conducted between Port Hacking and Broken Bay. In addition, eighteen vertical profiles of both light hydrocarbon distributions and SDL (fourteen vertical profiles only), data were collected in the water column from near the ocean outfalls and also in the vicinity of the estuaries.

The complete interpretation of the data collected with the CGT capability is beyond the scope of this Record. The data on light hydrocarbons (DHD) will be presented in an accompanying Record (Heggie & others., 1993a), and the SDL data (hydrographic data and dissolved oxygen and pH) are also reported separately and integrated with parts of the DHD data (Heggie & others., 1993b).

Vertical distributions of hydrocarbons

The locations of the vertical profiles conducted are summarised in Table 5.1, Figure 5.2 (without labels) and in detail in Enclosure 7. An overview of these data is summarised below. Typical background levels of hydrocarbons in seawater are : THC (total hydrocarbons) = 14 ppm; methane = 3 ppm, ethane and propane = 0.02 ppm, ethylene = 0.1 ppm, propylene = 0.07 ppm and butanes < 0.1 ppm).

One of the objectives of this survey was to test if the different ocean outfalls could be distinguished from each other on the basis of both molecular and isotopic compositions. Furthermore, if hydrocarbon plumes were detected emanating from the estuaries, it is important to be able to distinguish these plumes from ocean outfall plumes when mixed in the coastal zone. In the following three figures, the relative abundances of methane and the C_2+ hydrocarbons are compared and contrasted for vertical profiles from the ocean outfalls and those from the entrances to the estuaries.

Figure 5.3, plots methane versus percent hydrocarbon wetness for all data collected from near the ocean outfalls. Percent hydrocarbon wetness is a term used by the petroleum exploration community (and retained here in lieu of a more appropriate way to express these data), to express the relative abundances of the C_2+ hydrocarbons as a percentage of the total hydrocarbon abundance, and used here - [percent hydrocarbon wetness = sum($C_2+C_3+C_4$)/sum($C_1+C_2+C_3+C_4$) x 100]. Typical background methane values are about 3 ppm, while typical background seawater wetness values are < 3%.

In the plot of Figure 5.3, data from different ocean outfalls that plot on the same 'trend-line', have similar molecular abundances of methane and the C_2+ hydrocarbons, although the absolute concentrations of hydrocarbons between the outfalls may be very different. Among the vertical profiles, methane concentrations were as high as 22 ppm, but percent hydrocarbon wetness values were < 0.5 %. The trend-line of decreasing wetness (decreasing abundance of C_2+ hydrocarbons) characterise the ocean outfall data - with most data plotting on this line. Only three data points form one profile (VP112020) near North Head fall off this trend. These three points are all in surface waters and suggest an influence by surface runoff, and not the North Head outfall.

The cross-plot of methane versus percent hydrocarbon wetness for the vertical profiles conducted near the entrances to the estuaries is shown in Figure. 5.4. In this plot there is a cluster of data points around the 'background' values of methane < 5 ppm and wetness values < 3%, but there exists strongly developed trend-lines of increasing wetness with increasing methane content. For example, data from profile VP112017, from south of the entrance to Botany Bay (open squares) has percent hydrocarbon wetness values of >10% at methane concentration of about 12 ppm. The other data from near the entrance to Botany Bay (VP112016 - although this VP is closer to the Malabar outfall) show a trend of slightly decreasing wetness with increasing methane - reflecting the influence of the Malabar outfall rather than hydrocarbons from Botany Bay. Data from offshore Botany Bay (VP112010, open diamonds) represent background hydrocarbon concentrations.

Data from Port Jackson show two profiles with near background wetness and methane levels (VP 112003, VP112005), although the data from VP112005 (closed triangles) indicates a trend toward slightly decreasing wetness values at methane concentrations about twice typical background. This trend and the proximity of VP112005 to the North Head outfall indicates an influence from the outfall. The other profile

(VP112004, open triangles), collected from between North and South Head - and best located to reflect any hydrocarbons from Port Jackson, falls on the same trend-line (albeit at lower hydrocarbon values) as the data from south of the entrance to Botany Bay (VP112017).

The data from offshore Bate Bay (VP112018) show the largest increases in percent hydrocarbon wetness with small increases in methane. This is a surprising result given it's relative offshore location. This station is influenced by high levels of C_{2+} hydrocarbons, and is 'downstream' of the entrance to Botany Bay and directly offshore Bate Bay and Port Hacking.

The contrasts between these two types of compositional signals are shown in Figure 5.5. All of the ocean outfall data (including the VP 112016) from west of Malabar (near the entrance to Botany bay) plot on the trend-line of decreasing wetness with increasing methane. In contrast, those vertical profiles occupied near the entrances to major estuaries, with elevated hydrocarbon concentrations plot on a trend line of increasing wetness (increasing C_2+ abundance) with increasing methane content. These contrasts characterise the molecular compositional differences between ocean outfalls and hydrocarbon mixtures from near the estuaries.

Longitudinal profiles of light hydrocarbons in the coastal zone

The way-points for the CGT survey lines are summarised in Table 5.2. Figures of the ship tracks during the CGT surveys are shown in Figures 5.6 through 5.9. The survey around the WB ocean outfalls was carried out at four different tow-fish depths. For the surveys into Broken Bay and Bate Bay the tow-fish depth was at 5 to 10 m water depth unless noted otherwise. A brief summary of the longitudinal profiling is presented below.

Longitudinal profiles of THC (total hydrocarbons) methane, ethane, ethylene and methane, propane and propylene for survey lines 112005 (5 m water depth); 112009 (25 m water depth);112013 (45 m water depth) are shown in Figures 5.10, 5.11 and 5.12. Each of these lines pass over the ocean outfalls. On each of these profiles, the light hydrocarbon abundance is elevated, over typical background concentrations, in the vicinity of the ocean outfalls and also in the southern sector of the survey area in the vicinity of offshore Botany Bay. Elevated levels of THC and methane are evident particularly around the ocean outfalls, but there are no strong increases in C_2+

hydrocarbons near the ocean outfalls. Increases in the C_2+ hydrocarbons are strongest in the southern sector of the survey area.

These types of data have been used to construct a series of posted-value plots of both the methane and percent hydrocarbon wetness values along the survey lines. These plots are not reproduced here - they are presented and discussed in an accompanying Record (Heggie & others., 1993a) - but a brief summary of some preliminary observations from these plots is provided here.

At 5 m water depth there is little evidence of the North Head outfall influencing the surface waters (< 5m). The surface waters of the northern and most eastern parts of the survey area generally did not show any influences of the ocean outfalls at the time of this survey. However, methane values around Bondi and Malabar are frequently greater than two-fold background concentrations. These elevated values extend seaward and south of Cape Banks. Hence, the Malabar ocean outfall penetrates to shallower depths than the other outfalls - at least during this survey. This result may be a consequence of differences in the stratification in the water column at the three ocean outfall sites, and also be related to the larger volumes of freshwater (buoyant) discharge at Malabar as contrasted to Bondi and North Head, or combinations of both factors.

The percent hydrocarbon wetness plot from the 5 m survey shows relatively abundant levels of C_{2+} hydrocarbons near to and south of the entrance to Port Jackson and, east and south of the entrance to Botany Bay.

Methane distributions at 25 m water depth indicate that the discharges from Bondi and North Head outfalls are more prominent than they were at 5 m depth. The Malabar outfall remains the most prominent at 25 m, with many observations of methane greater than two-fold background over much of the survey lines south of the outfall. Isolated occurrences of methane greater than three-fold background were found near Bondi and south of Malabar (directly off the entrance to Botany Bay).

The C_{2+} hydrocarbons are low and less than background values over much of the survey area (<1.7 % of the hydrocarbon mixture), at 25 m water depth, except in a small area, directly offshore Botany Bay, and also south and east of Botany Bay and Cape Solander.

The ocean outfalls are evident throughout most of the study area at 45 m water depth. The highest concentrations of methane, at this depth, observed during the survey, >100 ppm, were found near the Bondi outfall.

The relative abundance of the C_{2+} hydrocarbons at 45 m depth (compared to the total hydrocarbon mix), is highest in a broad band south of the Malabar outfall encompassing the entrance to Botany Bay and extending to the most southern, western and offshore parts of the survey area.

Data for the mini-survey into Bate Bay indicated significantly elevated hydrocarbon percent wetness values (increased abundances of the C_{2+} hydrocarbons) of > 8.5%, or about four-fold background, were found throughout Bate Bay, even extending to offshore of Port Hacking.

Carbon isotope sample collection

The carbon isotopic compositions of methane, combined with the molecular abundances of hydrocarbon gas mixtures, have been used to determine the origin of hydrocarbons (e.g., Fuex 1977; Bernard & others., 1977). Because hydrocarbons added to the coastal zone offshore Sydney could be derived potentially from different sources (ocean outfalls and industrial discharges), samples were collected to determine the isotopic composition of the methane component. To investigate differences in isotopic compositions of methane from the different geographic areas of the survey, several 1-litre samples of mixed light hydrocarbons were collected when significant water-column anomalies were found. These samples were collected by diverting some of the gas stream from the gas extractor, and displacing water from an inverted 1-litre glass bottle. These samples were logged and stored for subsequent analyses. The logged samples, including the latitude and longitude of the beginning and end of sampling, the number of shot-points and the approximate median methane value are summarised in Table 5.3.

SDL (temperature, salinity, dissolved oxygen and pH data)

Temperature, salinity, dissolved oxygen and pH varied throughout the survey area. A complete presentation of these data is beyond the scope of this Record - these data and an interpretation are presented in an accompanying AGSO Record (Heggie & others., 1993c). Plots of THC (total hydrocarbons) and dissolved oxygen along the survey lines which traverse the ocean outfall diffuser outlets are illustrated in Figures 5.13 through 5.15.

At 5 m water depth there is no evidence of the North Head ocean outfall, but THC values increase near the Bondi outfall and continue to increase to the south. Highest THC values were found south of Malabar at levels about three-fold background concentrations. Local areas of elevated THC are coincident with depleted oxygen concentrations (Fig 5.13).

At 25 m water depth, elevated levels of THC were found near the North Head and Bondi ocean outfalls. Oxygen concentrations are depleted in these areas. However, while individual data do not always coincide (elevated THC and low oxygen), generally, the local changes in these parameters are coincident. [Some of the individual variations may be explained by difficulties in matching two independently, but simultaneously collected data sets. SDL data (oxygen) are collected in-situ at 15 second intervals, while THC data are measured in the ship laboratory at two minute intervals. The two data sets have time as the common denominator. SDL data plotted are those corresponding to two minute sampling intervals. THC concentrations increase systematically immediately south of the Malabar outfall, and oxygen concentrations systematically decrease south of the Malabar outfall (Fig 5.14).

At 45 m water depth, THC levels are elevated near the North Head and Bondi outfalls, and dissolved oxygen levels are lower than typical background concentrations. The increase in THC near the Malabar outfall is very local and evident over a distance of about 500 m south of the outfall. THC concentrations are about twice typical background concentrations south of Malabar (Fig 5.15).

Table 5.1 Locations of Vertical Profiles

VP	WP	Lat. (deg S)	Long. (deg E)	WD (m)	Location
VP112001	WP 2	33.569	151.323	49	Entrance to Broken Bay
VP112002	WP 5	33.808	151.348	65	1 nm north of North Head outfall
VP112003	WP 6	33.848	151.345	72	1.5 nm south of North Head outfall
VP112004	WP 8	33.831	151.296	30	Entrance to Port Jackson
VP112005	WP 7	33.838	151.321	50	2 nm east of South Head
VP112006	WP 9	33.897	151.303	67	0.5 nm south of Bondi outfall
VP112007	WP 10	33.898	151.327	71	1.5 nm east of Bondi outfall
VP112008	WP 11	33.990	151.289	85	1 nm south of Malabar outfall
VP112009	WP 12	33.998	151.307	93	1.5 nm south of Malabar outfall
VP112010	WP 13	34.038	151.281	103	3 nm southeast of Botany Bay entrance
VP112013	WP 35	33.832	151.334	62	0.5 nm southwest of North Head outfall
VP112014	WP 36	33.824	151.340	60	Over the North Head diffuser pipes
VP112015	WP 37	33.987	151.279	56	1 nm southwest of Malabar outfall
VP112016	WP 38	33.999	151.265	54	1.5 nm southwest of Malabar outfall
VP112017	WP 39	34.022	151.239	49	0.5 nm east of Botany Bay entrance
VP112018	WP 26	34.075	151.238	100	3 nm southeast of Bate Bay
VP112019	WP 34	33.827	151.338	60	Over the North Head diffuser pipes
VP112020	WP 35	33.832	151.335	63	0.5 nm southeast of North Head outfall

Table 5.2. Navigation data for the CGT survey

WP #	TIME SSS.DDD.HHMMSS	POSITION W.G.S.	DISTANCE LAST W.P.	COMMENTS
	112.266.102700	S33 34.147 E151 19.418		S.O.L. BROKEN BAY C.G.T.
	112.266.104300	S33 34.205 E151 20.825	2.17km.	
	112.266.113800	S33 38.834 E151 21.260	8.60km.	E.O.L. BROKEN BAY C.G.T.
	BROKEN	BAY C.G.T. TOTAL	10.77km.	
	112.268.010000	S34 01.334 E151 14.326		S.O.L. BATE BAY C.G.T.
	112.268.011200	S34 02.276 E151 13.806	1.92km.	
	112.268.014400	S34 03.363 E151 10.629	5.28km.	
	112.268.015700	S34 03.951 E151 11.151	1.35km.	
	112.268.023000	S34 04.514 E151 14.145	4.71km.	E.O.L. BATE BAY C.G.T.
	BATE	BAY C.G.T. TOTAL	13.26km.	
WP #19	112.268.080000	S34 04.327 E151 13.661		C.G.T. @ 5m. below surface
WP #20	112.268.091900	S33 58.342 E151 17.388	12.47km.	
WP #21	112.268.102200	S33 53.268 E151 17.644	9.41km.	
WP #22	112.268.113800	S33 47.339 E151 20.808	12.01km.	E.O.L PT. 1
WP #23	112.268.115800	S33 48.484 E151 20.869		S.O.L. PT. 2 C.G.T. @ 5m.
WP #24	112.268.125700	S33 53.154 E151 18.327	9.49km.	
WP #25	112.268.135500	S33 58.460 E151 17.862	9.85km.	
WP #26	112.268.151400	S34 04.472 E151 14.273	12.42km.	E.O.L. PT. 2
WP #40	112.268.170700	S34 04.677 E151 14.795		S.O.L. PT.3 C.G.T. @ 5m.
WP #41	112.268.174400	S34 01.968 E151 16.392	5.62km.	
WP #42	112.268.183100	S33 58.586 E151 18.501	7.05km.	
WP #43	112.268.193400	S33 53.309 E151 18.915	9.79km.	
WP #44	112.268.204500	S33 47.749 E151 21.764	11.19km.	E.O.L. PT. 3
WP #30	112.268.210500	S33 48.725 E151 21.883		S.O.L. PT. 4 C.G.T. @ 5m.
WP #29	112.268.220200	S33 53.368 E151 19.592	9.29km.	
WP #28	112.268.230000	S33 58.557 E151 19.149	9.64km.	
WP #27	112.269.003300	S34 05.907 E151 14.659	12.74km.	E.O.L. PT. 4
		C.G.T. @ 5m. TOTAL	130.97km.	

Table 5.2 continued.

WP #19	112.269.020000	S34 04.388 E151 13.643		C.G.T. @ 25m. below the surface
WP #20	112.269.032000	S33 58.433 E151 17.333	12.47km.	
WP #21	112.269.042400	S33 53.216 E151 17.637	9.41km.	
WP #22	112.269.054100	S33 47.321 E151 20.812	12.01km.	E.O.L. PT. 1
WP #23	112.269.060200	S33 48.425 E151 20.869		S.O.L. PT. 2 C.G.T. @ 25m.
WP #24	112.269.070400	S33 53.201 E151 18.312	9.49km.	
WP #25	112.269.080300	S33 58.383 E151 17.869	9.85km.	
WP #26	112.269.092700	S34 04.509 E151 14.266	12.42km.	E.O.L. PT. 2
WP #40	112.269.093800	S34 04.698 E151 14.713		S.O.L. PT. 3 C.G.T. @ 25m.
WP #41	112.269.101200	S34 02.038 E151 16.351	5.62km.	
WP #42	112.269.105500	S33 58.602 E151 18.490	7.05km.	
WP #43	112.269.115400	S33 53.325 E151 18.924	9.79km.	
WP #44	112.269.130500	S33 47.728 E151 21.881	11.19km.	E.O.L. PT. 3
WP #30	112.269.132500	S33 48.696 E151 21.894		S.O.L. PT. 4 C.G.T. @ 25m.
WP #29	112.269.143000	S33 53.362 E151 19.581	9.29km.	
WP #28	112.269.154800	S33 58.486 E151 19.171	9.64km.	
WP #27	112.269.175000	S34 04.903 E151 15.271	12.74km.	E.O.L. PT. 4 C.G.T. @ 25m.
		C.G.T. @ 25m. TOTAL	130.97km.	
WP #19	112.269.185700	S34 04.305 E151 13.669		C.G.T. @45 m. below the surface
WP #20	112.269.201300	S33 58.303 E151 17.368	12.47km.	
WP #21	112.269.211300	S33 53.181 E151 17.661	9.41km.	
WP #22	112.269.222600	S33 47.270 E151 20.856	12.01km.	E.O.L. PT.1
WP #23	112.269.225200	S33 48.441 E151 20.878		S.O.L. PT. 2 C.G.T. @ 45m.
WP #24	112.269.235700	S33 53.180 E151 18.333	9.49km.	
WP #25	112.270.010900	S33 58.412 E151 17.844	9.85km.	
WP #26	112.270.023700	S34 04.442 E151 14.286	12.42km.	E.O.L. PT.2 C.G.T. @45m.
WP #40	112.270.030900	S34 04.722 E151 14.718		S.O.L. PT. 3 C.G.T. @ 45m.
WP #41	112.270.034500	S34 02.034 E151 16.339	5.62km.	
WP #42	112.270.043200	S33 58.591 E151 18.474	7.05km	
WP #43	112.270.053400	S33 53.300 E151 18.884	9.79km.	
WP #44	112.270.065000	S33 47.704 E151 21.881	11.19km.	E.O.L. PT. 3
WP #30	112.270.071300	S33 48.717 E151 21.890		S.O.L. PT. 4 C.G.T. @ 45m.
WP #29	112.270.082500	S33 53.394 E151 19.603	9.29km.	

Table 5.2 continued.

WP #28	112.270.093500	S33 58.462 E151 19.166	9.64km.	
WP #27	112.270.105900	S34 04.914 E151 15.231	12.74km.	E.O.L. PT.4 C.G.T. @ 45m.
		C.G.T. @ 45m. TOTAL	130.97km.	
WP #27	112.270.122900	S34 04.905 E151 15.256		C.G.T. @ 15m. above sea floor
WP #28	112.270.150100	S33 58.542 E151 19.151	12.74km.	
WP #29	112.270.160100	S33 53.375 E151 19.581	9.64km.	
WP #30	112.270.170200	S33 48.725 E151 21.879	9.29km.	E.O.L. PT. 1 C.G.T. @ 15m.
WP #44	112.270.172100	S33 47.763 E151 21.817		S.O.L. PT. 2 + 1 n.m.
WP #43	112.270.183600	S33 53.318 E151 18.911	11.19km.	
	112.270.184200	S33 53.789 E151 18.876	0.87km.	FISH LOST C.G.T. @ 15m.
		C.G.T. @15m. TOTAL	43.73m.	
		C.G.T. TOTAL	460.67km.	

Table 5.3. List of samples collected for determination of the carbon isotopic composition of methane, including locations, approximate methane content and tow-fish depth.

Line	Sample	Shotpoint	Approx. Methane	Fish	Start	Start	Stop	Stop	Comments
			(ppm)	Depth (m)	Lat. (S)	Lon. (E)	Lat (S)	Lon. (E)	
Transit	SS112 NZ1			10	33.782	151.714			offshore
	SS112 NZ2			10					offshore
	SS112 NZ3			10					offshore
	SS112 NZ4			10					offshore
	SS112 NZ5			10					offshore
	SS112 NZ6			10					offshore
	SS112 NZ7			10					offshore
	SS112 NZ8			10					offshore
	SS112 NZ9			10					offshore
	SS112 NZ10			10			33.646	151.782	offshore
Hsurvey	SS112 01	173 - 177	1.0 - 3.0	13	33.578	151.364	33.571	151.346	Bath. survey
VP112001	SS112 02	9 - 14.	3.6	7	33.569	151.323	33.569	151.323	
VP112001	SS112 03	14 - 22	3.6	7 - 14	33.569	151.323	33.569	151.323	
VP112001	SS112 04	23 - 27	3.6	13	33.569	151.323	33.569	151.324	
VP112002	SS112 05	23 - 28	4.1	1	33.808	151.348	33.808	151.348	
VP112013	SS112 06	20 - 37	4.7 - 12.1	4 - 35.	33.832	151.335	33.832	151.334	WP35
VP112003	SS112 07	4 - 14.	3.5 - 3.9	1	33.850	151.347	33.848	151.346	WP3 North Head
VP112003	SS112 08	14 - 24	3.6	15 - 35	33.848	151.346	33.848	151.346	WP3 North Head
VP112003	SS112 09	24 - 34	3.5	35 - 68	33.848	151.346	33.848	151.346	WP3 North Head
VP112003	SS112 10	34 - 43	3.3 - 3.3	68 - 70	33.848	151.346	33.849	151.346	WP3 North Head
VP112004	SS112 11	21 - 32	6.1	9 - 24.	33.831	151.296	33.831	151.296	WP8
VP112014	SS112 12	30 - 32	12.1	55	33.824	151.340	33.823	151.340	WP36
VP112014	SS112 13	32 - 34	12.1	55	33.823	151.340	33.824	151.340	
VP112006	SS112 14	21 - 27	15 - 21.7	30 - 35	33.897	151.303	33.897	151.303	
VP112006	SS112 15	37 - 43	3.7 - 18.8	53 - 59	33.897	151.303	33.897	151.303	
VP112006	SS112 16	51 - 53	3.6 - 19	25	33.897	151.303	33.897	151.303	
VP112006	SS112 17	53 - 56	19 - 21	25	33.897	151.303	33.897	151.302	
VP112006	SS112 18	56 - 54	20 - 23 8	26	33.897	151.302	33.897	151.302	
VP112008	SS112 19	48 - 52	3.1 - 4.5	68	33.990	151.289	33.992	151.291	WP 11
VP112015	SS112 20	34 - 46	7.5 - 12.1	23 - 51	33.987	151.280	33.987	151.280	WP 37
VP112017	SS112 21	6 - 21.	3.2 - 8.7	1 - 9.	34.018	151.244	34.022	151.238	WP39 High C2 to C4

VP112017	SS112 22	23 - 33	5.3 - 11.1	9 - 22.	34.022	151.239	34.022	151.239	WP 39 High C2 to C4
VP112017	SS112 23	33 - 43	7.6 - 11.2	22 - 32	34.022	151.239	34.022	151.239	WP 39 High C2 to C4
112 003	SS112 24	1 - 12.	3.3 - 6	2 - 11.	34.022	151.239	34.049	151.210	Bate Bay Line
112 003	SS112 25	12 - 22.	5.2 - 9.5	12 - 5.	34.049	151.210	34.056	151.177	Bate Bay Line
112 005	SS112 26	81 - 86	7.6 - 8.8	4	34.017	151.272	34.029	151.265	
112 006	SS112 26	51 - 54	7.6 - 8.2	3	34.033	151.273	34.023	151.279	
112 008	SS112 27	10. - 17	4.1 - 9.8	25	34.100	151.210	34.081	151.222	
112 008	SS112 28	40 - 47	6.3 - 13.6	25	34.023	151.258	34.003	151.270	
112 008	SS112 29	82 - 86	4.7 - 45.5	25	33.909	151.293	33.898	151.294	
112 008	SS112 30	111 - 116	4.6 - 13	25	33.830	151.325	33.818	151.331	
112 009	SS112 31	18 - 25	3.5 - 11.6	26	33.825	151.339	33.843	151.329	
112 009	SS112 32	41 - 47	4.6 - 27.5	26	33.887	151.305	33.905	151.303	
112 009	SS112 33	82 - 87	8.3 - 17.5	26	34.004	151.280	34.017	151.272	
112 009	SS112 34	88 - 94	11.8 - 30	26	34.019	151.271	34.034	151.262	
112 009	SS112 35	95 - 104	10.1 - 21	26	34.039	151.259	34.060	151.247	
112 009	SS112 36	106 - 109	10.2 - 12	26	34.064	151.245	34.080	151.237	
112 010	SS112 37	4 - 9.	8.1 - 14	25	34.078	151.245	34.068	151.252	
112 010	SS112 38	10 - 14.	8.1 - 10	25	34.065	151.254	34.053	151.261	
112 013	SS112 39	15 - 25.	4.0 - 25	38 - 40	33.805	151.349	33.830	151.336	
112 013	SS112 40	42 - 50	24 - 107	18	33.872	151.313	33.893	151.305	High C1
112 014	SS112 41	60 - 64	3.5 - 5.3	42 - 44	33.957	151.311	33.945	151.311	
112 014	SS112 42	94 - 98	4.0 - 22	50	33.862	151.329	33.852	151.334	
112 019	SS112 43	20 - 25	2.6	32 - 40	33.827	151.349	33.827	151.336	
112 019	SS112 44	25 - 34	2.5	40 - 47	33.827	151.332	33.832	151.323	

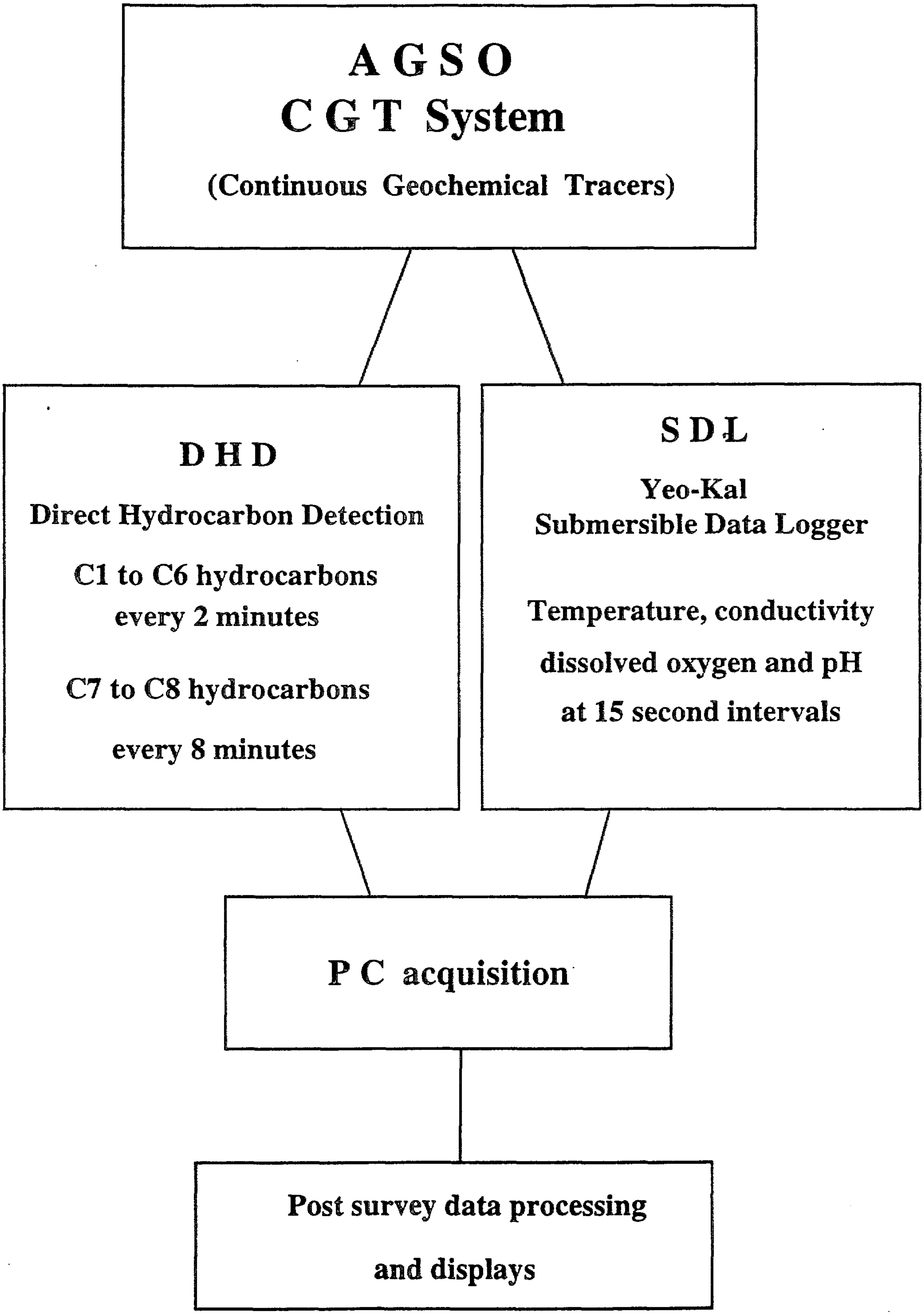


Figure 5.1 Schematic diagram of the CGT (Continuous Geochemical Tracer) capability aboard *Rig Seismic*

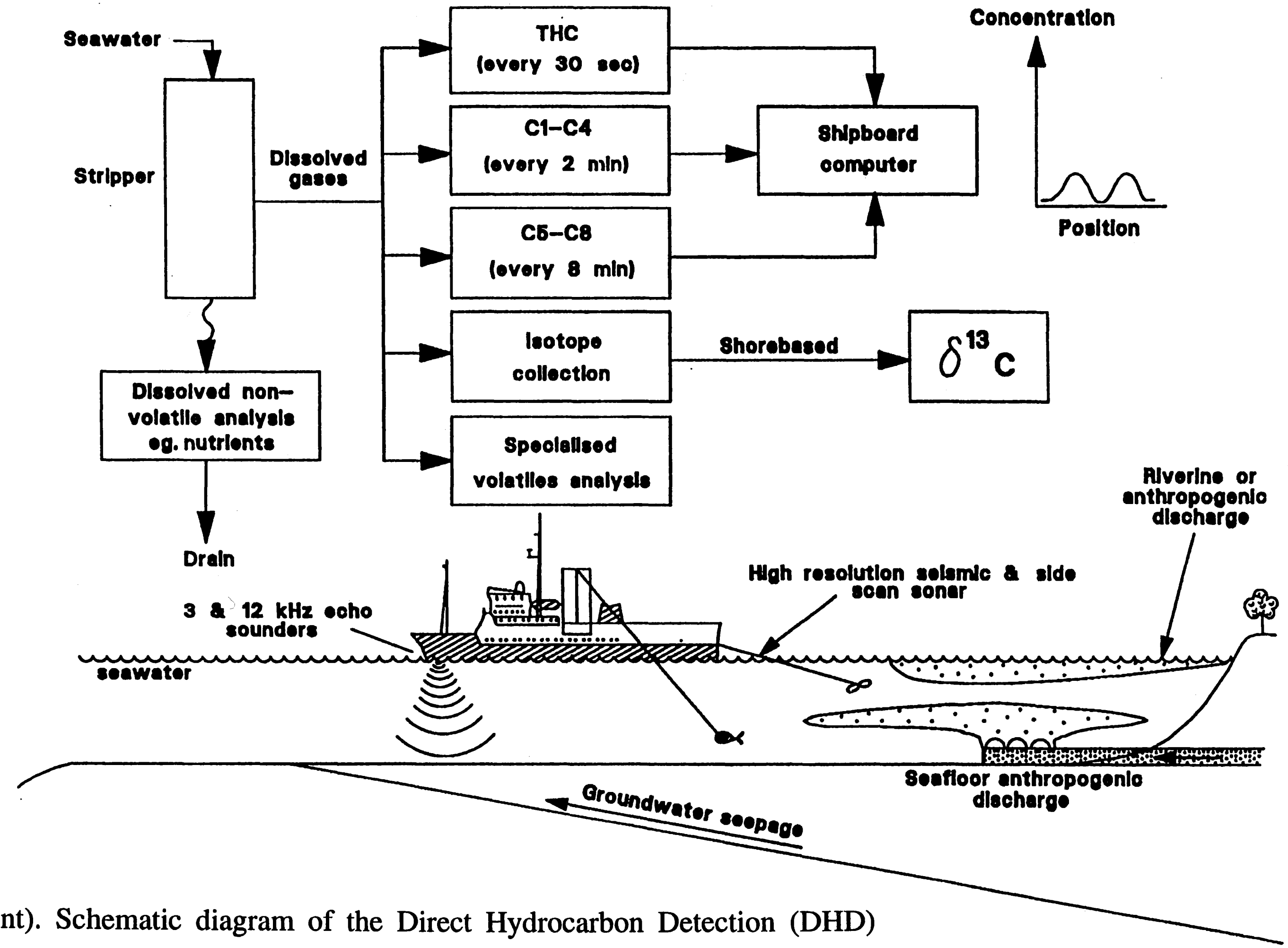


Figure 5.1 (cont). Schematic diagram of the Direct Hydrocarbon Detection (DHD) component of the CGT capability aboard *Rig Seismic.*

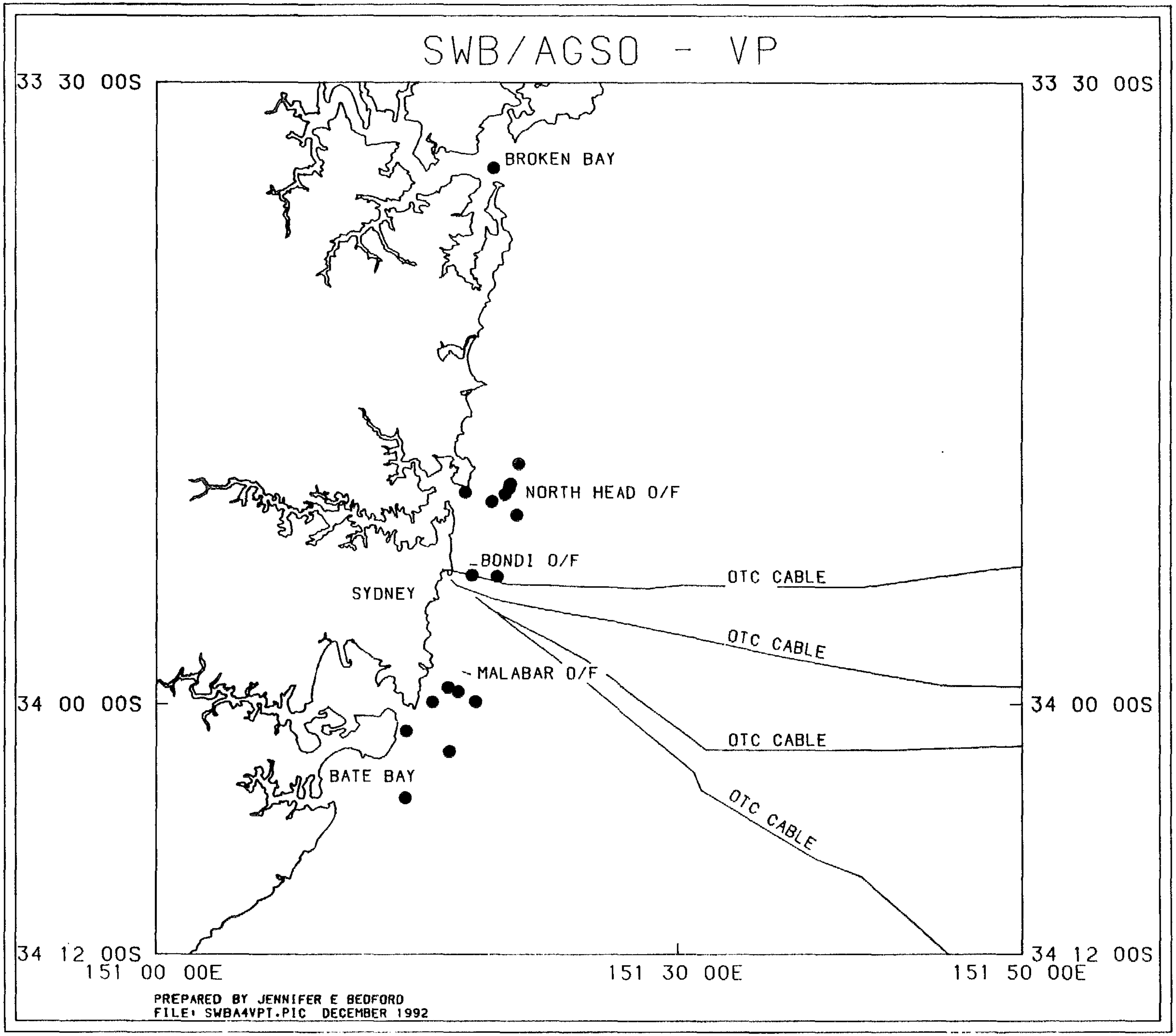


Figure 5.2 Map of the locations of vertical profiles conducted during Survey 112

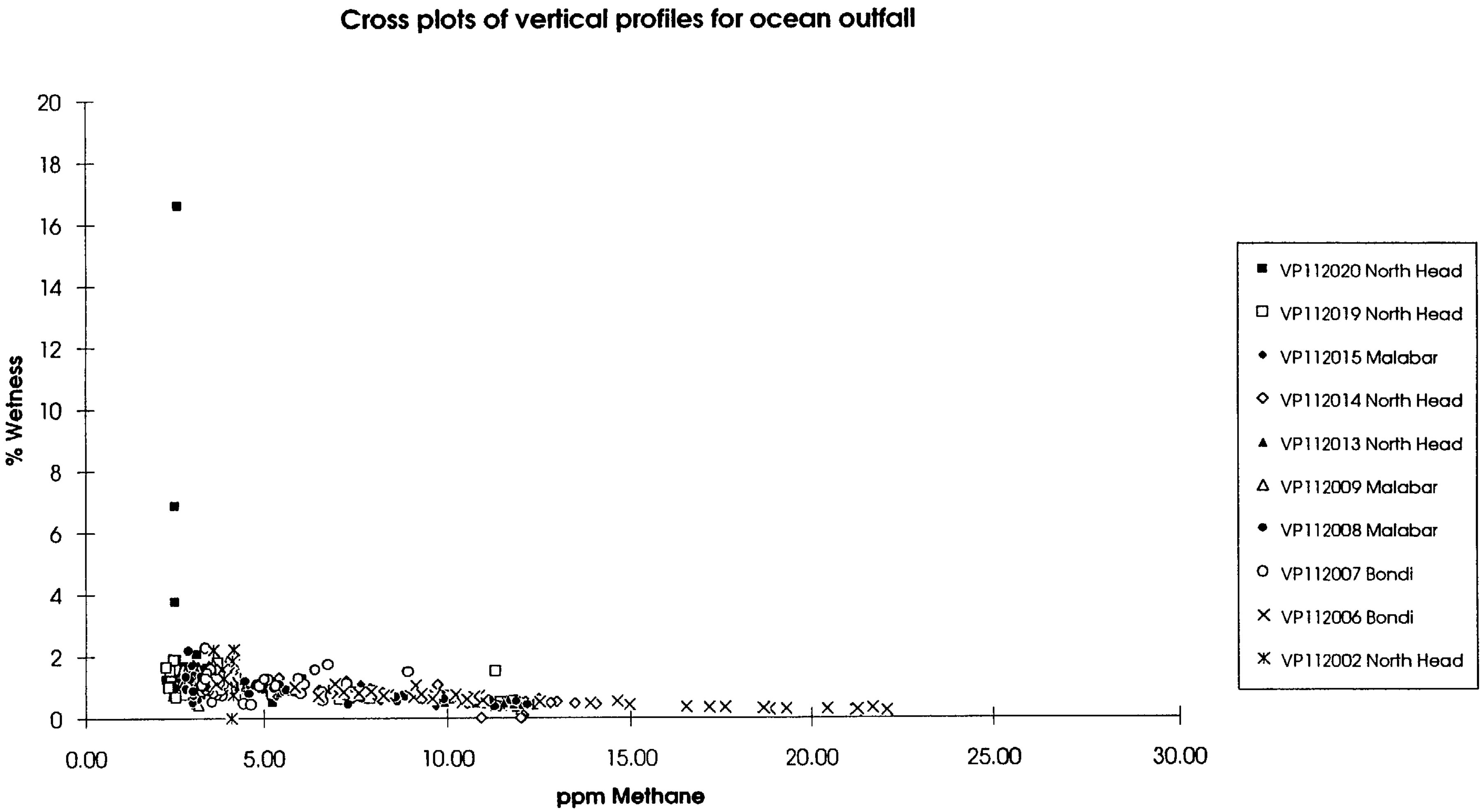


Figure 5.3 Percent hydrocarbon wetness and methane for the vertical profiles located near the ocean outfalls.

OOXP.XLC

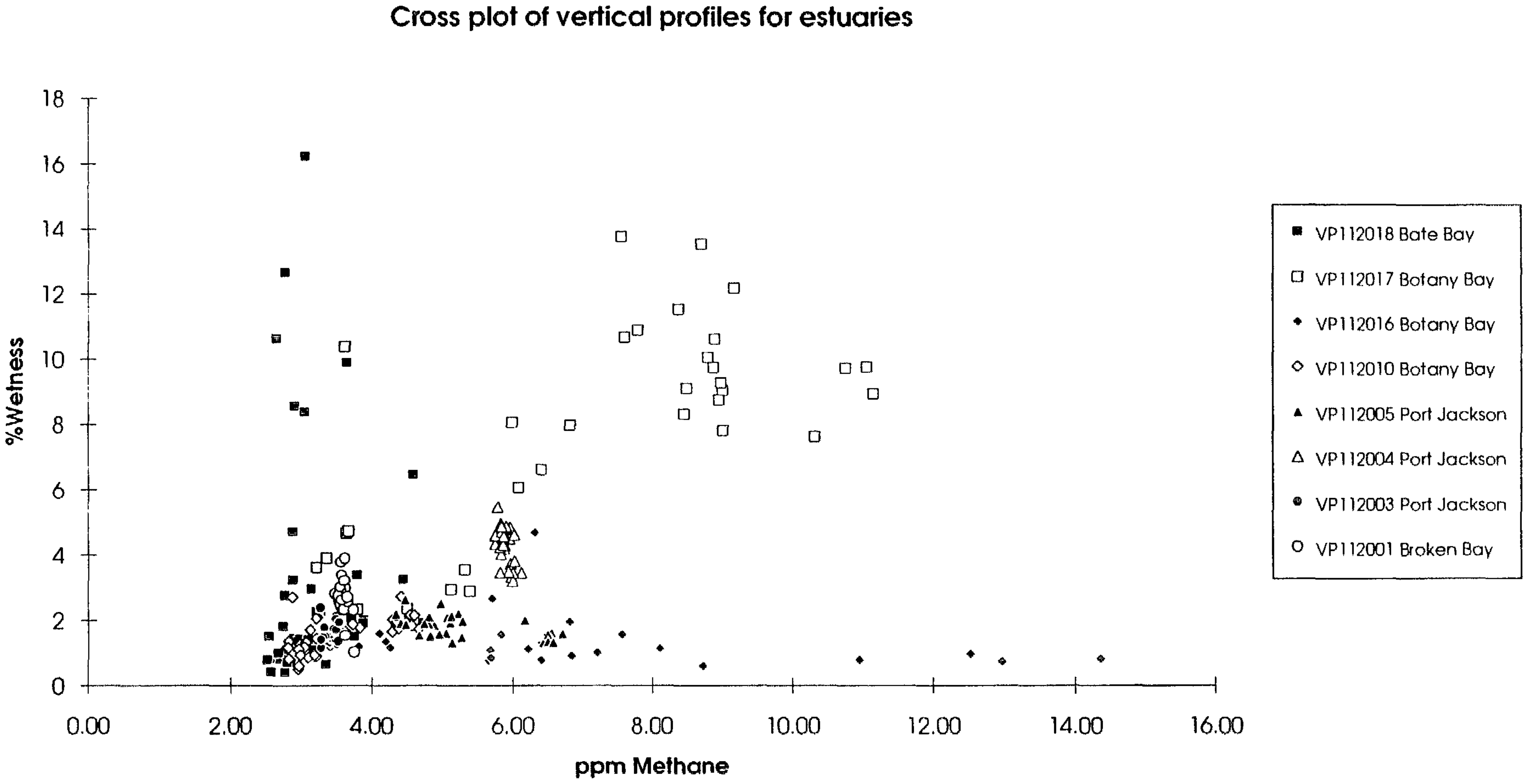


Figure 5.4 Percent hydrocarbon wetness and methane for the vertical profiles located near the entrances to estuaries.

ESTXP.XLC

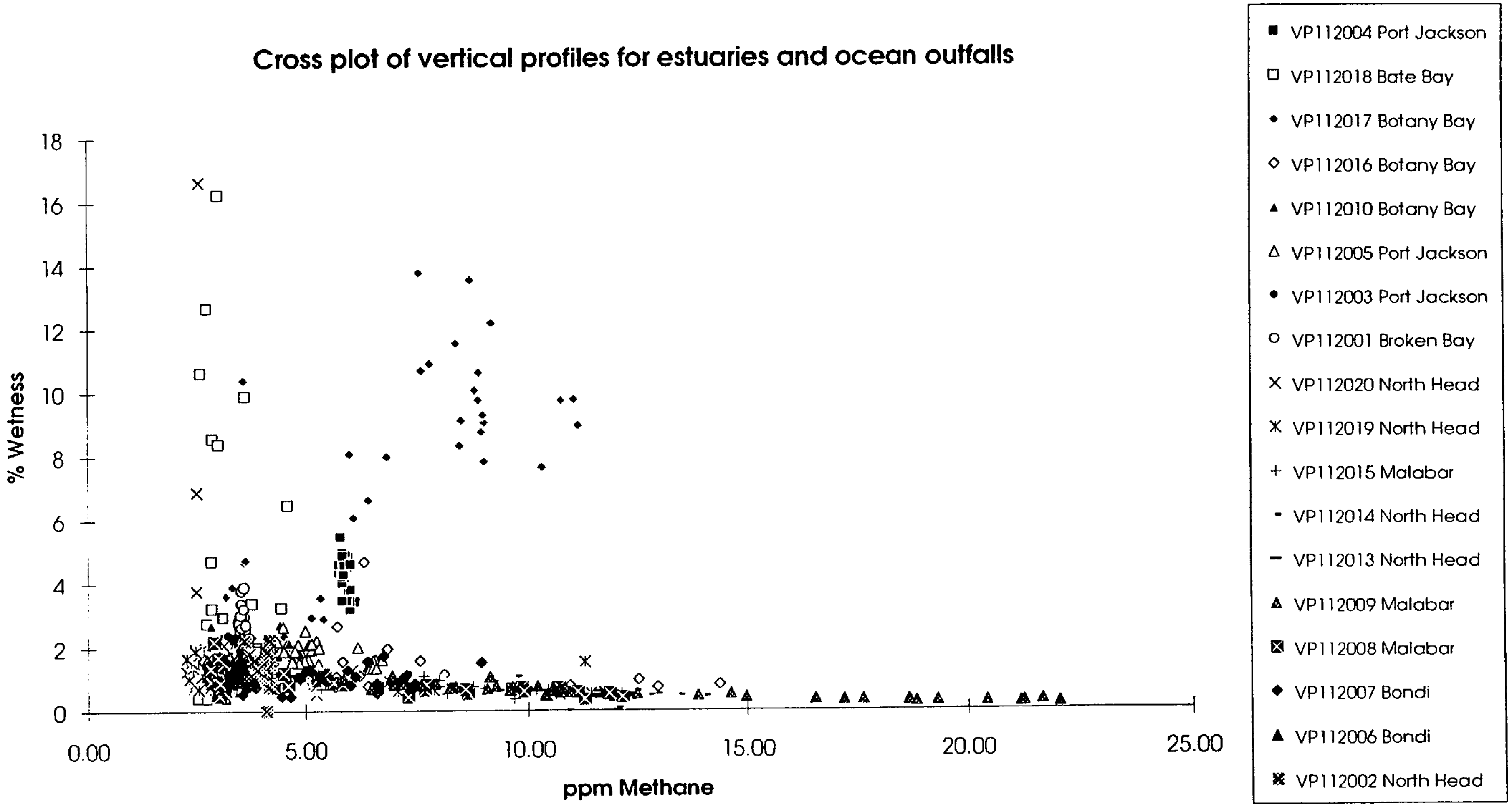


Figure 5.5 Percent hydrocarbon wetness and methane for all vertical profiles.

ESTOOXP.XLC

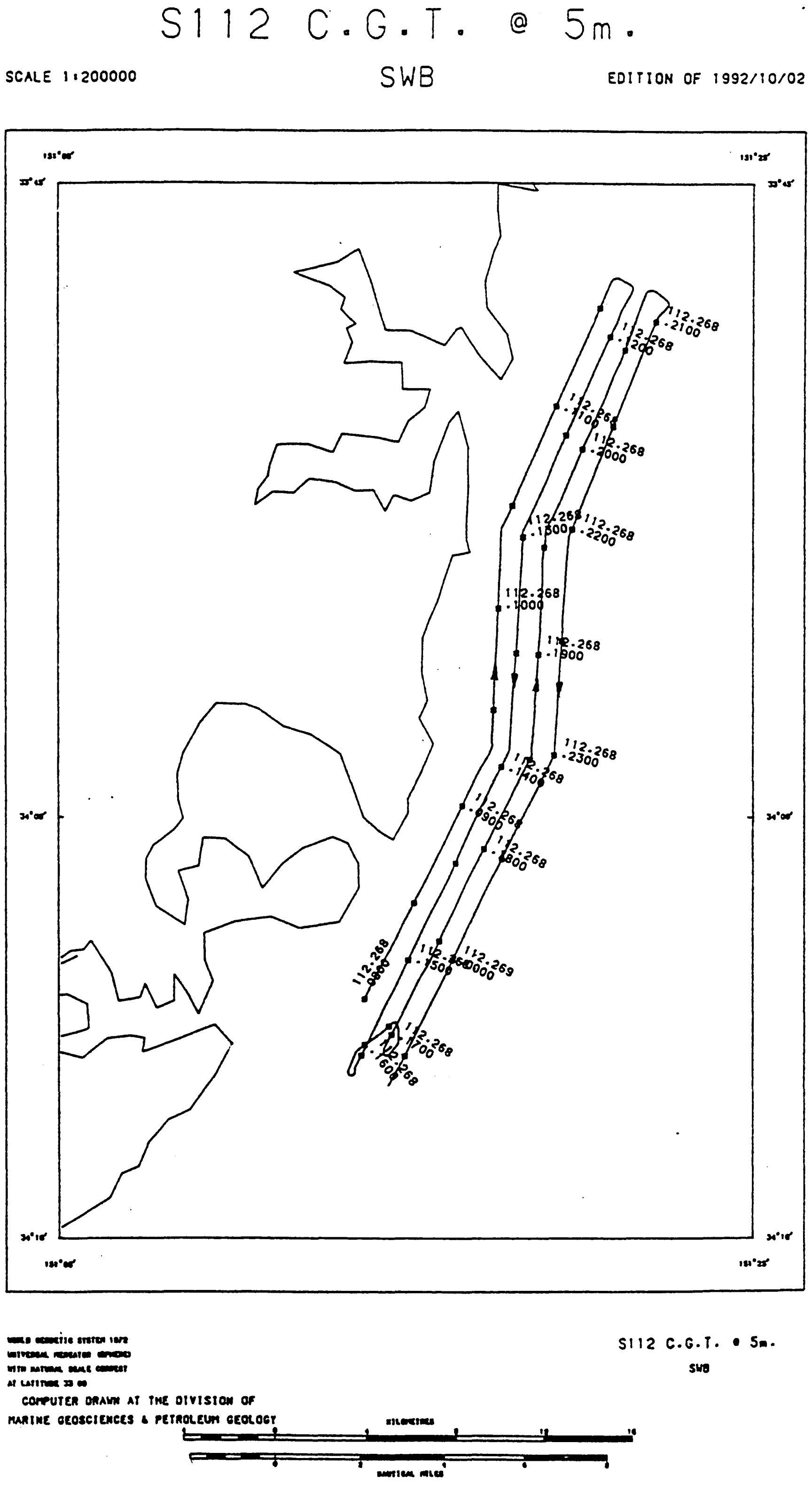


Figure 5.6 Map of the cruise track for the CGT survey conducted at 5 m water depth.

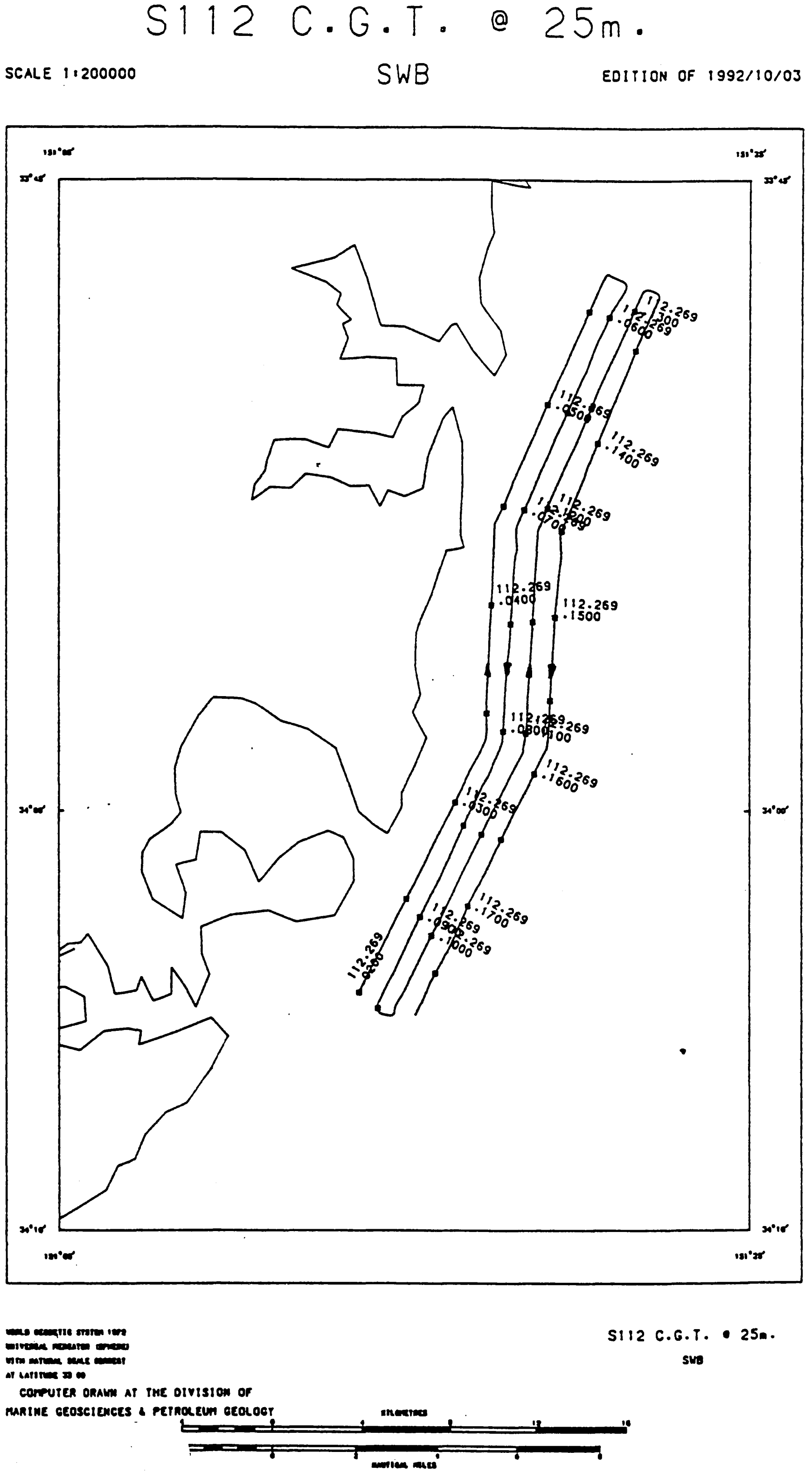


Figure 5.7 Map of the cruise track for the CGT survey conducted at 25 m water depth.

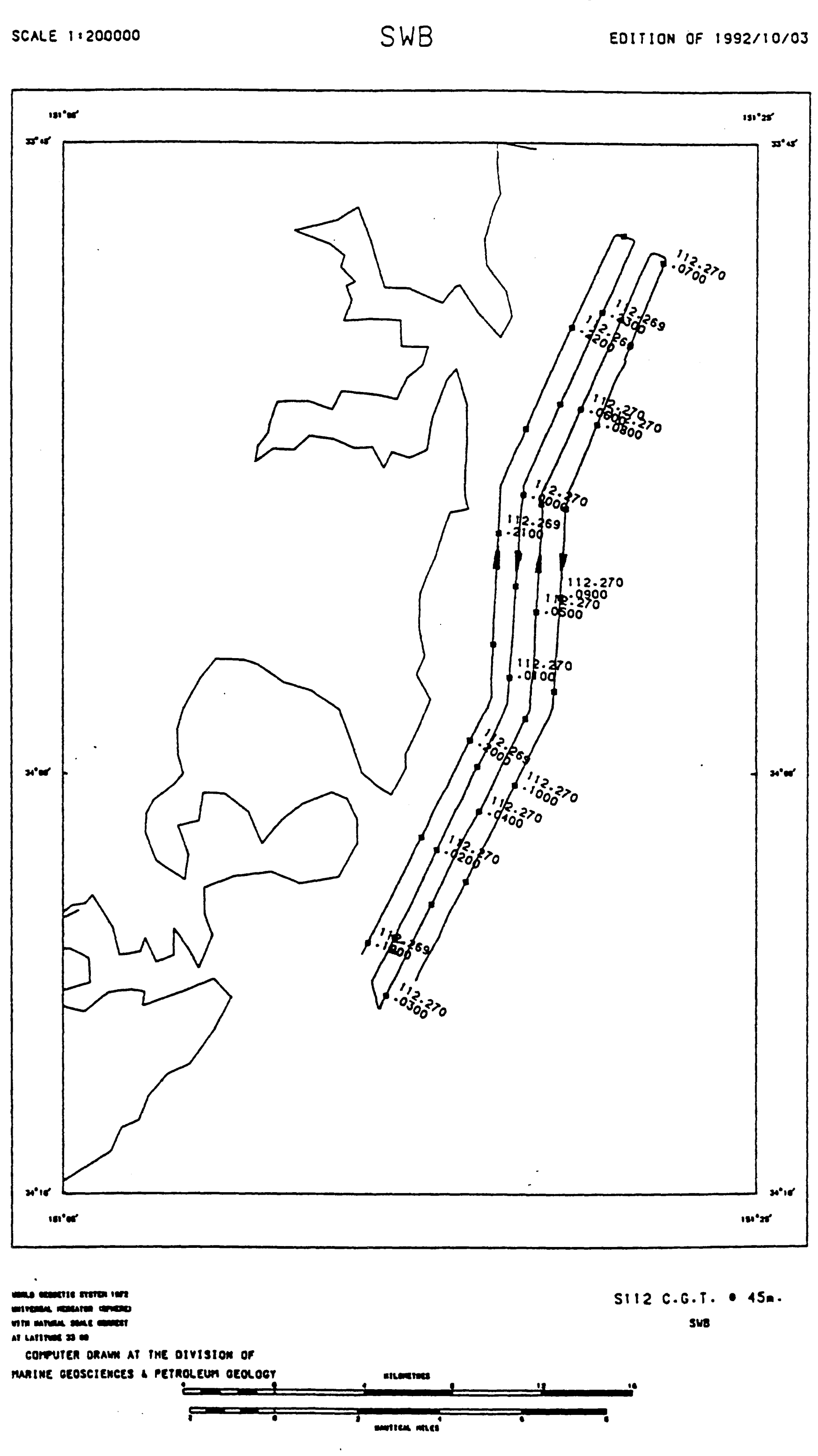


Figure 5.8 Map of the cruise track for the CGT survey conducted at 45 m water depth.

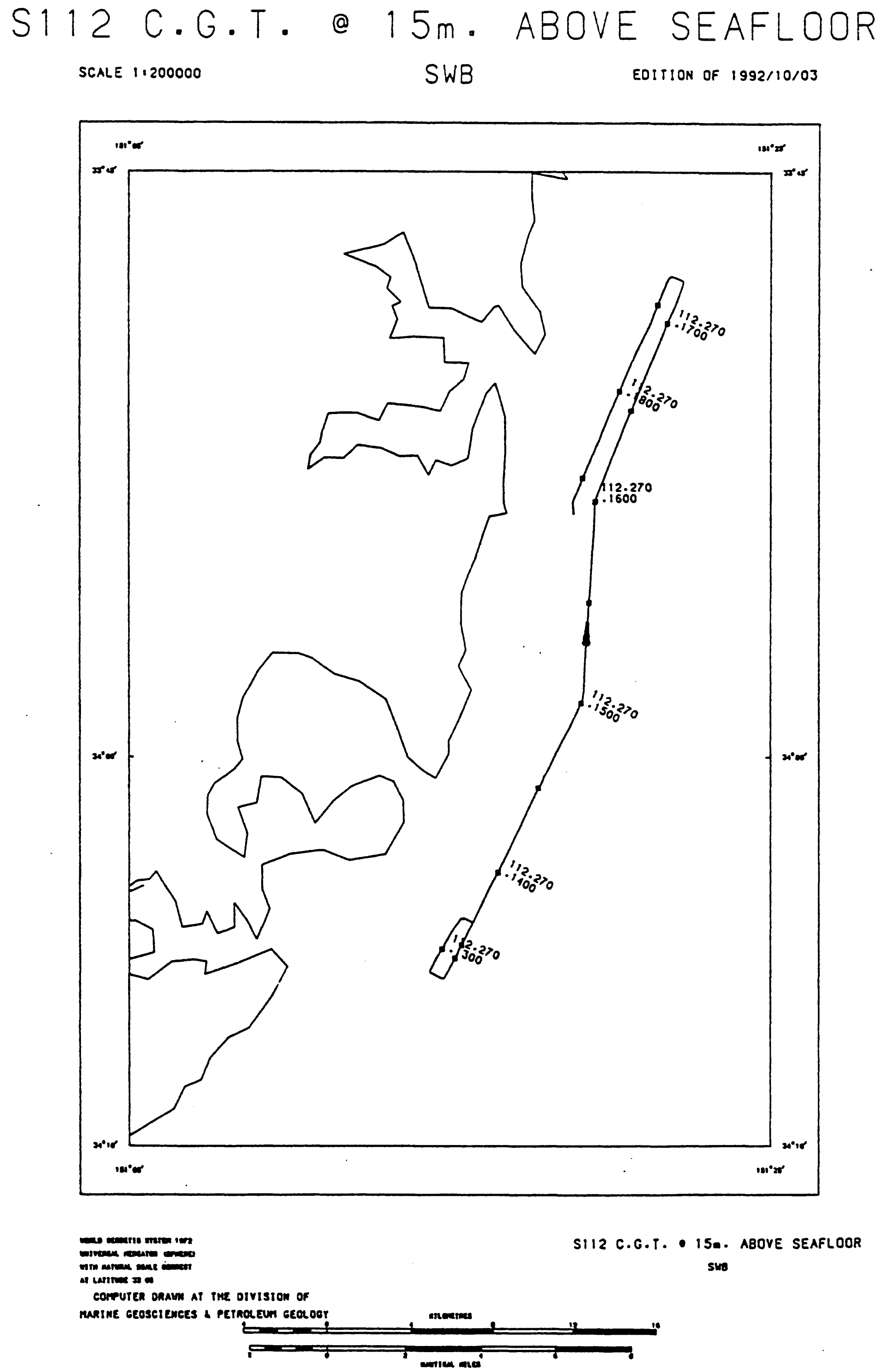


Figure 5.9 Map of the cruise track for the CGT survey conducted at about 15 m altitude above the seafloor.

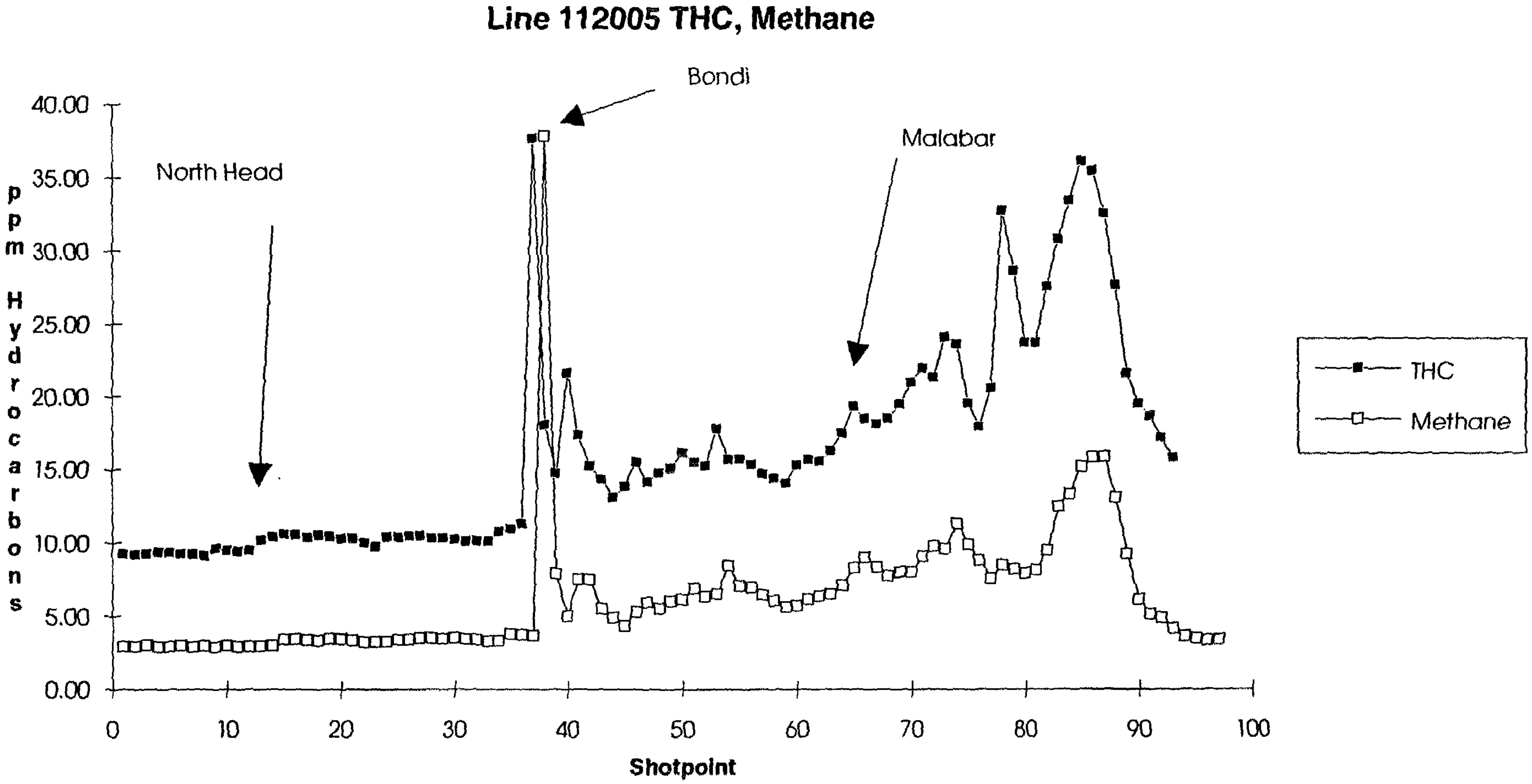


Figure 5.10. Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112005.

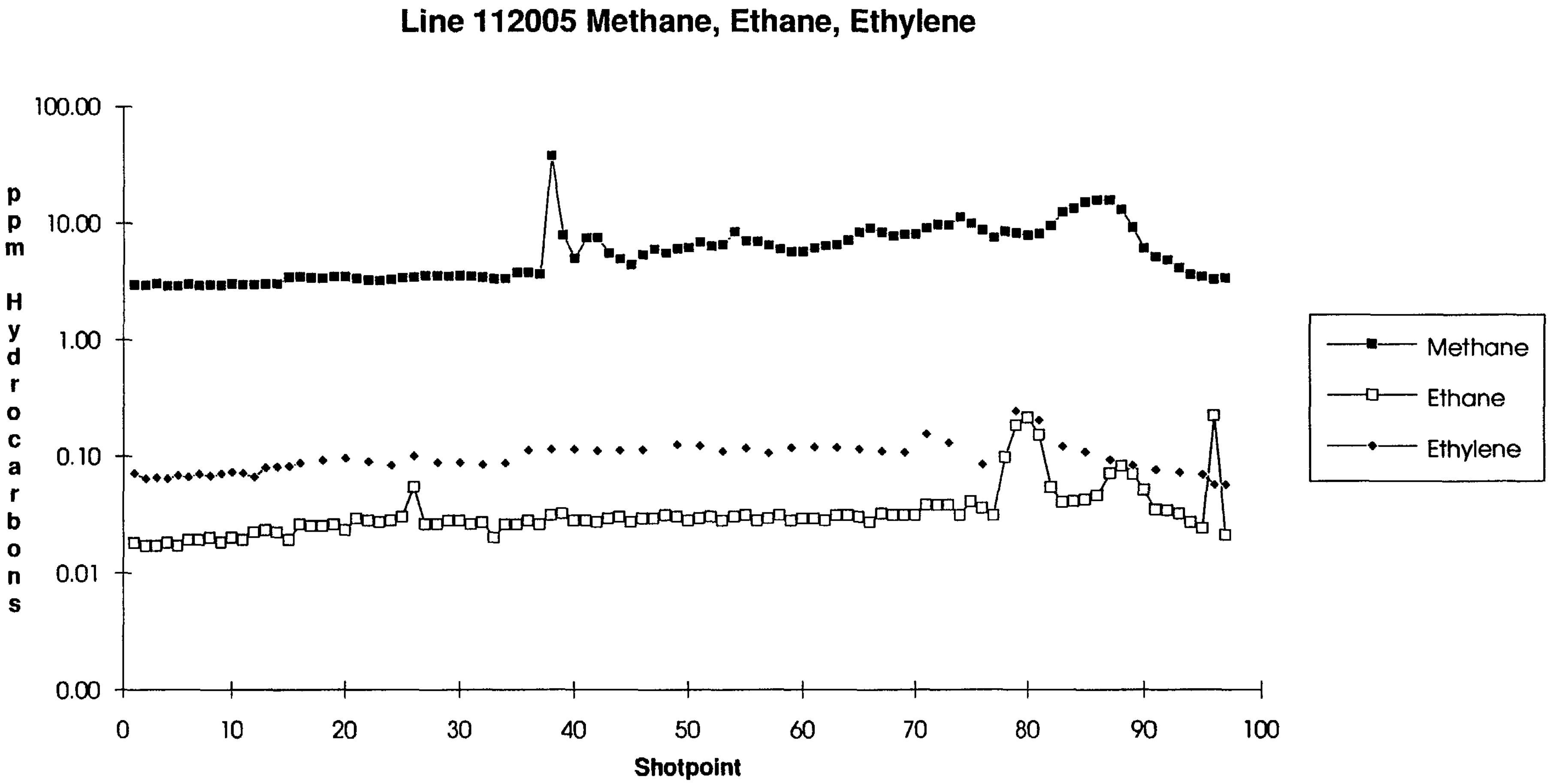


Figure 5.10 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112005.

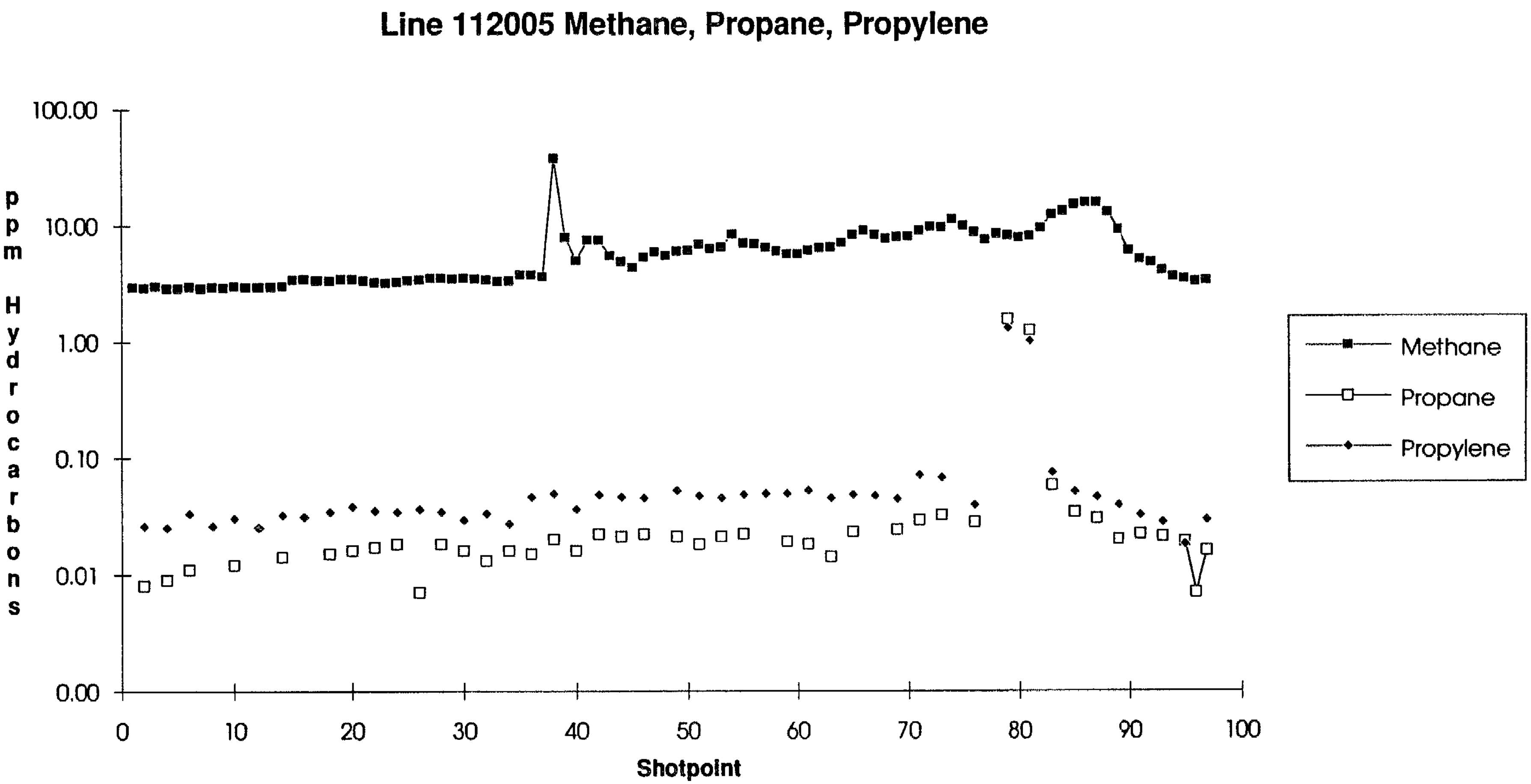


Figure 5.10 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112005.

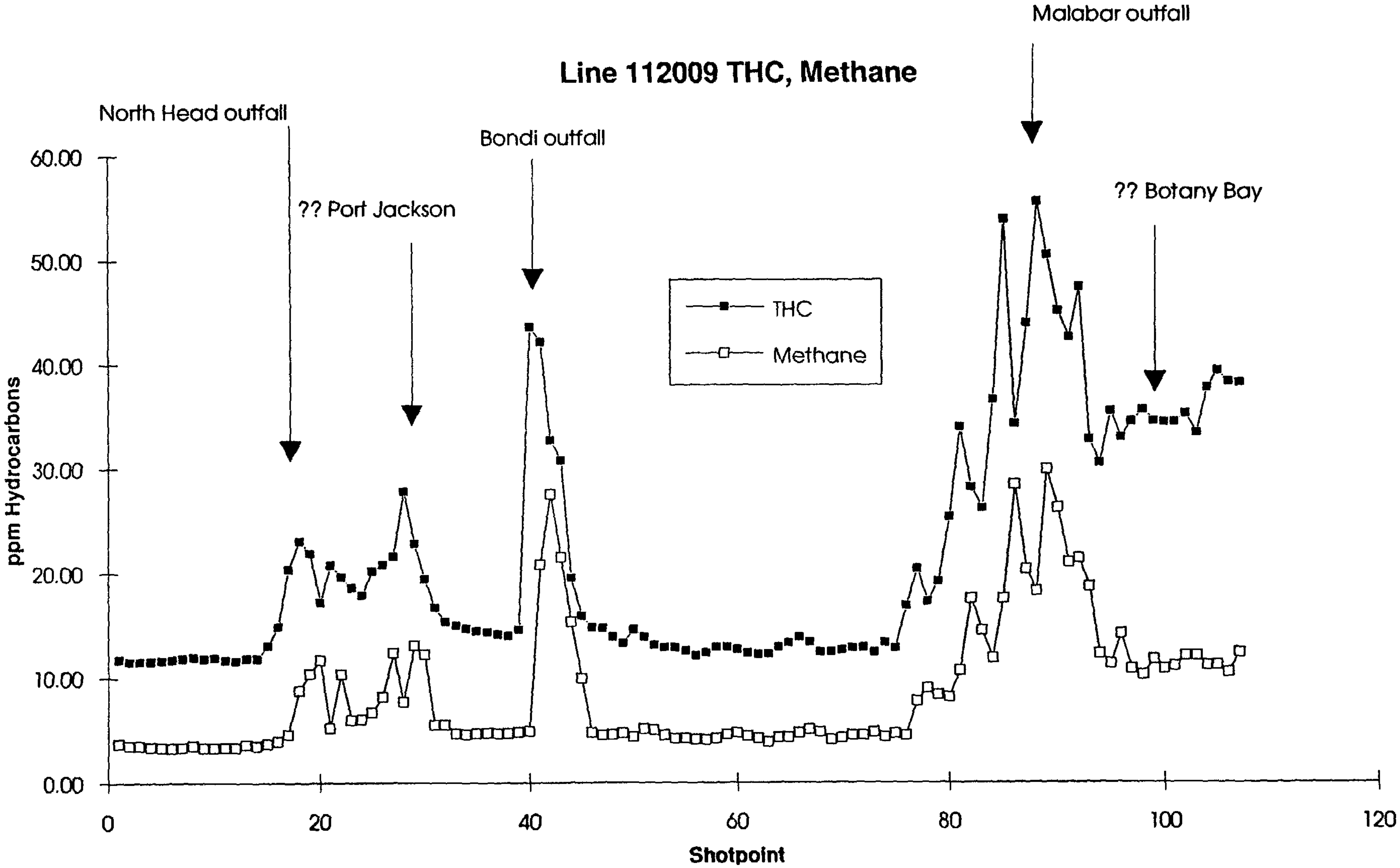


Figure 5.11 Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112009

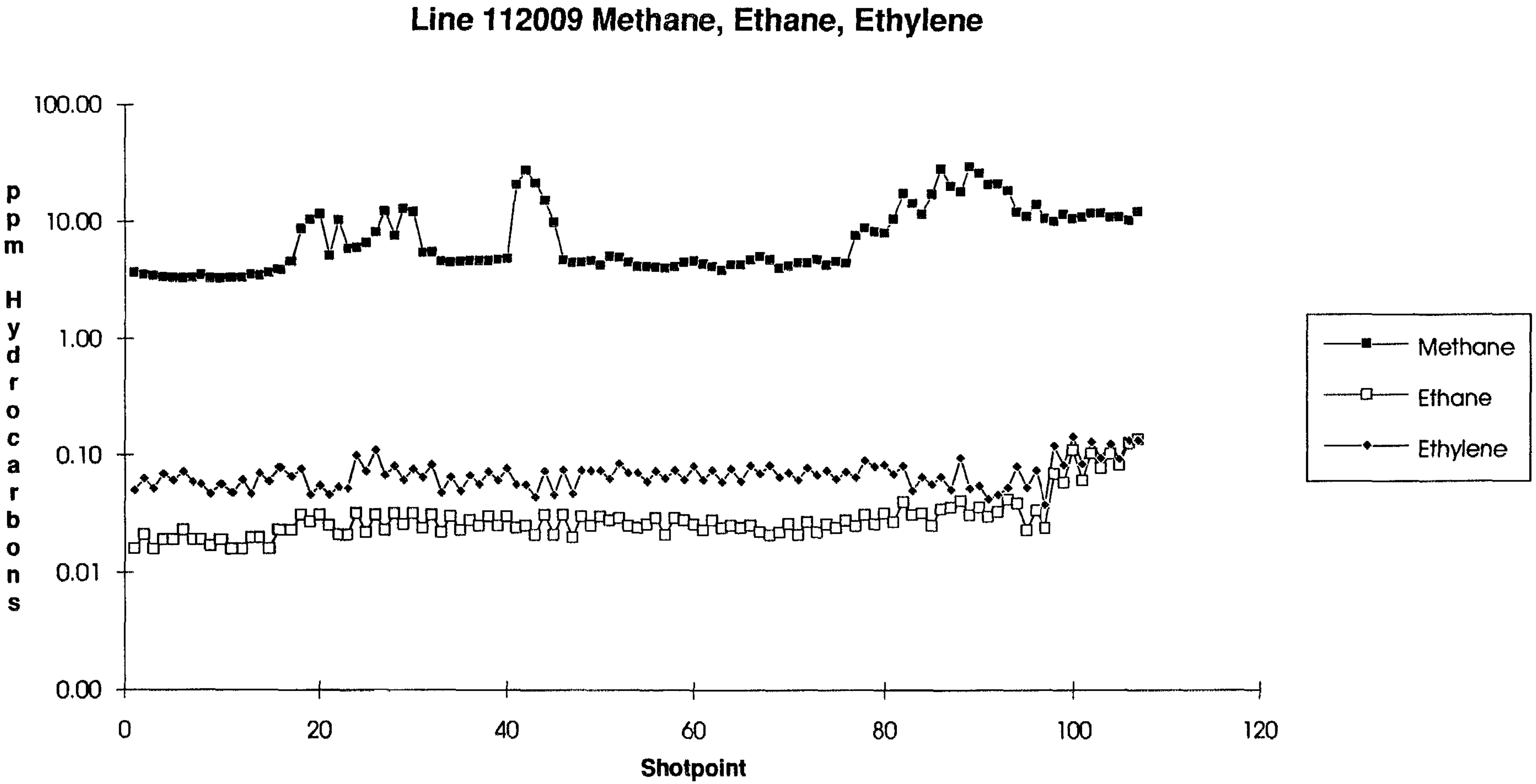


Figure 5.11 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112009

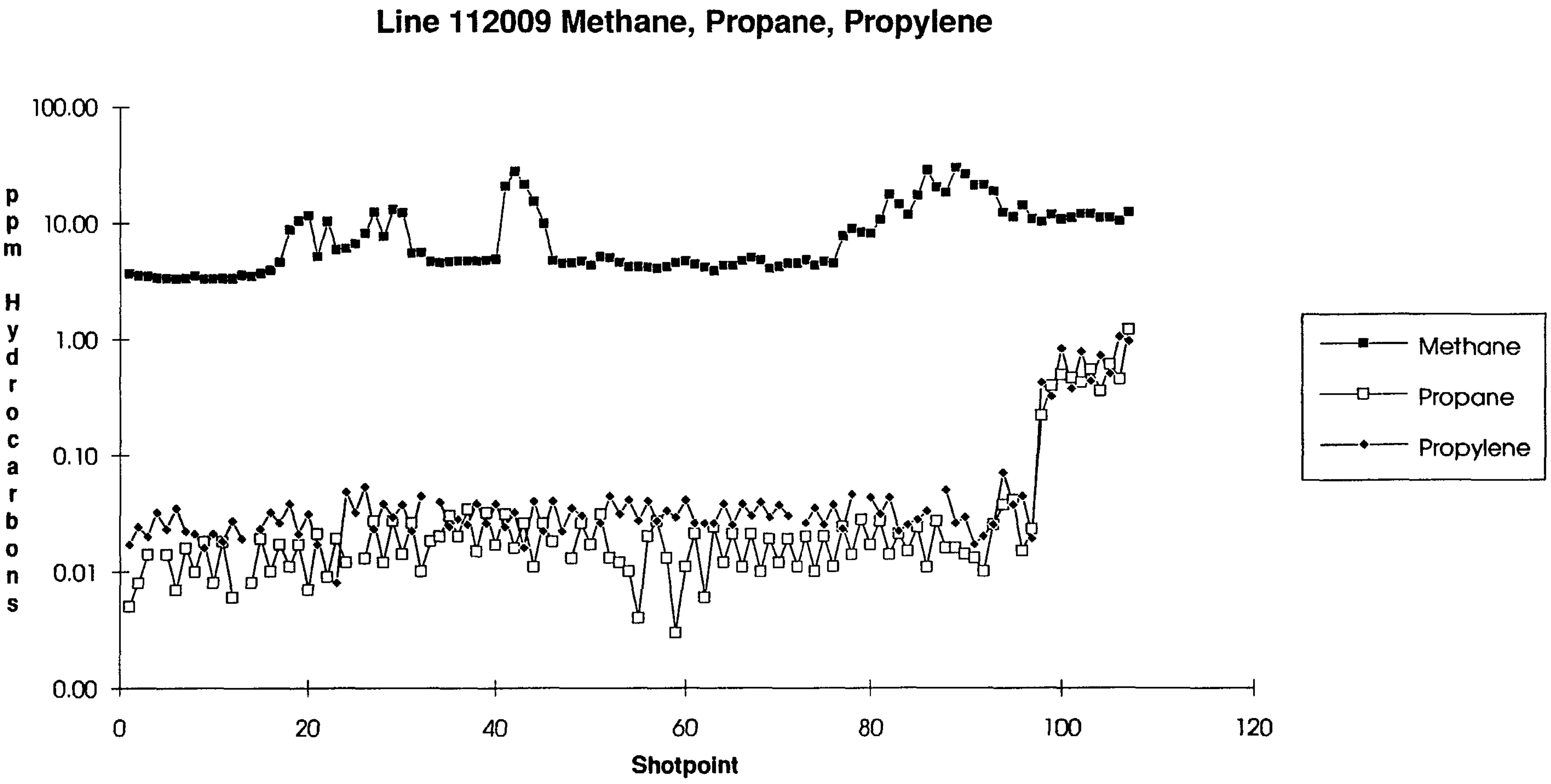


Figure 5.11 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112009

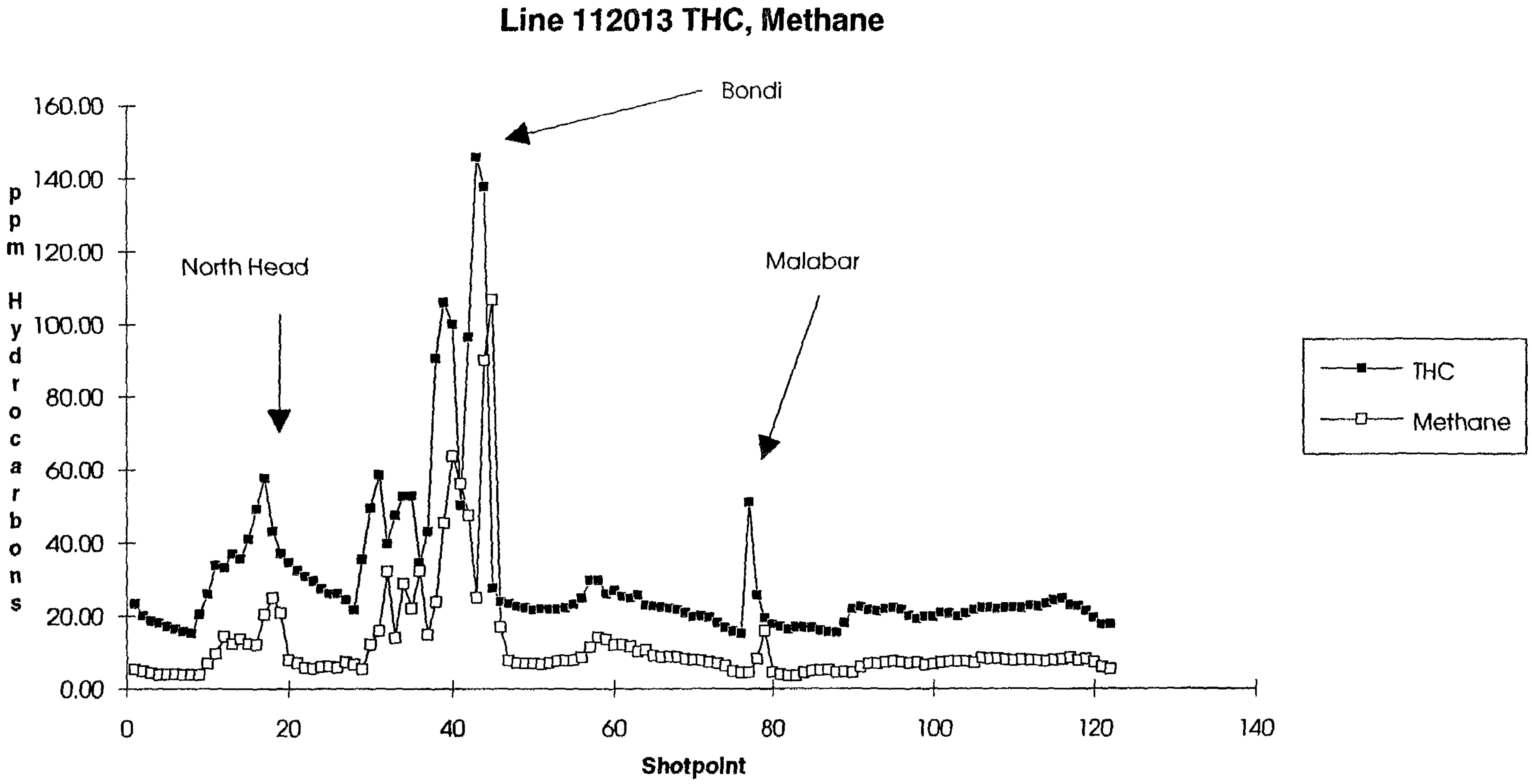


Figure 5.12 Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112013

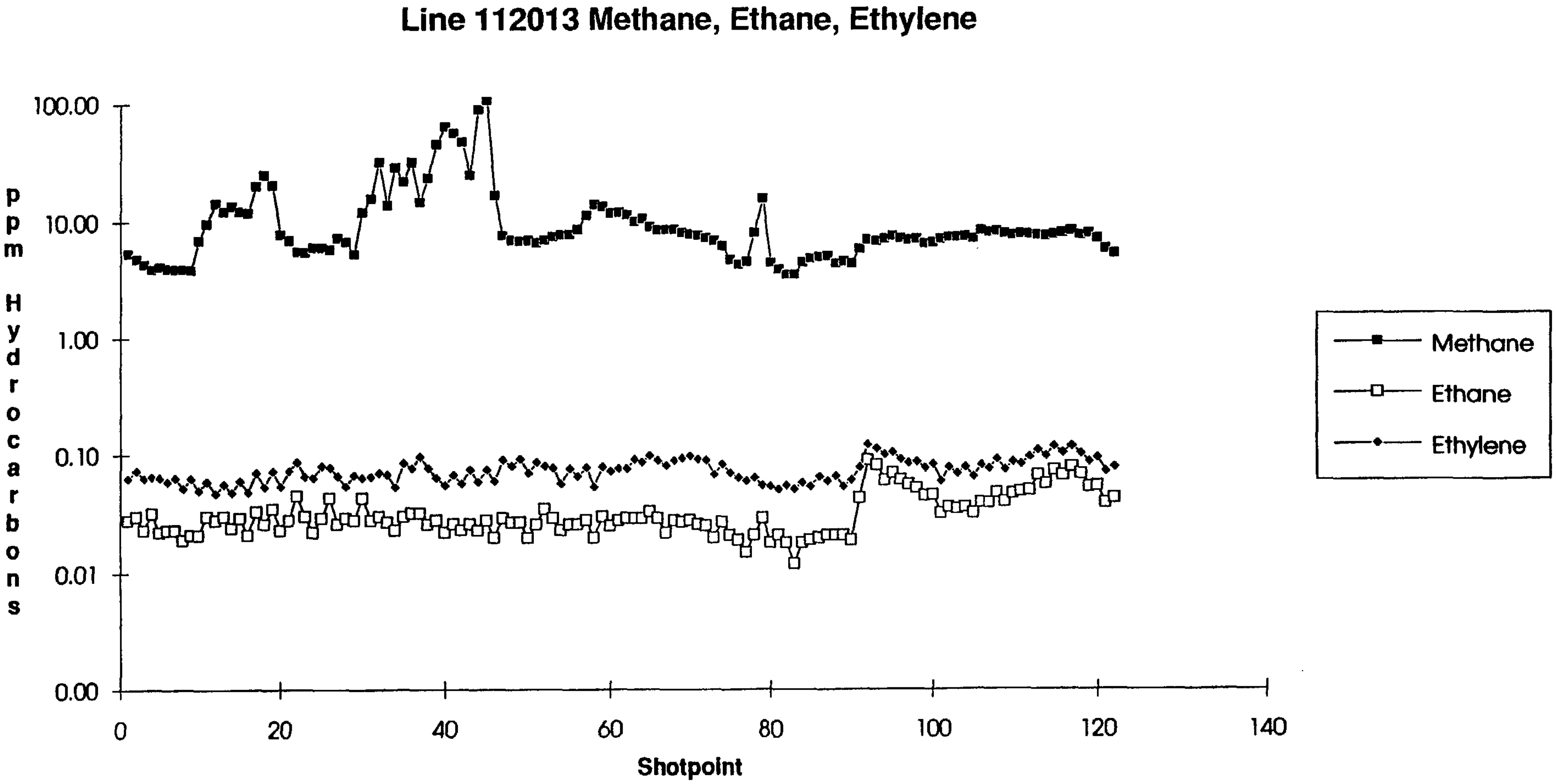


Figure 5.12 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112013

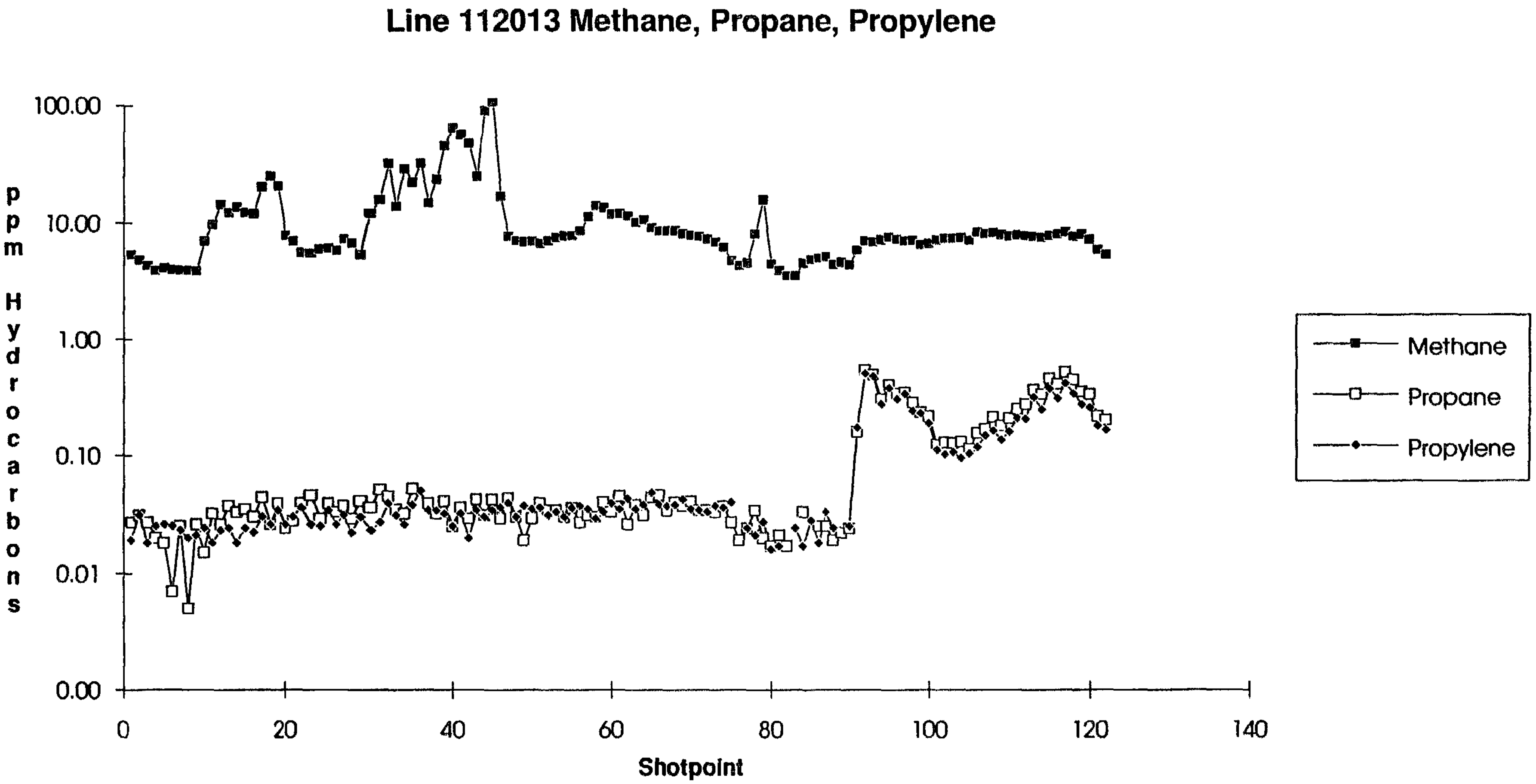


Figure 5.12 (cont.) Longitudinal profiles of THC and methane, methane, ethane and ethylene and methane, propane and propylene along the ship track for survey line 112013

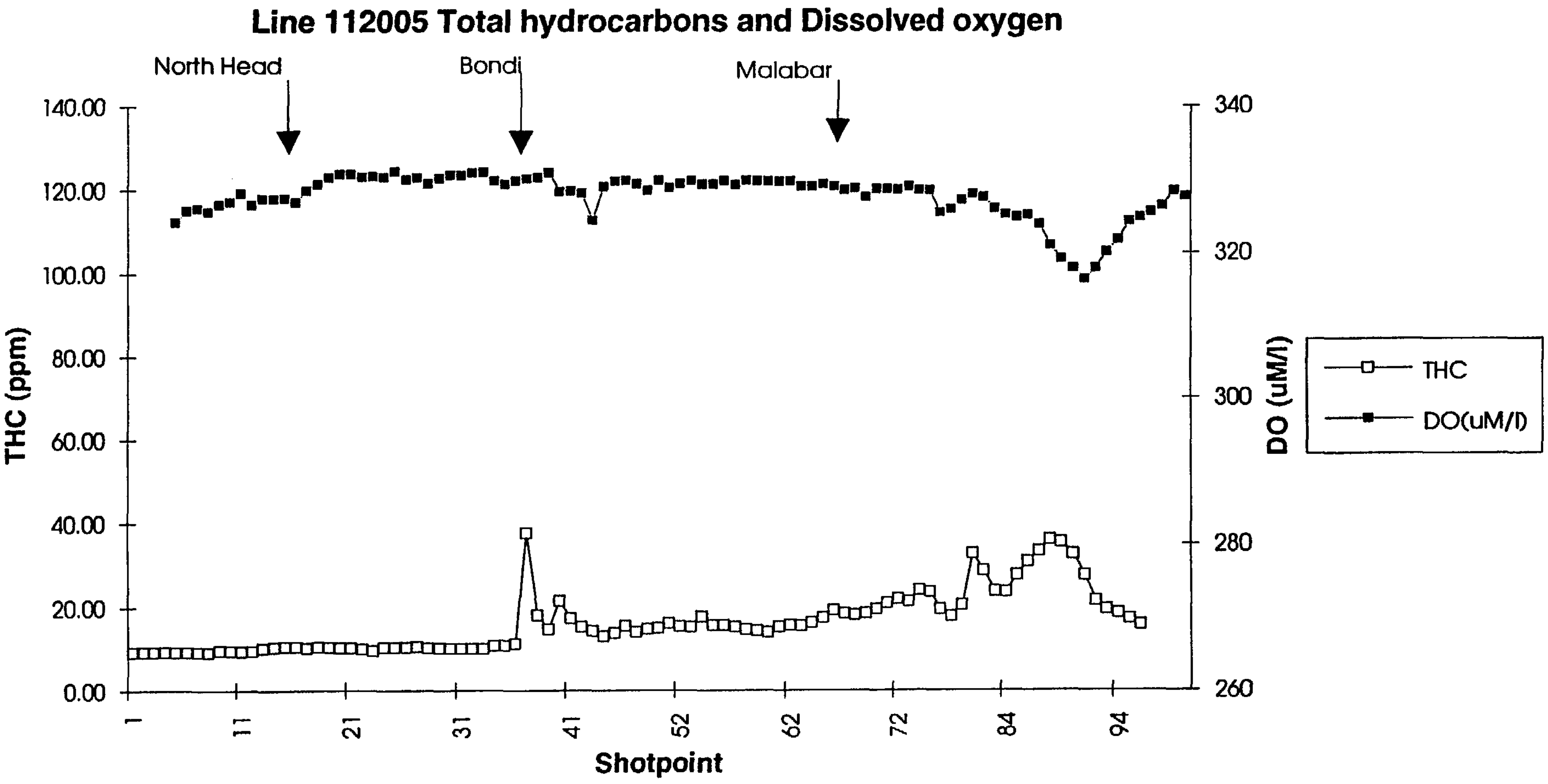


Figure 5.13 Longitudinal profiles of dissolved oxygen and THC along survey line 112005

112005DT.XLC

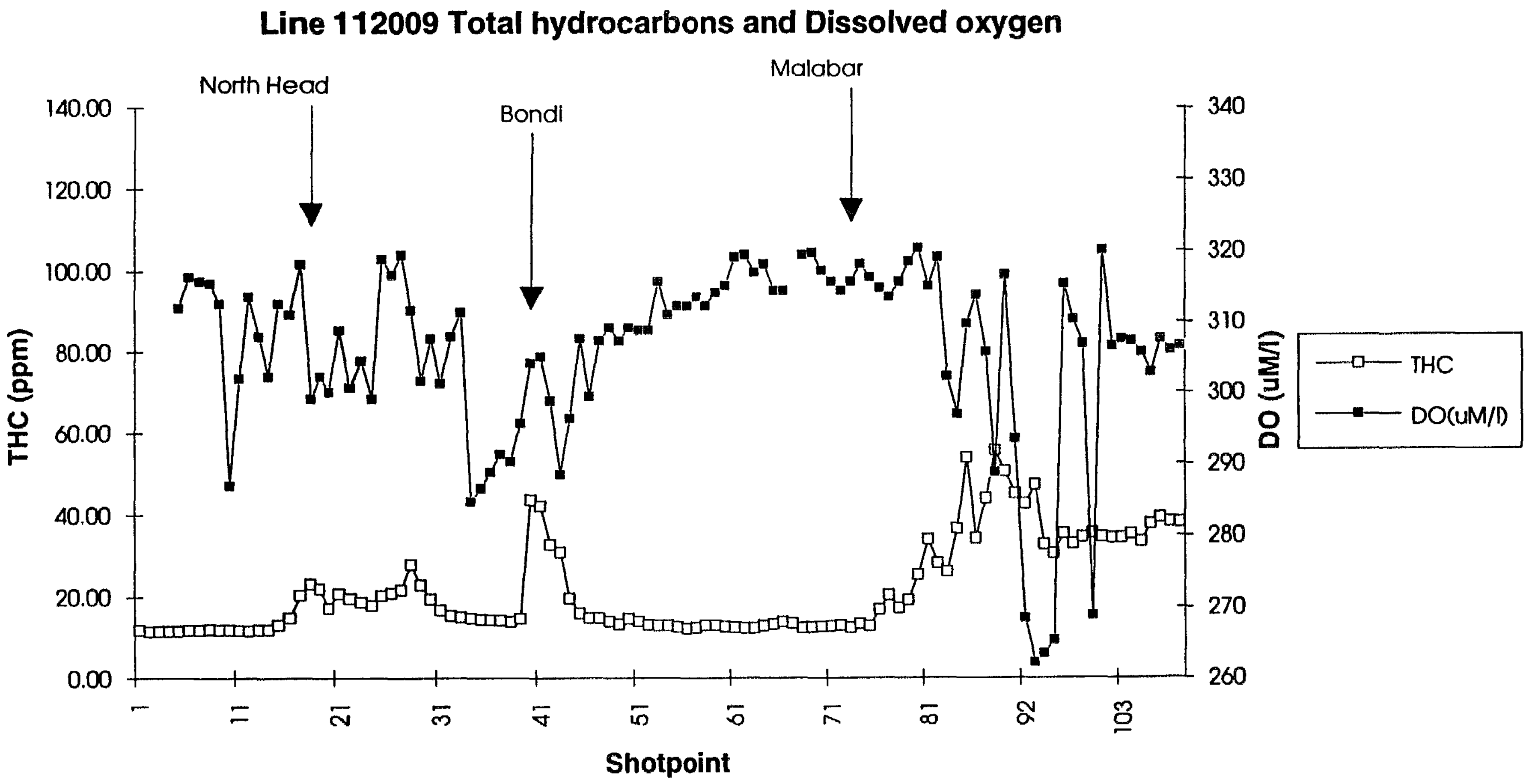


Figure 5.14 Longitudinal profiles of dissolved oxygen and THC along survey line 112009.

112009DT.XLC

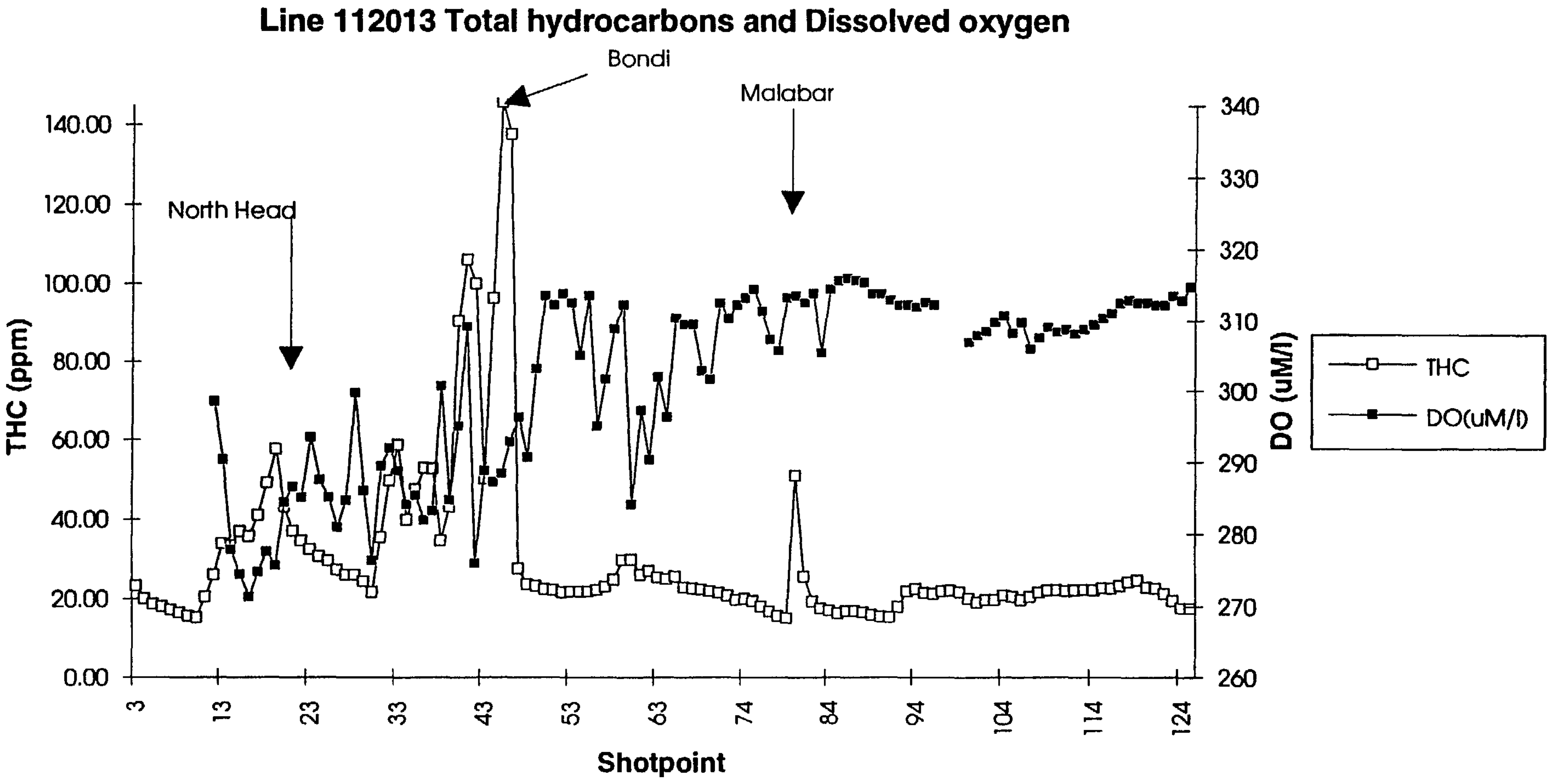


Figure 5.15 Longitudinal profiles of dissolved oxygen and THC along survey line 112013.

112013DT.XLC

6. Exractable (volatile) hydrocarbons in sediments

The pilot survey of light hydrocarbon abundances in seawater conducted during 1991 (Fig. 1.1) indicated elevated concentrations of methane in the water column, in the vicinity of the ocean outfalls, that are about an order of magnitude above background levels. The 'source' of this methane is probably from sewage discharge, as methane is generated by anaerobic metabolism during the oxidation of particulate sewage organic matter. This suggests that if particulate organic matter from the sewage discharge is incorporated into the sediments, anomalous concentrations of methane in the sediments would be sensitive indicators of the dispersion and deposition of particulate (sewage) organic matter . Methane and other light hydrocarbons were measured in sediments to test this idea.

Objectives

1. To test if light hydrocarbons (particularly methane abundances) in sediments are indicators of anthropogenic particulate organic carbon input to the seafloor.

2. To test if the sediments are a potential 'source' of light (dissolved) hydrocarbons to the bottom-waters of the coastal zone - specifically to examine if the enrichments in bottom-waters, measured on the pilot project (September 1991), are sourced from the sediments.

3. To measure the concentrations of volatile halogenated hydrocarbons in sediments.

Several sediment samples were collected for analysis of the light (C_1-C_4) hydrocarbons and also halogenated hydrocarbons. The locations of these samples are shown in Figure 6.1 and Enclosure 8. Samples for gas analysis were collected from box cores, grabs and vibro cores. Eighty one samples were analysed, for light hydrocarbons, by the following 'headspace' method.

1. Two hundred millilitres of wet sediment were placed in a 500 ml tin.

2. The tin was filled to the rim with clean seawater and 200 mls of the seawater removed with a 50 ml syringe, to create a 200 ml headspace above the wet sediment.

3. The lid was secured and the headspace flushed with nitrogen for 1 minute.

4. The tin was heated in a oven at 70 deg. C for 45 minutes and shaken vigorously for 45 minutes on a horizontal shaker.
5. Five millilitres of the headspace gas were removed with a syringe, injected onto a gas chromatograph (fitted with an activated alumina column), and analysed for C_1 to C_4 hydrocarbons.

The sample locations and light hydrocarbon concentrations (expressed in units of microlitres of hydrocarbon gas/ litre of wet sediment) are summarised in Table 6-1. The concentrations of sum C_1+C_2+C_3+C_4 hydrocarbons are shown in Enclosure 9. Light hydrocarbon concentrations varied between 1.0 and 11.2 ppm over the survey area. There are no distinct trends in the data although the lowest total hydrocarbon abundances were measured in samples collected from the 'offshore' stations, and generally higher concentrations were measured closer to the shore-line. The high methane abundances found in the plumes from the ocean outfalls - whose source is probably the particulate (sewage) organic matter - suggest that biomarker analyses of methanogen abundances in sediments, and also carbon isotope compositions of organic matter in sediments, may be useful tracers of particulate organic (sewage) matter from the ocean outfalls which has been deposited in the sediments.

During the survey, some sediment samples were collected and analysed for the concentrations of various volatile halogenated hydrocarbons. The preliminary analyses conducted at sea in the geochemical laboratory indicated some halogenated hydrocarbons were present in the sediments, but a large interference was evident - apparently resulting from the high oxygen abundances in the samples - which affects the response of the ECD (electron capture detector). The concentrations of halogenated hydrocarbons could not be quantified. Several samples were stored frozen and returned to Canberra. These samples are listed in Table 6.2.

Table 6.1 Locations of samples and concentrations of hydrocarbon gases measured in sediments

BMR Line	Core	Latitude	Longitude	Water Depth (m)	Depth in Core (cm)	Mean Depth (cm)	C1	C2	C2:1	C3	C3:1	iC4	nC4	C1-C4	Wet Gas %	C1/ C2+C3	C2/ C2:1	C3/ C3:1	iC4/ nC4
	112 GS 01	34.184	151.086	41		5	1.347	0.013	0.041	0.012	0.016	0.000	0.000	1.371	2.433	55.3	0.309	0.714	0.000
	112 GS 02	34.183	151.165	100		5	0.150	0.016	0.051	0.014	0.014	0.000	0.000	0.180	3.033	4.9	0.312	1.024	0.000
	112 BC 09	34.184	151.165	101		5	1.082	0.111	0.834	0.133	0.287	0.021	0.040	1.388	29.425	4.4	0.133	0.464	0.538
	112 GS 06	34.183	151.278	136		5	3.020	0.052	0.262	0.067	0.117	0.000	0.000	3.139	11.867	25.5	0.197	0.574	0.000
	112 GS 09	34.184	151.335	143		5	1.346	0.037	0.149	0.039	0.062	0.000	0.000	1.422	7.600	17.7	0.250	0.624	0.000
	112 GS 10	34.184	151.392	150		5	1.374	0.033	0.087	0.012	0.061	0.000	0.000	1.419	4.567	30.1	0.382	0.203	0.000
	112 BC 27	33.998	151.349	103		5	3.765	0.115	0.624	0.083	0.165	0.029	0.036	4.028	23.594	19.0	0.184	0.503	0.806
	112 GS 14	33.997	151.285	81		5	1.353	0.024	0.119	0.058	0.032	0.000	0.045	1.480	11.241	16.5	0.202	1.813	0.000
	112 BC 17	33.997	151.286	82		5	1.662	0.029	0.129	0.055	0.034	0.000	0.028	1.774	9.978	19.8	0.225	1.618	0.000
	112 BC 30	33.997	151.285	81		5	1.900	0.038	0.126	0.046	0.037	0.000	0.000	1.984	8.400	22.6	0.302	1.243	0.000
	112 BC 31	33.997	151.285	80		5	7.572	0.248	2.707	0.257	0.798	0.056	0.110	8.243	57.434	15.0	0.092	0.322	0.509
	112 BC 32	33.997	151.284	81		5	4.823	0.073	0.364	0.086	0.085	0.035	0.065	5.082	20.679	30.3	0.201	1.012	0.538
	112 BC 33	33.997	151.285	82		5	1.395	0.067	0.188	0.085	0.035	0.062	0.047	1.656	24.238	9.2	0.356	2.429	1.319
	112 VC 29	33.997	151.285	81	0 - 8	4	4.495	0.156	1.352	0.137	0.498	0.071	0.063	4.922	37.680	15.3	0.115	0.275	1.127
		33.997	151.285	81	20 - 28	24	3.012	0.162	1.204	0.158	0.414	0.049	0.057	3.438	38.558	9.4	0.135	0.382	0.860
		33.997	151.285	81	40 - 48	44	3.676	0.229	1.160	0.181	0.387	0.038	0.074	4.198	46.563	9.0	0.197	0.468	0.514
		33.997	151.285	81	60 - 68	64	5.933	0.152	0.532	0.110	0.193	0.000	0.038	6.233	26.810	22.6	0.286	0.570	0.000
		33.997	151.285	81	80 - 88	84	4.251	0.128	0.613	0.105	0.244	0.000	0.035	4.519	24.075	18.2	0.209	0.430	0.000
		33.997	151.285	81	100 - 108	104	4.230	0.141	0.622	0.108	0.241	0.029	0.046	4.554	28.810	17.0	0.227	0.448	0.630
		33.997	151.285	81	120 - 128	124	3.000	0.144	0.620	0.120	0.260	0.028	0.044	3.336	30.519	11.4	0.232	0.462	0.636
		33.997	151.285	81	140 - 148	144	2.049	0.094	0.329	0.151	0.232	0.000	0.119	2.413	29.432	8.4	0.286	0.651	0.000
		33.997	151.285	81	160 - 168	164	2.345	0.130	0.461	0.106	0.174	0.024	0.038	2.643	27.438	9.9	0.282	0.609	0.632
		33.997	151.285	81	180 - 188	184	3.379	0.169	0.561	0.119	0.203	0.026	0.044	3.737	32.577	11.7	0.301	0.586	0.591
		33.997	151.285	81	200 - 208	204	3.000	0.177	0.764	0.132	0.278	0.031	0.054	3.394	35.591	9.7	0.232	0.475	0.574
		33.997	151.285	81	220 - 228	224	3.035	0.177	0.759	0.117	0.250	0.030	0.049	3.408	33.838	10.3	0.233	0.468	0.612
		33.997	151.285	81	240 - 248	244	3.496	0.312	0.954	0.199	0.367	0.045	0.086	4.138	57.678	6.8	0.327	0.542	0.523
		33.997	151.285	81	260 - 268	264	1.787	0.161	0.284	0.093	0.087	0.031	0.054	2.126	31.040	7.0	0.567	1.069	0.574
	112GS 15	33.870	151.309	59		5	6.233	0.069	0.451	0.058	0.149	0.041	0.000	6.401	16.800	49.1	0.153	0.389	0.000
	112GS 16	33.871	151.333	65		5	3.634	0.117	0.605	0.095	0.144	0.026	0.037	3.909	24.747	17.1	0.193	0.660	0.703
	112GS 17	33.870	151.382	85		5	2.303	0.116	0.618	0.106	0.238	0.033	0.052	2.610	27.492	10.4	0.188	0.445	0.635
	112GS 18	33.811	151.351	67		5	2.022	0.086	0.559	0.070	0.188	0.029	0.043	2.250	20.411	13.0	0.154	0.372	0.674
	112GS 19	33.811	151.418	110		5	1.222	0.024	0.109	0.000	0.041	0.000	0.000	1.246	2.400	50.9	0.220	0.000	0.000
	112GS 20	33.811	151.474	127		5	0.961	0.074	0.331	0.086	0.156	0.000	0.000	1.121	16.000	6.0	0.224	0.551	0.000
	112GS 21	33.811	151.531	129		5	1.251	0.100	0.290	0.078	0.111	0.040	0.043	1.512	24.644	7.0	0.345	0.703	0.930
	112BC 41	33.811	151.531	128		5	1.097	0.086	0.237	0.061	0.069	0.028	0.000	1.272	17.500	7.5	0.363	0.884	0.000
	112BC 42	33.811	151.530	130		5	1.200	0.081	0.316	0.072	0.128	0.033	0.000	1.386	18.600	7.8	0.256	0.563	0.000
	112BC 44	33.811	151.588	141		5	0.812	0.074	0.353	0.065	0.120	0.019	0.033	1.003	19.090	5.8	0.210	0.542	0.576

Table 6.1 continued

	112GS 23	33.811	151.643	148		5	1.223	0.051	0.180	0.045	0.057	0.000	0.000	1.319	9.600	12.7	0.283	0.789	0.000
	112BC 47	33.811	151.644	148		5	0.994	0.062	0.215	0.048	0.092	0.000	0.000	1.104	11.000	9.0	0.288	0.522	0.000
	112GS 24	33.811	151.700	182		5	1.634	0.049	0.219	0.057	0.065	0.026	0.053	1.819	16.114	15.4	0.224	0.877	0.491
	112BC 49	33.811	151.700	180		5	1.258	0.065	0.449	0.060	0.163	0.032	0.035	1.450	18.114	10.1	0.145	0.368	0.914
	112GS 26	33.624	151.730	140		5	2.994	0.094	0.339	0.069	0.094	0.036	0.045	3.238	21.290	18.4	0.277	0.734	0.800
	112GS 27	33.624	151.675	135		5	2.377	0.114	0.677	0.096	0.273	0.031	0.054	2.672	26.121	11.3	0.168	0.352	0.574
	112GS 25	33.000	151.000	146		5	1.606	0.112	1.077	0.100	0.362	0.037	0.052	1.907	27.627	7.6	0.104	0.276	0.712
	112GS 28	33.625	151.620	129		5	1.681	0.107	0.880	0.081	0.268	0.029	0.045	1.943	24.016	8.9	0.122	0.302	0.644
	112BC 52	33.623	151.602	128		5	1.316	0.079	0.452	0.061	0.380	0.000	0.029	1.485	15.953	9.4	0.175	0.161	0.000
	112GS 29	33.624	151.565	119		5	1.276	0.076	0.498	0.056	0.146	0.016	0.031	1.455	16.931	9.7	0.153	0.384	0.516
	112BC 53	33.624	151.565	118		5	3.712	0.185	1.070	0.206	0.612	0.029	0.064	4.196	43.525	9.5	0.173	0.337	0.453
	112BC 54	33.624	151.565	118		5	4.071	0.182	2.206	0.224	0.767	0.050	0.073	4.600	47.187	10.0	0.083	0.292	0.685
	112BC 55	33.624	151.564	118		5	3.161	0.098	0.859	0.128	0.280	0.022	0.044	3.453	26.074	14.0	0.114	0.457	0.500
	112BC 56	33.625	151.565	121		5	6.162	0.285	1.751	0.285	0.714	0.050	0.095	6.877	63.381	10.8	0.163	0.399	0.526
	112GS 30	33.624	151.510	88		5	3.235	0.168	1.764	0.184	0.476	0.042	0.070	3.699	41.292	9.2	0.095	0.387	0.600
	112BC 57	33.624	151.510	88		5	3.912	0.241	1.768	0.227	0.49	0.047	0.081	4.508	53.297	8.4	0.136	0.463	0.580
	112BC 58	33.625	151.510	88		5	3.891	0.241	1.349	0.256	0.562	0.045	0.089	4.522	56.168	7.8	0.179	0.456	0.506
	112GS 31	33.625	151.565	119		5	2.486	0.183	1.302	0.225	0.582	0.032	0.066	2.992	46.206	6.1	0.141	0.387	0.485
	112VC 44	33.811	151.643	119	0 - 8	4	4.914	0.157	0.343	0.082	0.299	0.022	0.038	5.213	26.829	20.6	0.458	0.274	0.579
		33.811	151.643	119	20 - 28	24	1.266	0.061	0.093	0.025	0.128	0.000	0.000	1.352	8.600	14.7	0.656	0.195	0.000
		33.811	151.643	119	40 - 48	44	1.906	0.129	0.146	0.069	0.080	0.029	0.040	2.173	24.541	9.6	0.884	0.863	0.725
		33.811	151.643	119	60 - 68	64	1.929	0.132	0.150	0.098	0.076	0.039	0.045	2.243	28.906	8.4	0.880	1.289	0.867
		33.811	151.643	119	80 - 88	84	1.479	0.075	0.081	0.048	0.050	0.019	0.026	1.647	15.779	12.0	0.926	0.960	0.731
		33.811	151.643	119	100 - 108	104	4.233	0.067	0.166	0.039	0.161	0.012	0.000	4.351	11.800	39.9	0.404	0.242	0.000
		33.811	151.643	119	120 - 128	124	3.224	0.111	0.624	0.082	0.410	0.024	0.040	3.481	22.849	16.7	0.178	0.200	0.600
	112BC 59	33.625	151.564	119		5	2.589	0.147	1.042	0.150	0.315	0.000	0.027	2.913	30.627	8.7	0.141	0.476	0.000
	112BC 60	33.625	151.564	119		5	2.232	0.233	1.134	0.155	0.371	0.000	0.044	2.664	40.452	5.8	0.205	0.418	0.000
	112GS 32	33.625	151.528	97		5	2.706	0.141	0.851	0.151	0.310	0.028	0.051	3.077	33.657	9.3	0.166	0.487	0.549
	112BC 61	33.625	151.529	97		5	2.507	0.133	1.141	0.140	0.333	0.028	0.050	2.858	31.849	9.2	0.117	0.420	0.560
	112BC 62	33.625	151.529	97		5	2.545	0.174	1.240	0.180	0.404	0.033	0.066	2.998	40.901	7.2	0.140	0.446	0.500
	112GS 33	33.625	151.438	59		5	1.302	0.050	0.239	0.037	0.074	0.024	0.000	1.413	11.100	15.0	0.209	0.500	0.000
	112GS 35	33.870	151.382	91		5	10.905	0.116	1.115	0.130	0.344	0.022	0.046	11.219	27.210	44.3	0.104	0.378	0.478
	112VC 58	33.625	151.563	91	0 - 10	5	3.348	0.182	1.584	0.195	0.475	0.030	0.071	3.826	42.556	8.9	0.115	0.411	0.423
		33.625	151.563	91	20 - 28	24	9.876	0.527	2.154	0.374	0.725	0.052	0.148	10.977	96.648	11.0	0.245	0.516	0.351
		33.625	151.563	91	40 - 48	44	8.635	0.552	2.159	0.424	0.783	0.059	0.152	9.822	105.048	8.8	0.256	0.542	0.388
		33.625	151.563	91	60 - 68	64	4.936	0.279	1.135	0.241	0.388	0.029	0.086	5.571	56.444	9.5	0.246	0.621	0.337
		33.625	151.563	91	80 - 88	84	7.794	0.302	0.976	0.245	0.362	0.088	0.128	8.557	64.996	14.2	0.309	0.677	0.688
		33.625	151.563	91	100 - 108	104	8.629	0.275	0.805	0.217	0.315	0.025	0.000	9.146	51.700	17.5	0.342	0.689	0.000
		33.625	151.563	91	140 - 148	144	11.750	0.331	1.325	0.275	0.548	0.054	0.142	12.552	67.131	19.4	0.250	0.502	0.380
		33.625	151.563	91	160 - 168	164	11.905	0.306	1.642	0.250	0.615	0.041	0.104	12.606	60.525	21.4	0.186	0.407	0.394

Table 6.1 continued

	112BC 66	33.870	151.383	94		5	1.006	0.052	0.346	0.062	0.148	0.072	0.000	1.192	18.600	8.8	0.150	0.419	0.000
	112BC 67	33.870	151.383	93		5	1.211	0.063	0.428	0.067	0.130	0.086	0.096	1.523	27.903	9.3	0.147	0.515	0.896
	112BC 68	33.870	151.358	75		5	1.462	0.078	0.350	0.052	0.108	0.031	0.000	1.623	16.100	11.2	0.223	0.481	0.000
	112BC 69	33.870	151.358	74		5	2.771	0.116	0.567	0.078	0.159	0.082	0.044	3.091	29.023	14.3	0.205	0.491	1.864
	112VC 65	33.870	151.383	94	0 - 8	4	3.069	0.110	0.185	0.227	0.212	0.000	0.000	3.406	33.700	9.1	0.595	1.071	0.000
		33.870	151.383	94	20 - 28	24	3.593	0.106	0.203	0.091	0.060	0.000	0.000	3.790	19.700	18.2	0.522	1.517	0.000
		33.870	151.383	94	40 - 48	44	3.914	0.074	0.116	0.054	0.041	0.000	0.034	4.076	13.634	30.6	0.638	1.317	0.000
		33.870	151.383	94	60 - 68	64	4.546	0.159	0.325	0.128	0.113	0.000	0.440	5.273	37.044	15.8	0.489	1.133	0.000
		33.870	151.383	94	80 - 88	84	3.029	0.091	0.249	0.056	0.093	0.000	0.000	3.176	14.700	20.6	0.365	0.602	0.000
		33.870	151.383	94	100 - 108	104	2.486	0.074	0.149	0.051	0.053	0.000	0.000	2.611	12.500	19.9	0.497	0.962	0.000
		33.870	151.383	94	120 - 128	124	1.626	0.067	0.164	0.042	0.052	0.000	0.000	1.735	10.900	14.9	0.409	0.808	0.000
		33.870	151.383	94	140 - 148	144	2.757	0.164	0.722	0.134	0.296	0.022	0.054	3.131	33.725	9.3	0.227	0.453	0.407
		33.870	151.383	94	160 - 168	164	2.515	0.140	0.596	0.103	0.239	0.022	0.049	2.829	28.232	10.3	0.235	0.431	0.449
		33.870	151.383	94	180 - 188	184	1.000	0.056	0.144	0.038	0.061	0.000	0.000	1.094	9.400	10.6	0.389	0.623	0.000

Table 6.2. Inventory of samples collected for halogenated hydrocarbon analysis

Core	Latitude (south)	Longitude (east)	Water Depth (m)	Mean Depth (cm)
112 BC 09	34.184	151.165	101	5
112 BC 27	33.998	151.349	103	5
112 BC 29	33.997	151.286	82	5
112 BC 30	33.997	151.285	81	5
112 BC 31	33.997	151.285	80	5
112 BC 32	33.997	151.284	81	5
112 BC 33	33.997	151.285	82	5
112 BC 41	33.811	151.531	128	5
112 BC 42	33.811	151.530	130	5
112 BC 44	33.811	151.588	141	5
112 BC 47	33.811	151.644	148	5
112 BC 49	33.811	151.700	180	5
112 BC 54	33.624	151.565	118	5
112 BC 55	33.624	151.564	118	5
112 BC 57	33.624	151.510	88	5
112 BC 58	33.625	151.510	88	5
112 BC 59	33.625	151.564	119	5
112 BC 60	33.625	151.564	119	5
112 BC 61	33.625	151.529	97	5
112 BC 62	33.625	151.529	97	5
112 BC 66	33.870	151.383	94	5
112 BC 67	33.870	151.383	93	5
112 BC 68	33.870	151.358	75	5
112 BC 69	33.870	151.358	74	5
112 BC 70	33.982	151.291	79	5
112 BC 71	33.003	151.285	84	5
112 BC 72	33.998	151.285	82	5
112 BC 73	33.987	151.300	83	5
112 GR 01	34.184	151.086	41	5
112 GR 02	34.183	151.165	100	5
112 GR 06	34.183	151.278	136	5
112 GR 09	34.184	151.335	143	5
112 GR 10	34.184	151.392	150	5
112 GR 14	33.997	151.285	81	5
112 GR 15	33.870	151.309	59	5
112 GR 16	33.871	151.333	65	5
112 GR 17	33.870	151.382	85	5
112 GR 18	33.811	151.351	67	5
112 GR 19	33.811	151.418	110	5
112 GR 20	33.811	151.474	127	5
112 GR 21	33.811	151.531	129	5
112 GR 23	33.811	151.643	148	5
112 GR 24	33.811	151.700	182	5

Table 6.2 continued

112 GR 25	33.000	151.000	146	5
112 GR 26	33.624	151.730	140	5
112 GR 27	33.624	151.675	135	5
112 GR 28	33.625	151.620	129	5
112 GR 32	33.625	151.528	97	5
112 GR 33	33.625	151.438	59	5
112 GR 35	33.870	151.382	91	5
112 GR 38	33.982	151.291	80	5

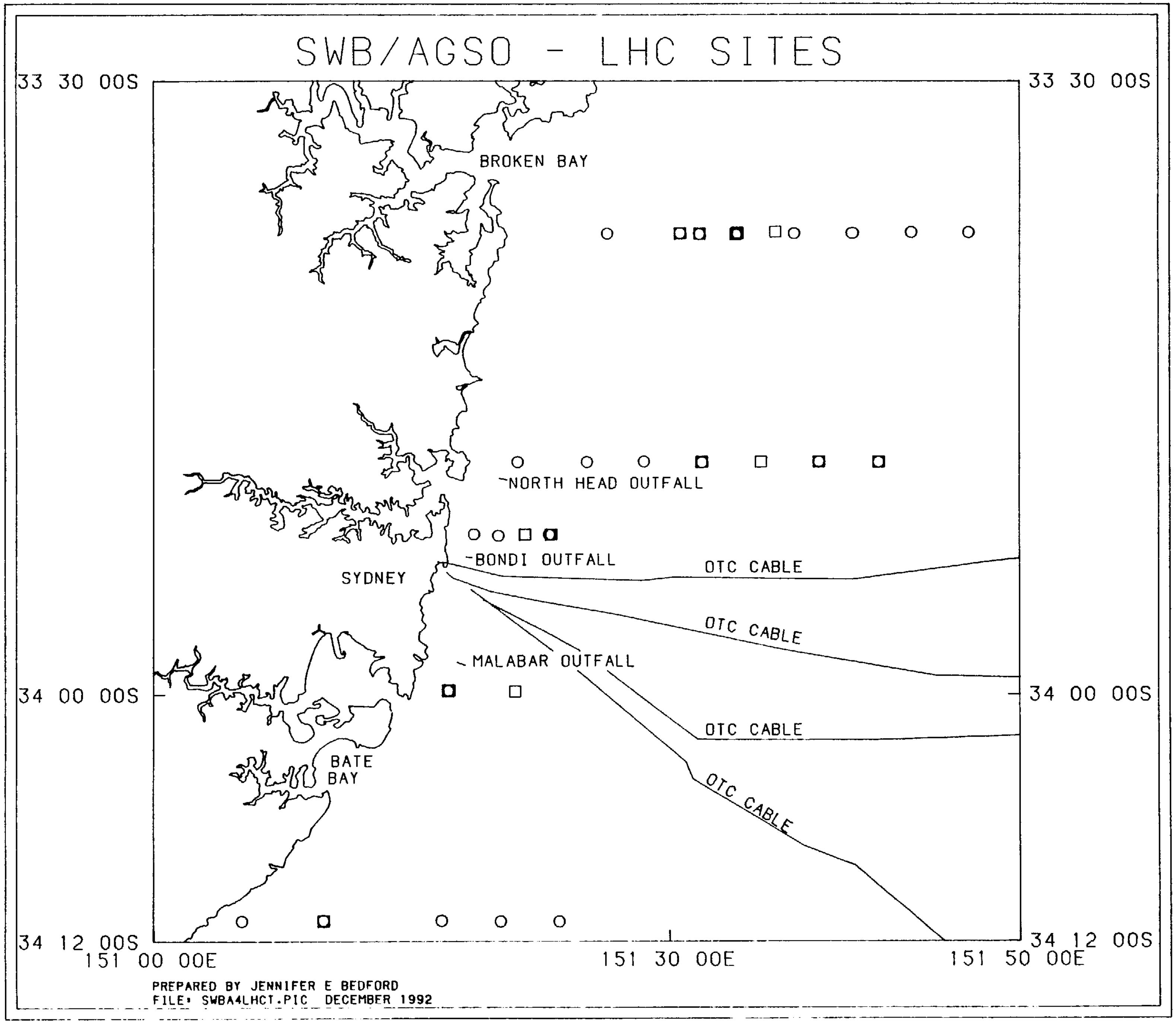


Figure 6.1. Map of the locations of LHC (light hydrocarbon) sampling sites.

7. Summary

AGSO and the Water Board conducted a combined survey on the *RV Rig Seismic*, offshore Sydney, during September/October 1992. A variety of seafloor sampling devices, including Van Veen grabs, vibro cores, box cores and gravity cores were deployed, along four transects perpendicular to the coastline, to collect sediments for 'baseline' studies of toxicants in sediments and a variety of sedimentological and geochemical process studies. In addition, four hundred and sixty one line-km of CGT (light hydrocarbon concentrations and temperature, salinity, oxygen concentrations and pH in seawater) data were collected, together with eighteen vertical profiles of light hydrocarbons, and fourteen vertical profiles of temperature, salinity, dissolved oxygen and pH data, in the water column from the vicinities of the ocean outfalls and near the entrances to major estuaries.

Sedimentology and contaminant sampling

The primary objective of the sedimentological and contaminant sampling component was to document the concentrations and distributions of selected organic (organochlorine) and inorganic (heavy metals) trace contaminants on the continental shelf adjacent to Sydney. Sixty two sediment cores from thirty sites, along four east-west transects on the continental shelf offshore of Sydney, were collected for sedimentological and shore-based contaminant analysis. This investigation to the edge of the continental shelf combined with previous Water Board sediment sampling programs nearer the coastline will address regional and cross-shelf contaminant dispersal from Sydney.

Sediment samples were collected primarily by vibro coring using 3m core barrels and, by box coring when adverse weather conditions or muddy sediments precluded the use of the vibro corer. The onboard cruise component consisted of core collection, splitting, logging and describing sediment character, plus removal of subsamples for further shore-based analysis.

Onboard core descriptions provided a preliminary understanding of surficial sediment character and distribution, as well as down-core structure. Initial interpretations identify sediment distributions similar to previous surveys, with indications of relationships between the distribution of reef systems and muddy sediments.

The boomer survey plus the 3.5 and 12 kHz bathymetric surveys provided valuable data on reef systems and associated sediments showing, the presence of generally thin pockets of sediment cover interspersed by exposed basement. These reefs may exert a significant control on the distribution of muds and contaminants in the coastal zone.

Further, shore-based analysis of the sediment grain-size, total organic carbon and contaminants contents will enable the objectives of the study to be met, and a better understanding of the physical, sedimentological and chemical processes occurring on the continental shelf adjacent Sydney to be developed.

Nutrient status of sediments

Fine-grained sediments from coastal sites near Sydney were collected for assessment of ambient rates of benthic metabolism, organic carbon turnover (oxidation) rates, nutrient (nitrogen and phosphorus) fluxes, as well as physico-chemical features such as porewater and solid phase nutrient concentrations, grain-size distribution and porosity.

Generally, four subcores from box cores were processed for solid phase and porewater nutrient analyses, oxygen profiles were determined from two subcores and nutrient (NH_4^+, PO_4^-, NO_3^-, NO_2^-) and oxygen flux rates were determined from measurements from four subcores. Samples from porewater extractions and flux rate determinations were analysed for ammonia and phosphate at sea. Samples for nitrite and nitrate determinations were frozen for subsequent analysis.

Oxygen concentrations in the fine-grained sediments decreased to undetectable levels within the top 0.5 cm of the sediment surface. Carbon utilisation rates ranged from 0.3 to 1.7 gm C m^{-2} d^{-1}. At most sites, there was a net release of nutrients (NH_4^+, PO_4^-) from the sediments to the overlying water column.

The determination of baseline conditions and processes related to organic carbon and nutrient dynamics in sediments of the Sydney region will provide information regarding establishment of ongoing monitoring programs for the coastal zone. This work is part of a larger program to determine key processes influencing the remineralisation and storage of organic matter in the coastal zone and as such involves assessment of both water column and sediment processes. This information is fundamental to assessing the impact of anthropogenic inputs in the Sydney region and to allow appropriate decisions regarding options for managing point and non-point sources of organic matter and nutrients.

Continuous geochemical tracers and light hydrocarbon geochemistry.

Approximately 460 line-km of CGT data were collected from the coastal zone, between Broken Bay and Port Hacking. Eighteen vertical profiles of DHD data were collected near the ocean outfalls and the entrances to the major estuaries. Sediment samples were analysed for total light hydrocarbon concentrations and molecular compositions.

Analysis of the vertical profiles of light hydrocarbons in the water column indicated molecular compositional differences between those hydrocarbons near the ocean outfalls and those near the entrances to estuaries. Light hydrocarbons from the ocean outfalls are dominated by methane with minor amounts of C_{2+} hydrocarbons. Light hydrocarbons near the entrances to estuaries, in contrast appear to be dominated by increased abundances of the C_{2+} hydrocarbons.

Analysis of the 460 line-km of DHD data from the coastal zone indicated light hydrocarbon anomalies at several depths near the ocean outfalls at Bondi, North Head and south of Malabar. Analysis of these data also indicated anomalous levels of C2+ hydrocarbons near the entrances to both Port Hacking and Botany Bay, indicating some influence of the estuaries on the near-shore light hydrocarbon concentrations and compositions in the surface waters. Total hydrocarbons (THC) and its molecular compositional differences are therefore sensitive tracers of anthropogenic additions to the coastal zone.

When THC and dissolved oxygen concentrations (from the SDL unit in the DHD tow-fish) are plotted together, the data indicate that zones of elevated THC concentrations are coincident with zones of depressed dissolved oxygen concentrations, particularly near the locations of the ocean outfalls. These data are (at least in part) indicative of a demand on the seawater dissolved oxygen inventory by microbial activity associated with organic matter (in sewage) discharged at sea.

Light hydrocarbon gas concentrations in sediments appear to be lower at the offshore stations and somewhat higher at inshore stations, although this observation has not been tested statistically.

The data collected on this survey provide essential 'baseline' data that will be utilised for environmental monitoring purposes. The data collected also provide valuable insights into oceanographic (ocean outfall plume dispersion) processes; sedimentological and sediment geochemical processes - particularly those associated with the degradation of organic matter and those associated with recycling and (potential) storage of contaminants in the coastal zone. All data collected on this survey contribute to the development of environmental monitoring strategies by helping define those parameters that are indicative of environmental change.

8. Acknowledgements.

The principal investigators from the AGSO and the Water Board acknowledge the major contribution to the success of the survey provided by the AGSO and AMSA crews, and scientific and technical support staff aboard *Rig Seismic*.

AGSO complement.
David Heggie, Jeremy Bishop, Gary Bickford, Andrew Hislop, Stephen Dutton, David Sewter, John Roberts, Chris Lawson, Claude Saroch, Colin Tindall, Leo Kalinisan, Simon Milnes, Richard Schuler, Heather Miller, Peter Davis, Vojciech Wierzbicki, Jon Stratton, Tony Hunter, Janusz Lazar (16 - 22 September 1992)

WB complement.

Judi Hansen, Peter Schneider, Simon Davey, Peter Fagan, Ron Johnstone, Janine Dolton, Ellen O'Brien, Anne Stockenberg

AMSA complement.
Bob Hardinge, Cedric Hellier, Roger Thomas, Ian McCarthy, Bob Dickman, Phil Hutchinson, Tony Dale, Mike Pitcher, Graham Pretsel, Bill Fowler, Geoff Conley, Pat Hutchins, Mark Cummer, Trevor Walters (16 - 24 September 1992), Bill Orgill (24 - 29 September 1992)

We wish to acknowledge the contribution to post processing of the hydrocarbon data by Greg Sparksman, Colin Tindall and David Evans, and the significant contribution by Jenny Bedford for the production of many Petroseis maps for this and the accompanying AGSO Records from this survey. We thank Chris Klimpton from the Water Board for the preparation of several standards of halogenated hydrocarbons, and with advice on halogenated hydrocarbon analyses with the ECD. Drewe Hampton (AGSO) provided methods development for halogenated hydrocarbon analyses with the ECD. We thank Jim Colwell for a thorough and constructive review of the document.

9. References

Baudo, R. and Muntau, H. (1990). Lesser known in-place pollutants and diffuse source problems. In: Baudo, R., Giesy, J. and Muntau, H. (Eds.), *Sediments: Chemistry and Toxicity of In-place Pollutants.* Lewis Publishers, Michigan. pp 1-14.

Bembrick, C.S. (1973). Preliminary interpretation of continental shelf sediments, Narooma 1;100,000 sheet. *New South Wales Geological Survey - Quarterly Notes,* 13:6-18.

Bernard, B. B., Brooks, J.M. and Sackett, W.M. (1976) Natural gas seepage in the Gulf of Mexico. *Earth and Planetary Science Letters,* 31, 48-54.

Bolin, B. and Cook, R.B. (1983) *The Major Biogeochemical Cycles and their Interactions.* John Wiley and Sons, Brisbane, Australia.

Boyd, R., (1974). *A Marine Geological Investigation of the New South Wales Coast Between Port Stephens and Norah Head.* University of Sydney - B.Sc. Hons Thesis (unpubl.).

Burgess, R.M. and Scott, K.J. (1992). The significance of in-place contaminated marine sediments on the water column: Processes and effects. In: Burton Jnr, G.A. (Ed.), *Sediment Toxicity Assessment.* Lewis Publishers, Michigan. pp 129-165.

Carman, R. and Wulff, F. (1989) Adsorption capacity of phosphorous in Baltic Sea sediments. *Estuarine Coastal Shelf Science* 29:447-456.

Davies, P.J. (1979). *Marine Geology of the Continental Shelf Off Southeast Australia.* Australia, Bureau of Mineral Resources - Bulletin 195. 51pp.
Denton, G.R.W. and Burdon-Jones, C. (1986). Trace metals in surface water from the Great Barrier Reef. *Marine Pollution Bulletin,* 17(3):96-98.

Fuex, A.N. (1977) The use of stable carbon isotopes in hydrocarbon exploration. *Journal of Geochemical Exploration,* 7, 155-188.

Ginn, T.C. (1989). Assessment of contaminated sediments in Commencement Bay, Puget Bay, Washington. In: *Contaminated Marine Sediments: Assessments and*

Remediation, National Research Council (Washington, D.C.: National Academy Press, 1989), pp 425.439.

Gordon, A.D. and Hoffman, J.G. (1986). Sediment features and processes of the Sydney continental shelf. In: E. Frankel, J.B. Keene and A.E. Waltho (Eds.), *Recent Sediments in Eastern Australia, Marine Through Terrestrial.* Geological Society of Australia, Sydney, NSW Division. pp 29-52.

Gordon, A.D. and Hoffman, J.G. (pers. comm.). *Unpublished Results from Water Board Diffuser Studies.*

Heggie, D.T., Bickford, G.P. and Bishop, J.H. (1993a) Direct Hydrocarbon Detection and tracing of anthropogenic hydrocarbon plumes offshore Sydney: Results from *Rig Seismic* Survey 112. *Australian Geological Survey Record* 1993/9.

Heggie, D.T., Bickford, G.P. and Bishop, J.H. (1993b) Continuous Geochemical Tracers (CGT) and anthropogenic discharges in the sea off Sydney: Results from *Rig Seismic* Survey 112. *Australian Geological Survey Record* 1993/10.

Hites, R.A. and Lopez-Avila, B. (1980). Sedimentary accumulation of industrial organic compounds discharged into a river. In: Baker, R.A. (Ed.), *Contaminants and Sediments. Vol. 1.* Ann Arbor, Michigan. pp 53-66.

Howard, P.H. (1991). *Handbook of Environmental Fate and Exposure Data for Organic Chemicals.* Lewis Publishers, Michigan. 684pp.

Huyer, A., Smith, R.L., Stabeno, P.H., Church, J.A. and White, N.J. (1988). Currents off south-eastern Australia: Results from the Australian coastal experiment. *Australian Journl. Marine Freshwater Research,* 39:245.248.

Launiainen, J., Matthdus, W., Fonselius, S., and Francke, E. (1987) First periodic assessment of the state of the marine environment in the Baltic Sea area, 1980-1985. *Baltic Sea Environment Proceedings* 17B. pp 335.

Leppdkoski, E. (1980) Mans impact on the Baltic Ecosystem. *Ambio* 9:174-181.

Marshall, J.P. (1979). The development of the continental shelf of northern New South Wales. *BMR Journal of Australian Geology and Geophysics,* 4:281-288.

McLaren, P. (1981). An interpretation of trends in grain-size measures. *Journal of Sedimentary Petrology*, 51:611-624.

Merian, E. (1991). *Metals and their Compounds in the Environment.* VCH, New York. 1438pp.

Officer, C.B., Biggs, R.B., Taft, J.L., Cronin, E., Tyler, M.A., Boynton, W.R. 1984. Chesapeake Bay anoxia: origin, development, and significance. *Science* 223:22-27.

Parsons, T.R., Maita, Y. Lalli, C.M. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*, Pergamon Press.

Peirson, W.L., Brown, D.A. and Tong, G.D. (1991). Cross-shelf variability of coastal currents at Sydney. In: Lee and Cheung (Eds.), *Environmental Hydraulics.* A.A. Balkema, Rotterdam, Holland. pp 249-254.

Roy, P.S. (1983). Quaternary geology. In: Herbert, C. (Ed.). *Geology of the Sydney 100,000 sheet 9130.* New South Wales Geological Survey, Sydney. pp 41-91.

Roy PS. (1985). Marine sand bodies on the south Sydney shelf, southeast Australia. *Coastal Studies Unit Technical Report No. 85/1.* Department of Geography, University of Sydney, Sydney, NSW 2006. 180pp.

Rudstam, L.G.(1988) Patterns of zooplanktivory in a coastal area of the northern Baltic proper. Ph.D. thesis. Dept. of Zoology, Stockholm University, Stockholm, Sweden.

Sandstrom, M.W., Tirendi, F. and Nott, A. (1986). Direct determination of organic carbon in modern reef sediments and calcareous organisms after dissolution of carbonate. *Marine Geology*, 70:321-329.

Schneider, P.M. and Wyllie, S.J. (1991). An efficient vibro coring System for collecting coastal sediments: A comparison with other techniques. *10th Australasian Conference on Coastal and Ocean Engineering, Auckland, 2-6 Dec.* Water Quality Centre Publ. No 21. Hamilton, New Zealand.

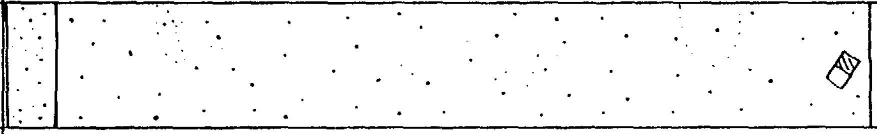
Seitzinger, S., Nixon, S., Pilson, E.Q., and Burke, S. (1980) Denitrification and N_2O production in nearshore marine sediments. *Geochimica Cosmochimica Acta,* 44:1853-1860.

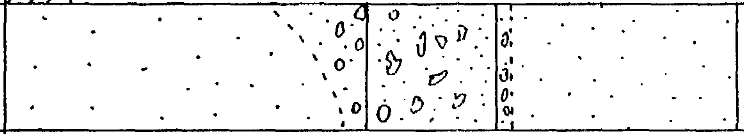
Swift, D.J., Stanley, D.J. and Curray, J.R. (1971). Relict sediments on continental shelves: a reconstruction. *Journal of Geology*, 79:322-346.

Appendix 1. Core logs provided by the Water Board.

LOG SHEET CORE NO- 001 SPLIT- 18 SEPT 1992 T-NO. B-NO.

SITE- WB28 TIME- 0647.30 LGTH- 65.0cm Lat- 34 11.00 Long- 151 05.15 DATE- 17/9/92 DEPTH- 40.1m

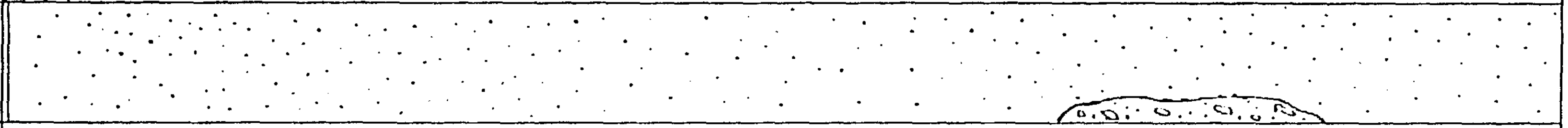
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	
VISUAL LOG	
COLOR	10YR 4/1 5Y 4/1 5Y 5/2
SORTING/ ROUNDNESS	poorly sorted med. well sorted
CARBONATE%	+ + + + ++
FOSSILS	forams, spicule, gastropods echinoid spines
SEDIMENTARY STRUCTURES	
REMARKS	1mm mud drape muddy to 30cm with foraminiferal diversity, poorly sorted, fine grain quartz sand 30 - 65cm medium to coarse quartz sand with minor iron staining, minor biogenic carbonate mottling down core generally darker (10YR 7/6) non rusted hexagonal nut at 62cm.

LOG SHEET	CORE NO- 003 SPLIT- 18 SEPT 1992 T-NO. B-NO.
SITE- WB28	TIME- 0844.30 LGTH- 55.5cm Lat- 34 11.00 Long- 151 05.19 DATE- 17/9/92 DEPTH- 39.2m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/3 2.5YR 6/4 7.5YR 4/0 5Y 5/3
SORTING/ ROUNDNESS	well sorted subround mod. sorted
CARBONATE%	++ +++ +++ +++ ++
FOSSILS	forams
SEDIMENTARY STRUCTURES	
REMARKS	0 - 25cm medium, well sorted, subround quartz sand, 30% iron stained quartz 10% carbonate, 5% lithics, 55% clear, non-iron stained quartz 25 - 38cm more muddy, coarse carbonate layer in well sorted, medium sand This darker band also exhibits mottling (5Y 4/3) Up to 5% mud. 38 - 55.5cm same as top 25cm.

1/3

LOG SHEET CORE NO- 005 SPLIT- 18/9/92 T-NO. B-NO.

SITE- 28 TIME- 0958 LGTH- 175cm Lat- 34 11.04 Long- 151 5.15 DATE- 17/9/92 DEPTH-40.2m

LENGTH (MM)	100	200	300	400	500	600	700	800	900	1000	1100	
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR	5Y 5/2	5Y 5/3			5Y 7/4					5Y 6/3	5Y 6/4	
SORTING/ ROUNDNESS	well sorted well rounded							well sorted well rounded				
CARBONATE%	+++		++		++			++		++		
FOSSILS	foraminifera											
SEDIMENTARY STRUCTURES	<----- fining											

REMARKS

0-0.2cm mud drape (with worm).
0.2-60cm fine to medium quartz sand, slightly muddier in top 3cm. 85% quartz,10% carbonate, 5% mud. No iron staining, large foraminiferal diversity.
42-58cm large patch of lighter coloured sediment (5Y 7/4). As for 0.2-60cm.
60-100cm fine to medium quartz sand. 95% subrounded quartz of which about 20% is ironstained. 5% carbonate.
80-100cm a thin patch of shell grit (colour 5Y 6/3) adjacent the core wall. Poorly sorted.
100-120cm fine to medium quartz sand consisting of well sorted, subangular to subrounded particles of which 20% are iron stained. 80% quartz, 10% carbonate, 5% lithics and 5% mud.

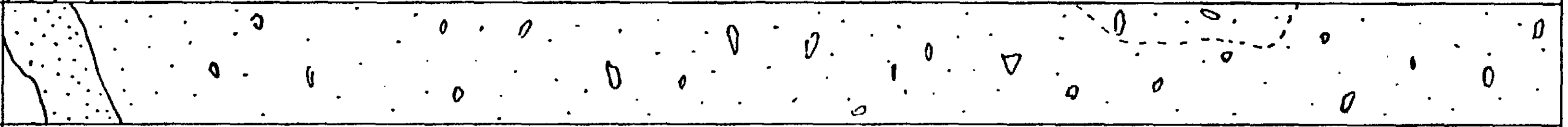
1/14

LOG SHEET CORE NO- 005A SPLIT- 18/9/92 T-NO. B-NO.

SITE- 28 TIME- 0958 LGTH- 175cm Lat- 34 11.04 Long- 151 5.15 DATE- 17/9/92 DEPTH-40.2m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 6/4 5Y 6/3 5Y 6/4
SORTING/ ROUNDNESS	well sorted well rounded poor well sorted well rounded
CARBONATE%	++ +++ ++
FOSSILS	
SEDIMENTARY STRUCTURES	
REMARKS	120-175cm fine to medium quartz sand consisting of well sorted, subangular to subrounded particles. 20% of these are iron stained. Composition 80% quartz, 10% carbonate, 5% lithics, 5% mud. 140-158cm a carbonate rich patch made up of shell grit (5Y 6/3) adjacent core wall.

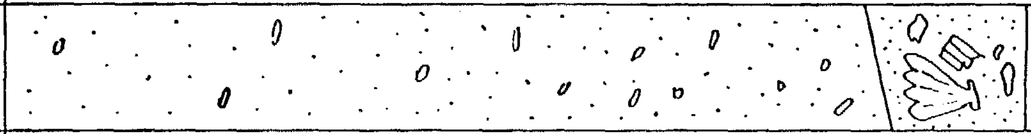
1/5

LOG SHEET	CORE NO- 007 SPLIT- 19 SEPT 1992 T-NO. B-NO.
SITE- WB25 TIME- 0027.1 LGTH- 196cm	Lat- 34 11.02 Long- 151 16.66 DATE- 18/9/92 DEPTH- 136m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/3 5Y 5/3 5Y 5/3 5Y 5/3
SORTING/ ROUNDNESS	poorly sorted angular/subround poorly sorted angular/subround
CARBONATE%	+++ +++ +++ +++
FOSSILS	forams forams forams bivalve
SEDIMENTARY STRUCTURES	<-----¦ fining up
REMARKS	0 - 10cm medium/coarse shell hash in olive mud 80% iron stained carbonate, 10% lithics, 10% mud no detrital quartz 10 - 100cm 80% medium/coarse shell grit, 20% mud 100 - 120cm medium/coarse carbonate sand, 80% carbonate, 10% mud, 10% quartz. surface disturbed by sponge!

1/6

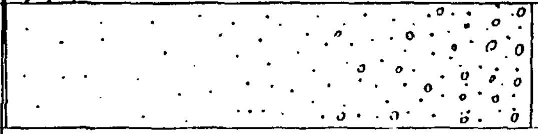
LOG SHEET CORE NO- 007 SPLIT- 19 SEPT 1992 T-NO. B-NO.

SITE- WB25 TIME- 0027.1 LGTH- 196cm Lat- 34 11.02 Long- 151 16.66 DATE- 18/9/92 DEPTH- 136

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/3 5Y 4/3 5Y 4/3
SORTING/ ROUNDNESS	poor sorting angular poor sorting angular
CARBONATE%	++ ++ ++ ++ +++
FOSSILS	forams sponge spicules forams
SEDIMENTARY STRUCTURES	<--¦ very gradual fining upwards
REMARKS	120 - 183cm coarse shell hash in fine muddy matrix 70% carbonate, 10% mud, 20% quartz (iron stained),trace lithics 183 - 196cm, 50% coarse, well rounded,iron stained,quartz grains 40% coarse carbonate 10% mud, plus large pectin shells and bivalve shells Quartz appears to increase down core.

LOG SHEET CORE NO- 008 SPLIT- 26 Sept 1992 T-NO. B-NO.

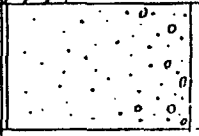
SITE- WB25 TIME- 0052.0 LGTH-40cm Lat- 34 11.04 Long- 151 16.65 DATE- 18/9/92 DEPTH- 135m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 10YR 3/3
SORTING/ ROUNDNESS	Well sorted Angular/subangular
CARBONATE%	+++ +++ +++
FOSSILS	
SEDIMENTARY STRUCTURES	<---------------------------¦ Fining up
REMARKS	4mm Mud drape 0.5 - 5cm medium well sorted non iron stained carbonate sand 5 - 30cm coarse carbonate sand, 80% carbonate 20% quartz subround/subangular, iron stained 30 - 40cm Carbonate gravel,10% quartz,90% carbonate

1/8

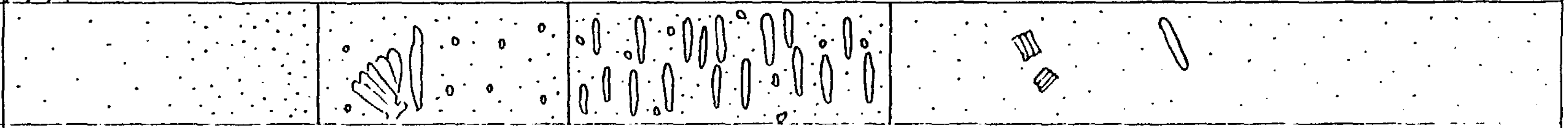
LOG SHEET CORE NO- 010 SPLIT- 19 SEPT 1992 T-NO. B-NO.

SITE- WB24 TIME- 0320 LGTH- 15cm Lat- 33 11.05 Long- 151 20.09 DATE- 18/9/92 DEPTH- 142m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 3/3
SORTING/ ROUNDNESS	mod. sorting angular/subangular
CARBONATE%	+++ +++
FOSSILS	forams gastropods
SEDIMENTARY STRUCTURES	<-------¦ fining up
REMARKS	1mm mud drape 0 - 10cm medium to coarse carbonate sand, 20% quartz, 75% carbonate, 5% lithics 10 - 15cm coarse carbonate sand, 65% carbonate, 30% quartz, 5% lithics, subround to subangular with minor iron staining

LOG SHEET CORE NO- 011 SPLIT- 19 SEPT 1992 T-NO. B-NO.

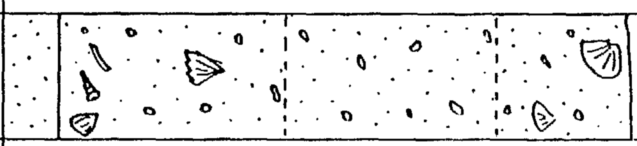
SITE- WB24 TIME- 0350 LGTH-168cm Lat- 34 11.03 Long- 151 20.09 DATE- 18/9/92 DEPTH- 141m

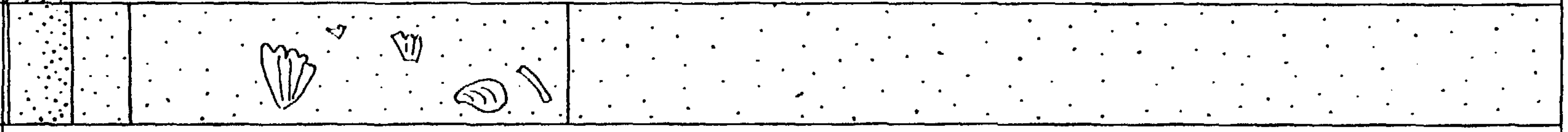
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/1 5Y 4/1 10YR 4/4
SORTING/ ROUNDNESS	mod. sorted round/subround well sorted angular/subangular poorly sorted subangular/subround
CARBONATE%	++ +++ +++ +++ +++
FOSSILS	forams forams, pectins, bivalves echinoid spines pectins, bivalve forams worm tubes
SEDIMENTARY STRUCTURES	<---------------| fining up
REMARKS	0 - 20cm fine/medium carbonate sand, 85% carbonate, 15% quartz, trace lithics minor iron staining 20 - 25cm coarse carbonate sand, 75% ironed stained carbonate, 25% quartz 25 - 45cm fine/coarse carbonate sand, 85% carbonate, 10% quartz, 5% mud, trace lithics 45 - 68cm fine to coarse carbonate sand,85% carbonate, 10% quartz, 5% lithics 73cm worm tubes, pectins 68 - 125cm fine to coarse carbonate sand, 60% carbonate, 20% quartz, 20% lithics minor iron staining 90cm large pectin

1/10

LOG SHEET CORE NO- 011 SPLIT- 19 SEPT 1992 T-NO. B-NO.

SITE- WB24 TIME- 0350 LGTH- 168CM Lat- 34 11.03 Long- 151 20.09 DATE- 18/9/92 DEPTH- 141m

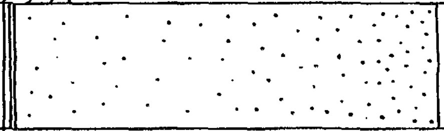
LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 5/1 5Y 6/1 5Y 5/1
SORTING/ ROUNDNESS	poorly sorted subround/subangular
CARBONATE%	+++ +++
FOSSILS	pectins, bivalves pectins bivalves
SEDIMENTARY STRUCTURES	
REMARKS	125 - 168cm fine to coarse carbonate sand 60% carbonate 20% quartz 10% lithics 10% mud

LOG SHEET	CORE NO-012 SPLIT- 26 Sept 1992 T-NO. B-NO.
SITE-WB 23 TIME- 0608 LGTH- 122cm	Lat- 33 11.06 Long- 151 23.46 DATE- 18/9/92 DEPTH- 150m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR(MD) 6/3 10YR 5/4 10YR 4/4
SORTING/ ROUNDNESS	Mod. Sorted Angular/subangular Poorly Sorted Subangular/subround Mod. Sorted angular/subangular
CARBONATE%	+++ +++ +++ +++ +++
FOSSILS	Forams Forams
SEDIMENTARY STRUCTURES	<--| Fining up
REMARKS	0-0.5cm mud drape (10YR 6/3) 0.5 - 3cm Moderately sorted medium carbonate sand, Fe staining, angular/subangular 20% quartz, 80% carbonate(10YR 6/4) 3.0 - 6.0cm Fine to coarse, poorly sorted, fe stained carbonate sand, subangular/subround 10% quartz, 90% Carbonate (10YR 4/4) 6.0 - 8.0cm Medium to coarse carbonate sand, mod. sorted, 10% quartz, 90% carbonate Trace lithics, (5Y 4/3) 6.0 - 10.0cm Medium to coarse, moderately sorted, subangular to subround carbonate sand. 10.0 - 45.0cm Medium to coarse, poorly sorted carbonate sand. 95% Carbonate, 5% Mud Fe stained, Subangular to subround 45 - 122cm Medium to coarse carbonate sand, Moderately sorted, angular/subangular Heavily Fe stained.

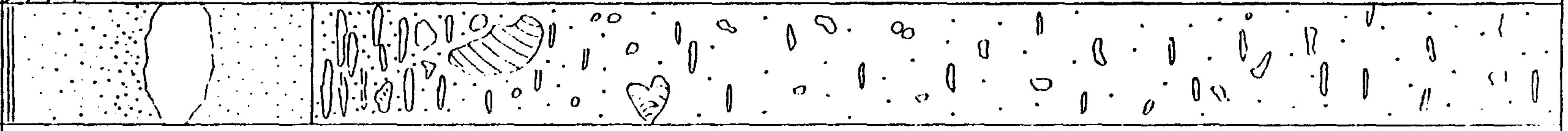
1/12

LOG SHEET CORE NO- 014 SPLIT- 18 SEPT 1992 T-NO. B-NO.

SITE- WB23 TIME- 0729 LGTH- 32cm Lat- 34 11.00 Long- 151 23.47 DATE- 18/9/92 DEPTH- 150m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/3 10YR 4/3
SORTING/ ROUNDNESS	mod. sorting angular
CARBONATE%	+++ +++
FOSSILS	forams gastropods forams, gastropods echinoid spines
SEDIMENTARY STRUCTURES	<---------------------| fining up
REMARKS	3mm mud drape 0 - 20cm medium/coarse carbonate sand, 80% carbonate, 15% quartz, 5% lithics angular and iron stained 20 - 32cm coarse carbonate sand, 90% angular iron stained carbonate, 5% quartz 5% lithics

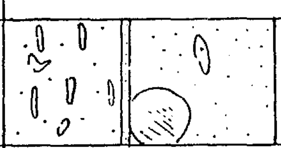
1/13

LOG SHEET	CORE NO- 015 SPLIT- 24 Sept 1992 T-NO. B-NO.
SITE- WB23	TIME- 0817 LGTH- 140cm Lat- 34 11.04 Long- 151 23.48 DATE- 18/9/92 DEPTH- 150m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 6/3 10YR 4/3 10YR 5/4 10YR 5/4
SORTING/ ROUNDNESS	poorly sorted angular poorly sorted angular mod. well sorted subround
CARBONATE%	+++ +++ +++
FOSSILS	forams forams, pectins echinoid spines forams, sponge spicules bryozoans
SEDIMENTARY STRUCTURES	<------| fining up ||| |||
REMARKS	3mm mud drape 0.3 - 24cm medium iron stained carbonate rich sand 85% carbonate (75% iron stained) 10% quartz 5% authigenic glauconite filled foram tests 24 - 50cm more compacted coarse shell gravel in carbonate sand matrix 60% carbonate (iron stained) 30% quartz 5% lithics 5% white clay 50 - 127cm fine to medium, iron stained carbonate sand 75% carbonate 10% quartz, 10% clay, 5% lithics N.B. sponge found in void, 10 - 15 cm.

11/4

LOG SHEET CORE NO- 015 SPLIT- 24 Sept 1992 T-NO. B-NO.

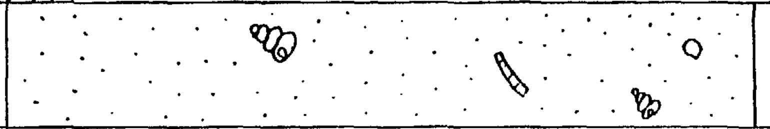
SITE- WB23 TIME- 0817 LGTH- 140cm Lat- 34 11.04 Long- 151 23.48 DATE- 18/9/92 DEPTH- 150m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	
SORTING/ ROUNDNESS	mod. sorted well rounded
CARBONATE%	+++
FOSSILS	forams sponge spicules
SEDIMENTARY STRUCTURES	│││
REMARKS	127 - 140cm very fine carbonate sand, iron stained similar to 0 - 20cm but finer 85% carbonate 10% quartz 5% authigenic glauconite filled foram tests

11/5

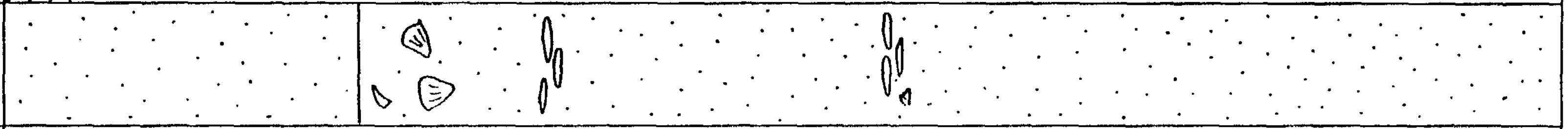
LOG SHEET CORE NO- 016 SPLIT- 20/9/92 T-NO. B-NO.

SITE- 22 TIME- 1041 LGTH- 58cm Lat- 34 11.04 Long- 151 26.88 DATE- 18/9/92 DEPTH- 238m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/1
SORTING/ ROUNDNESS	poorly sorted sub-angular
CARBONATE%	+++ +++ +++
FOSSILS	foraminifera gastropods
SEDIMENTARY STRUCTURES	sedimentary structures absent
REMARKS	0-15cm extremely porous fine carbonate sand. Carbonate consists of foraminifera and shell mash. Carbonate 74%, quartz 25%, lithics 1%. 15-58cm as for 0-15cm except that the porosity is markedly reduced and sediment appears partially dewatered.

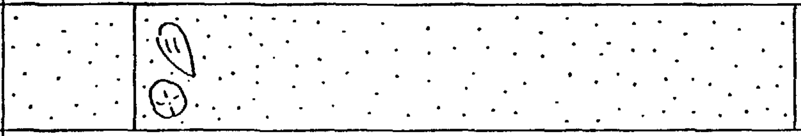
LOG SHEET CORE NO- 017 SPLIT- 26/9/92 T-NO. B-NO.

SITE- 22 TIME- 1124 LGTH- 180cm Lat- 34 11.04 Long- 151 26.87 DATE- 18/9/92 DEPTH- 238m

LENGTH (MM)		100	200	300	400	500	600	700	800	900	1000	1100
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR		5Y 3/2					5Y 4/2					5Y 4/2
SORTING/ ROUNDNESS		poor subangular				poor subangular					poor subangular	
CARBONATE%	+++				+++				+++			+++
FOSSILS					gastropods			pectins bivalves				
SEDIMENTARY STRUCTURES												
REMARKS	0-27cm fine silty carbonate sand. Lighter coloured sediment in top 27cm grades gradually into darker colour of sediment between 27-134cm. Would appear to have a high organic component. Carbonate 70%, quartz 29% and a trace of lithics (~1%). 27-120cm fine carbonate sand. 70% carbonate, 1-5% lithics and 25% quartz. 30cm scattered small shell material i.e. pectins and bivalves. Free water pooling on sediment surface. 70-120cm sediment appears organic rich and cohesive.											

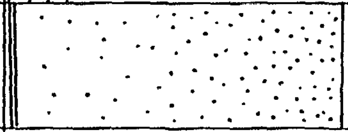
1117

LOG SHEET	CORE NO- 017A	SPLIT- 26/9/92	T-NO.	B-NO.			
SITE- 22	TIME- 1124	LGTH- 180cm	Lat- 34 11.04	Long- 151 26.87	DATE- 18/9/92	DEPTH- 238m	

LENGTH (MM)	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SUB-SAMPLE											
VISUAL LOG											
COLOR	5Y 4/2		5Y 3/2			5Y 3/2					
SORTING/ ROUNDNESS	poor subangular			poor subangular							
CARBONATE%	+++				+++						
FOSSILS	foraminifera				foraminifera sand dollars						
SEDIMENTARY STRUCTURES	¦¦¦										
REMARKS	120-130cm fine carbonate sand. 70% carbonate, 25% quartz and 1-5% lithics. Sediment appears organic rich and cohesive. Free water pooling on sediment surface. 130-180cm fine carbonate sand. 70% carbonate, 1% lithics, remainder quartz. sediment appears organic rich and is markedly less porous than 0-130cm section.										

LOG SHEET CORE NO- 018 SPLIT- 24 SEPT 1992 T-NO. B-NO.

SITE- WB21 TIME- 1513.50 LGTH- 26cm Lat- 33 59.83 Long- 151 33.80 DATE- 18/9/92 DEPTH- 205m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 2.5Y 6/2
SORTING/ ROUNDNESS	mod. sorted ; poorly sorted subround/subangular;angular
CARBONATE%	+++ +++
FOSSILS	echinoid spines, spicules forams, bryozoa
SEDIMENTARY STRUCTURES	<----------------¦ fining upwards
REMARKS	2mm mud drape 0 - 15cm fine/medium carbonate sand, 75% carbonate, 20% quartz, 5% lithics some iron staining, subround/subangular 15 - 26cm coarse sand/gravel, 100% slightly iron stained carbonate, angular

LOG SHEET CORE NO- 019 SPLIT- 24 SEPT 1992 T-NO. B-NO.

SITE-WB21 TIME- 1544 LGTH- 280cm Lat- 33 59.86 Long- 151 33.85 DATE- 18/9/92 DEPTH- 205m

LENGTH (MM)	100	200	300	400	500	600	700	800	900	1000	1100	
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR	5Y 3/2							5Y 3/2				5Y 4/2
SORTING/ ROUNDNESS	mod. poorly sorted subangular							mod. sorted subangular				
CARBONATE%	+++			+++			+++				+++	
FOSSILS	forams	gastropods			forams, sponge spicules echinoid spines					Bryozoa, forams sponge spicules		
SEDIMENTARY STRUCTURES												
REMARKS	no mud drape 10cm fine/med carbonate sand, 30% quartz, 50% slightly iron stained carbonate 20% mud, 5% lithics 40cm fine carbonate sand, 25% quartz, 50% carbonate, 20% mud, 5% lithics consistant down core											

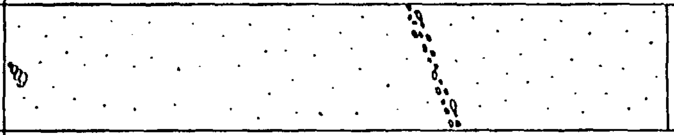
LOG SHEET CORE NO- 019 SPLIT- 24 SEPT 1992 T-NO. B-NO.

SITE- WB21 TIME-1544 LGTH- 280cm Lat- 33 59.86 Long- 151 33.85 DATE- 18/9/92 DEPTH- 205m

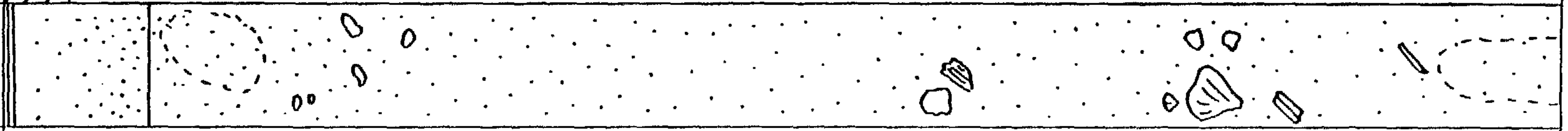
LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/2
SORTING/ ROUNDNESS	mod. well sorted sub angular mod. poor sorting subangular/angular
CARBONATE%	+++ +++ +++
FOSSILS	Bryozoa sponge spicules forams, Bryozoa worm tubes bivalve
SEDIMENTARY STRUCTURES	
REMARKS	fine quartz/carbonate sand 40% carbonate 35% quartz 15% mud 10% lithics non iron stained, sub angular consistant down core

LOG SHEET CORE NO- 019 SPLIT- 24 SEPT 1992 T-NO. B-NO.

SITE- WB21 TIME- 1544 LGTH- 280cm Lat- 33 59.86 Long- 151 33.85 DATE- 18/9/92 DEPTH- 205m

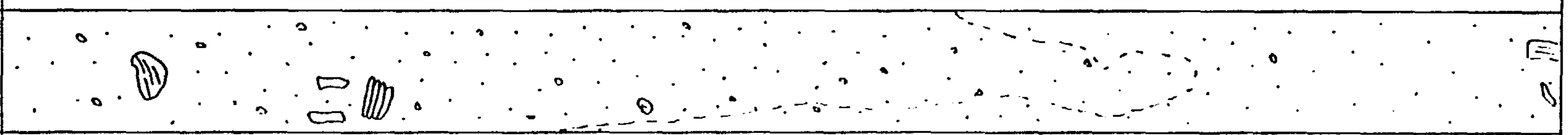
LENGTH (MM)	2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/2
SORTING/ ROUNDNESS	subround subangular/angular
CARBONATE%	+++ +++ +++
FOSSILS	Bryozoa, forams gastropods sponge spicules forams, worm tubes
SEDIMENTARY STRUCTURES	
REMARKS	fine carbonate sand, 60% carbonate, 20% fine subround non-iron stained quartz 5 - 10% lithics, 10% mud. variety of forams 260 - 265 cm shelly layer

1/22

LOG SHEET	CORE NO- 021 SPLIT- 24/9/92 T-NO. B-NO.
SITE- 20 TIME- 1805	LGTH- 261cm Lat- 33 59.85 Long- 151 31.98 DATE- 18/9/92 DEPTH- 160m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	2.5Y 5/2 5Y 4/2 2.5Y 4/2 10YR 4/1 10YR 5/3
SORTING/ ROUNDNESS	moderate subround poor angular/subangular poor angular/subangular
CARBONATE%	+++ +++ +++ +++ +++
FOSSILS	foraminifera sponge spicules echinoid fragments, foraminifera, pectin, bivalves, bryozoa worm tubes, sponge spicules, encrusting coralline algae
SEDIMENTARY STRUCTURES	<------¦ fining ¦
REMARKS	0-0.3cm fawn coloured mud drape. 0.3-11cm fine to medium carbonate sand. Moderately sorted, upward fining sequence. Numerous and diverse foraminiferal representation. 75% carbonate, 20% quartz, 2-3% lithics and 2-3% organic mud. 11-105cm medium to coarse carbonate sand. Large fragments of shell material up to 2cm in size scattered throughout. Some ironstaining of carbonates. 70% carbonate, 20% quartz, 5% lithics and 5% organic mud. 105-120cm a lighter coloured patch of medium to coarse carbonate sand. This lighter patch is less iron stained than either the overlying or surrounding sands. 80% carbonate, 10% quartz, 5% lithics and 5% pale mud.

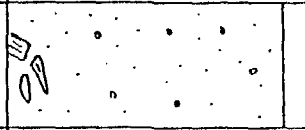
LOG SHEET CORE NO- 021A SPLIT- 24/9/92 T-NO. B-NO.

SITE- 20 TIME- 1805 LGTH- 261cm Lat- 33 59.85 Long- 151 31.98 DATE- 18/9/92 DEPTH- 160m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	2.5Y 6/4 5Y 3/1
SORTING/ ROUNDNESS	poor subround/subangular moderate angular/subangular/subrounded moderate poor subangular/angular
CARBONATE%	+++ +++ +++ +++
FOSSILS	bivalves, foraminifera, bryozoa gasteropods, echinoid spines, pectin barnacles, bivalves bryozoans, echinoid spines
SEDIMENTARY STRUCTURES	¦¦
REMARKS	120-170cm medium to coarse carbonate sand. Marked iron staining of some carbonates. 80% carbonate, 15% quartz, 5% lithics. Mud trace throughout. 170-200cm medium carbonate sand. Minor iron staining of some carbonates. Similar to 120-170cm with 80% carbonate but less than 10% quartz. A large number of what appear to be mineralised foraminiferal tests. 200-240cm coarse carbonate sand. Heavy iron staining of carbonates. 85% carbonate, 15% quartz. Carbonate shell remnants would indicate a large faunal diversity.

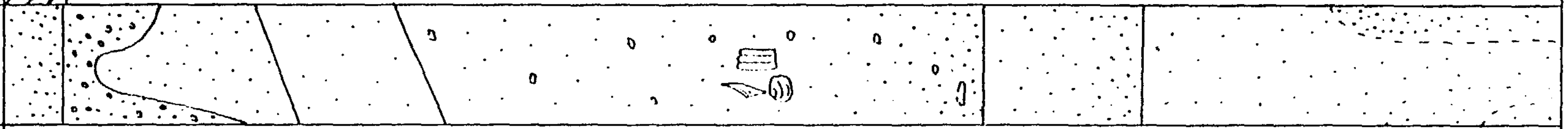
LOG SHEET CORE NO- 021B SPLIT- 24/9/92 T-NO. B-NO.

SITE- 20 TIME- 1805 LGTH- 261cm Lat- 33 59.85 Long- 151 31.98 DATE- 18/9/92 DEPTH- 160m

LENGTH (MM)	2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 3/1
SORTING/ ROUNDNESS	moderate/poor angular/subang.
CARBONATE%	+++
FOSSILS	foraminifera bivalves
SEDIMENTARY STRUCTURES	‖
REMARKS	240-261cm medium to coarse carbonate sand. Minor iron staining of carbonates. 80% carbonate, 15% foraminifera infilled by authigenic glauconite, 5% lithics Abundant shell material including gastropods, worm tubes, bivalves and foraminifera.

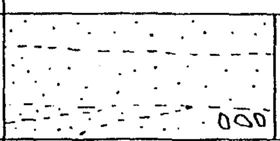
LOG SHEET CORE NO- 022 SPLIT- 19/9/92 T-NO. B-NO.

SITE- 20 TIME- 1824 LGTH- 140cm Lat- 33 59.86 Long- 151 31.99 DATE- 18/9/92 DEPTH- 160m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	2.5Y 7/4 5YR 5/4 5YR 5/3 5YR 5/4 2.5Y 7/4 5YR 5/4 5YR 5/4 5Y 7/3
SORTING/ ROUNDNESS	poorly sorted sub-rounded to angular poorly sorted poorly sorted moderate to poor sorting
CARBONATE%	+++ +++ ++ ++ ++
FOSSILS	foraminifera foraminifera, pectin, bivalves, gastropods foraminifera sponge spicules
SEDIMENTARY STRUCTURES	<----- Fining <-------------- fining upwards <-------- fining |----------> fining down
REMARKS	0-5cm very fine quartz/carbonate sand with 20% white clay. 5-12cm coarse iron stained quartz and larger shell fragments to 2cm. Subrounded angular grains. 0-30cm quartz 45%, carbonate 30%, clay 20%, lithics 5%. 30-73cm largely iron stained, medium quartz grains with small percentage carbonate. Carbonate component made up of foraminifera and shell fragments. Coarse shelly hash at 20-30cm consisting of pectin fragments and bivalves. Quartz 75%, carbonate 10%, clay 10%, lithics 5%. 75-85cm redder facies resulting from heavier iron staining of quartz and carbonate. 85-120cm fine to medium grained, moderately to poorly sorted quartz and carbonate. Quartz iron stained, carbonate primarily non-stained foraminifera tests and shell fragments. No clays or fines. Quartz 50%, carbonate 48%, lithics 2%.

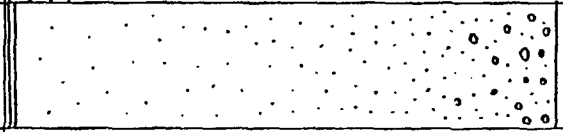
LOG SHEET CORE NO- 022A SPLIT- 19/9/92 T-NO. B-NO.

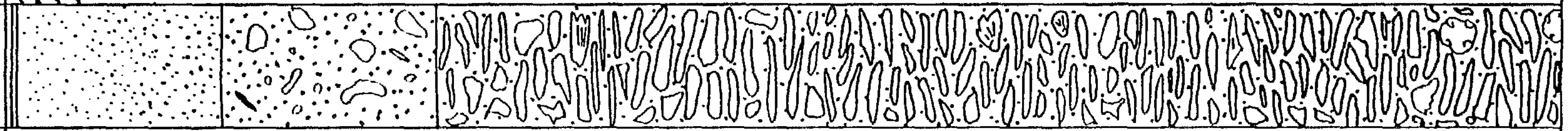
SITE- 20 TIME- 1824 LGTH- 140cm Lat- 33 59.86 Long- 151 31.95 DATE- 18/9/92 DEPTH- 160m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 7.5YR 5Y 7/3 6/2 4/3
SORTING/ ROUNDNESS	poorly sorted subrounded
CARBONATE%	+++ +++
FOSSILS	sponge spic. pectin,bryoz.
SEDIMENTARY STRUCTURES	----------->| fining down |
REMARKS	110-140cm very fine poorly sorted quartz sand. Mostly iron stained. Carbonate angular, quartz subrounded. 5% white clay. Pectin fragments at base. Colour variation on core walls are a likely coring artifact. A comparatively dry core of relatively low porosity. 5% lithics.

LOG SHEET CORE NO- 023 SPLIT- 24 Sept 1992 T-NO. B-NO.

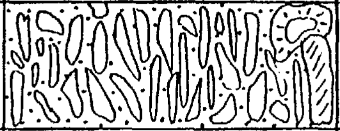
SITE- WB19 TIME- 2038 LGTH- 42cm Lat- 33 58.49 Long- 151 29.28 DATE- 18/9/92 DEPTH- 148m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 5/2 10YR 3/4 10YR 5/2
SORTING/ ROUNDNESS	mod. well sorted subround mod. well sorted subround
CARBONATE%	+++ +++ +++
FOSSILS	urchine spine forams
SEDIMENTARY STRUCTURES	<---------------------------¦ fining up
REMARKS	2mm olive mud drape medium grained carbonate sand, 90% iron stained carbonate 5% clear quartz, angular 5% lithics similar composition down core, but coarsens to a coarse sand/gravel beautiful fining up sequence!

LOG SHEET	CORE NO- 024 SPLIT- 19/9/92 T-NO. B-NO.
SITE- 19	TIME- 2109 LGTH- 145cm Lat- 33 58.50 Long- 151 29.29 DATE- 18/9/92 DEPTH- 148m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/3 5YR 3/4
SORTING/ ROUNDNESS	moderate/well subround/angular poorly sorted poorly sorted angular
CARBONATE%	++ ++ ++ +++ +++
FOSSILS	foraminifera sponge spicules Worm tubes foraminifera rugose coral
SEDIMENTARY STRUCTURES	<-------------- fining upwards ¦ ¦¦¦ ¦¦¦
REMARKS	3mm mud drape fine sand, 5% mud, organic rich, 5% lithics, 60% carbonate, 30% well rounded, non-ironstained quartz. Coarser, Fe stained quartz, medium and well rounded. 5% lithics, ~1% mud, 50% quartz, 35% carbonate, large gravel sized shell fragments derived from gastropods and worm tubes. Very coarse shell hash, horizontally oriented shell fragments up to 50mm with small amount of well rounded ironstained, medium to coarse grained quartz (< 2%). Pectin remains predominate, very angular, pink and white. Gastropods, both fragments and whole. Echinoid remains, clearly identifiable spines and plates. Bivalves, bryozoans, encrusting coralline algae, sand dollars and rugose coral.

LOG SHEET CORE NO- 024 SPLIT- 19/9/92 T-NO. B-NO.

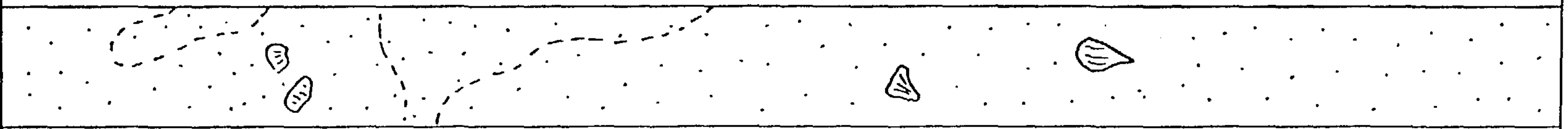
SITE- 19 TIME- 2109 LGTH- 145cm Lat- 33 58.50 Long- 151 29.29 DATE- 18/9/92 DEPTH- 148m

LENGTH (MM)	1300 1400	1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE		
VISUAL LOG		
COLOR		
SORTING/ ROUNDNESS	poorly sorted angular	
CARBONATE%	+++	
FOSSILS	rugose coral	
SEDIMENTARY STRUCTURES		
REMARKS	lumps of cemented carbonate at base of core	

LOG SHEET	CORE NO- 025 SPLIT- 25 SEPT 1992 T-NO. B-NO.
SITE- WB 17 TIME- 0157	LGTH- 268cm Lat- 33 59.87 Long- 151 21.03 DATE- 19/9/92 DEPTH- 103m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 3/2 5Y 4/2 5Y 3/2 10YR 3/2
SORTING/ ROUNDNESS	mod. sorted subround/subangular poorly sorted subangular mod. sorted subround/subangular
CARBONATE%	++ ++ ++ ++ ++
FOSSILS	pectin bivalve forams, Bryozoa, bivalves echinoid spines
SEDIMENTARY STRUCTURES	
REMARKS	2mm mud drape 0 - 35cm medium, moderately sorted quartz sand. 80% quartz , 15% carbonate 5% lithics, minor iron staining. 35cm - 100cm medium/coarse quartz, minimal iron staining 80% quartz, 5% carbonate, 10% lithics 100 - 120cm fine quartz sand, 80% quartz sand, 15% carbonate, 5% lithics light iron staining of carbonate 105cm large bivalve(4cm)

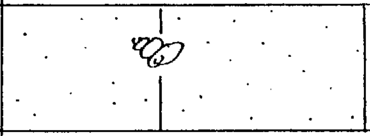
LOG SHEET CORE NO- 025 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB 17 TIME- 0157 LGTH- 268cm Lat- 33 59.87 Long- 151 21.03 DATE- 19/9/92 DEPTH- 103m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	10YR 3/2 10YR 2/2 10YR 5/2 10YR 3/2 10YR 3/2
SORTING/ ROUNDNESS	mod. well sorted subangular/angular poorly sorted subround/subangular mod. poorly sorted subround/subangular mod. well sorted subangular
CARBONATE%	++ ++ ++ ++
FOSSILS	forams bivalves bivalves
SEDIMENTARY STRUCTURES	
REMARKS	120 - 150cm fine quartz sand, 80% quartz, 15% carbonate, 5% lithics light iron staining of carbonate 150 - 170cm fine/medium quartz sand, large shell fragments - gastropods 80% quartz, 15% carbonate, 5% lithics 170 - 200cm fine/medium quartz sand, 75% quartz, 15% carbonate, 10% lithics trace mud , and mottled 205cm large bivalves 200 - 240cm as 170 - 200cm but slightly finer

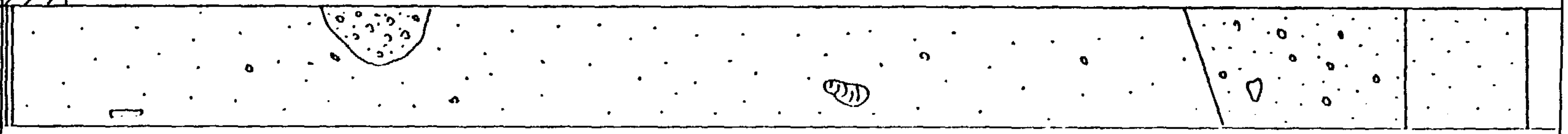
LOG SHEET CORE NO- 025 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB17 TIME- 0157 LGTH- 268CM Lat- 33 59.87 Long- 151 21.03 DATE- 19/9/92 DEPTH- 103M

LENGTH (MM)	2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500
SUB-SAMPLE	
VISUAL LOG	
COLOR	10YR 3/2 2.5YR 3/2
SORTING/ ROUNDNESS	mod. poor sorting subangular/angular
CARBONATE%	++ ++
FOSSILS	echinoid spine gastropod
SEDIMENTARY STRUCTURES	
REMARKS	240 - 255cm fine/medium quartz sand, 1% quartz gravel, some minor iron staining 250cm large gastropod 250 - 268cm fine quartz sand, 80% quartz, 10% lithics, 10% carbonate, trace mud

LOG SHEET CORE NO- 027 SPLIT- 21 Sept 1992 T-NO. B-NO.

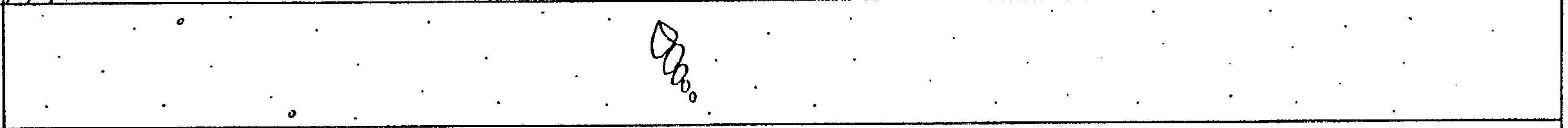
SITE- WB17 TIME- 0246 LGTH- 118cm Lat- 33 59.86 Long- 151 20.99 DATE- 19/9/92 DEPTH- 102m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/3 5Y 6/4 5Y 4/3 5Y 5/3 5Y 6/4 5Y 4/1
SORTING/ ROUNDNESS	mod. well sorted subangular/subround poorly sorted mod. angular/subangular mod. well sorted subround
CARBONATE%	++ ++ ++ +++ ++
FOSSILS	worm tubes forams forams sponge spicules bivalve gastropods, forams sponge spicules
SEDIMENTARY STRUCTURES	
REMARKS	5mm olive mud drape 0.5 - 90cm fine/medium quartz sand, 75% quartz (50% non iron stained), 5% lithics 15% carbonate, 5% organic mud 90 - 108cm med/coarse quartz sand, 40% carbonate, 60% non iron stained quartz 108 - 118cm fine quartz sand, 60% non iron stained quartz, 30% carbonate 10% lithics Carbonate content increases downcore to 108cm.

1/34

LOG SHEET CORE NO- 030 SPLIT- 24 Sept 1992 T-NO. B-NO.

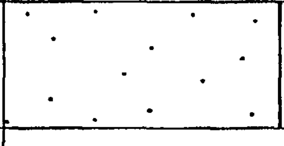
SITE- WB16 TIME- 0905 LGTH- 142cm Lat- 33 59.81 Long- 151 17.06 DATE- 19/9/92 DEPTH- 80.8m

LENGTH (MM)		100	200	300	400	500	600	700	800	900	1000	1100
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR	5Y 3/1							5Y 4/2				
SORTING/ ROUNDNESS	poorly sorted subround								mod. poorly sorted subround			
CARBONATE%	+				++				++			+++
FOSSILS	worm tubes forams					Gastropod					forams	
SEDIMENTARY STRUCTURES												
REMARKS	no mud drape fine/medium quartz sand 60% non iron stained quartz 20% carbonate 10% lithics 10% mud consistant compositionally downcore, but slightly fines to 100cm.											

11/35

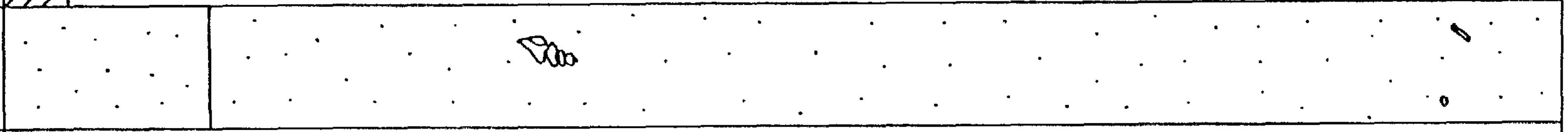
LOG SHEET CORE NO- 030 SPLIT- 24 Sept 1992 T-NO. B-NO.

SITE- WB16 TIME- 0905 LGTH- 142 Lat- 33 59.81 Long- 151 17.06 DATE- 19/9/92 DEPTH- 80.8m

LENGTH (MM)	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SUB-SAMPLE											
VISUAL LOG											
COLOR	5Y 3/2										
SORTING/ ROUNDNESS	poorly sorted subround/subangular										
CARBONATE%	+++										
FOSSILS	forams										
SEDIMENTARY STRUCTURES											
REMARKS	fine to coarse quartz sand, 70% quartz, 30% carbonate non-iron stained.										

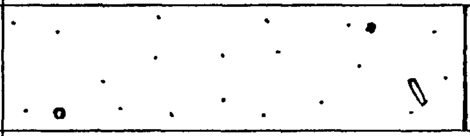
LOG SHEET CORE NO- 032 SPLIT- 24/9/92 T-NO. B-NO.

SITE- 16 TIME- 0951 LGTH- 155cm Lat- 33 59.80 Long- 151 17.10 DATE- 19/9/92 DEPTH- 81.3

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 2/2 5Y 4/2 5Y 4/2
SORTING/ ROUNDNESS	moderate angular/subangular moderate/well angular/subangular poor subangular
CARBONATE%	+ ++ ++ ++ ++
FOSSILS	foraminifera echinoid spines foraminifera, gastropods, coral, echinoid spines, sponge spicules
SEDIMENTARY STRUCTURES	
REMARKS	0-15cm fine to medium quartz sand. Extremely porous. No iron staining. 45% quartz, 35% lithics, 15% mud, 5% carbonate. 15-120cm fine to medium quartz sand. No iron staining. Lighter in colour than surface 0-15cm. 80% quartz, 15% carbonate, 5% lithics.

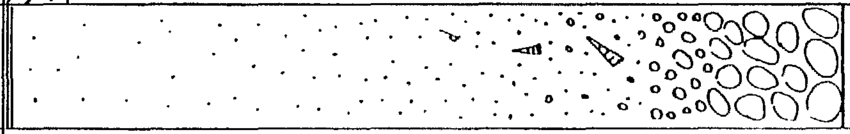
LOG SHEET CORE NO- 032A SPLIT- 24/9/92 T-NO. B-NO.

SITE- 16 TIME- 0951 LGTH- 155cm Lat- 33 59.8 Long- 151 17.10 DATE- 19/9/92 DEPTH- 81.3m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300		
SUB-SAMPLE			
VISUAL LOG			
COLOR	5Y 4/2		
SORTING/ ROUNDNESS	poor subangular		
CARBONATE%	+++	+++	
FOSSILS	bivalves wormtubes	bivalves wormtubes	
SEDIMENTARY STRUCTURES			
REMARKS	120-155cm fine to medium quartz sand 50% quartz, 30% carbonate, 10% mud and 10% lithics. No iron staining.		

LOG SHEET CORE NO- 034 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB15 TIME- 1441 LGTH- 63cm Lat- 33 48.66 Long- 151 21.08 DATE- 19/9/92 DEPTH- 66.1m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5Y 3/1 4/2
SORTING/ ROUNDNESS	mod. sorting mod. well sorted mod. well sorted subangular angular rounded/angular
CARBONATE%	+++ +++ +++ +++
FOSSILS	forams, echinoid spines bryozoans, bivalves sponge spicules gastropods
SEDIMENTARY STRUCTURES	<---------------------------------------¦ fining up
REMARKS	4mm mud drape fine carbonate sand, 75% carbonate, 20% quartz, trace mud, trace lithics some iron staining 20 - 40cm biogenic debris (bryozoan, bivalve, gastropod) 2mm to 10mm in size 50cm mud ball 40 - 63cm biogenic shell debris plus rounded river pebbles large gravel to 50mm.

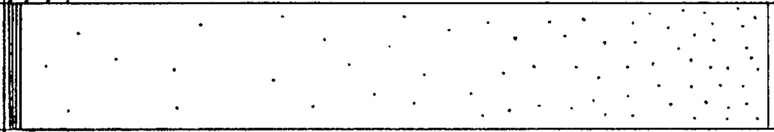
11/34

LOG SHEET CORE NO- 035 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB15 TIME- 1458 LGTH- 14cm Lat- 33 48.66 Long- 151 21.07 DATE- 19/9/92 DEPTH- 65.5m

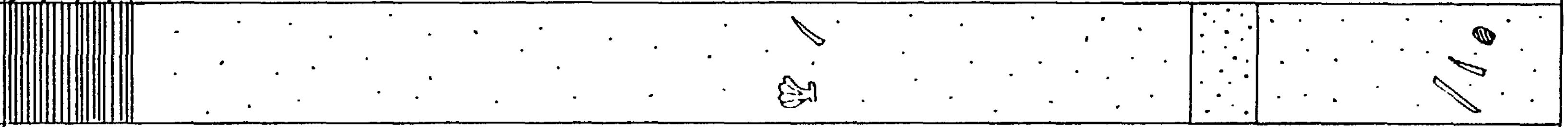
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/1
SORTING/ ROUNDNESS	mod. well sorted subround/angular
CARBONATE%	+++ +++
FOSSILS	forams, sponge spicules gastropods, bivalves, worm tubes.
SEDIMENTARY STRUCTURES	
REMARKS	2mm mud drape fine calcarous sand, 90% carbonate, 5% clear, non-iron stained quartz 5% lithics, trace mud.

1140

LOG SHEET CORE NO- 037 SPLIT- 20/9/92	T-NO. B-NO.
SITE- 14 TIME- 2026 LGTH- 58cm Lat- 33 48.66 Long- 151 25.08	DATE- 19/9/92 DEPTH- 110m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/3 generally olive grey 5Y 5/2
SORTING/ ROUNDNESS	moderate to poor sorting throughout, angular grains.
CARBONATE%	+++ +++ +++
FOSSILS	sponge spicules, echinoid spines, foraminifera.
SEDIMENTARY STRUCTURES	<------------------------------------¦ fining upwards
REMARKS	0-1.5cm mud drape. 1.5-45cm very fine grained muddy sand. Noticeable absence of foraminifera, mud appears organic rich. Carbonate angular. Carbonate 70%, mud 20%, quartz 5%, lithics 5%. 45-58cm medium to fine sand, carbonate component coarser than in upper 45cm. Carbonate 85%, quartz 5%, mud 5%, lithics 5%. N.B. The core was capped at 1305, 20/9/92 after being allowed to settle for one day. When split at 1340 the same day a 300mm void at the core top was observed. Core length was taken from the bottom of the void and measured 58cm. Original capped length was 87cm. On splitting surface of core appeared disturbed.

LOG SHEET CORE NO- 038 SPLIT- 26/9/92 T-NO. B-NO.

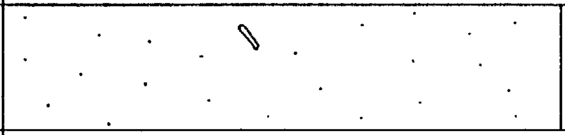
SITE- 14 TIME- 1052 LGTH- 162cm Lat- 33 48.64 Long- 151 25.08 DATE- 19/9/92 DEPTH- 110m

LENGTH (MM)	100	200	300	400	500	600	700	800	900	1000	1100	
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR	5Y 4/2			5Y 4/2						10YR 6/3		5Y 4/2
SORTING/ ROUNDNESS	moderate angular/subangular									moderate subangular		
CARBONATE%	+			++			++		++			++
FOSSILS							pectin scaphopod			scaphopod, worm tubes, bivalves		
SEDIMENTARY STRUCTURES												
REMARKS	0-10cm mud drape. 10-90cm fine quartz sand. 50% quartz, 40% carbonate, 5% lithics and 5% mud. Large pectin shell and scaphopods at 60cm. 90-95cm partially cemented fine to medium quartz sand. 70% quartz, 25% carbonate, 5% milky white mud. This 5cm band of sediment has a distinct yellow appearance. 95-120cm fine sandy mud. 30% mud, 30% carbonate, 30%fine quartz sand, 10% lithics.												

1/42

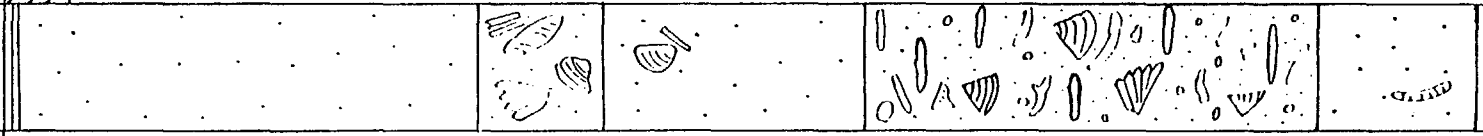
LOG SHEET CORE NO- 038A SPLIT- 26/9/92 T-NO. B-NO.

SITE- 14 TIME- 1052 LGTH- 162cm Lat- 33 48.64 Long- 151 25.08 DATE- 19/9/92 DEPTH- 110m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/2
SORTING/ ROUNDNESS	moderate subangular
CARBONATE%	++ ++
FOSSILS	worm tubes foraminifera
SEDIMENTARY STRUCTURES	
REMARKS	120-162cm fine sandy mud. 30% mud, 30% carbonate, 30% quartz and 10% lithics.

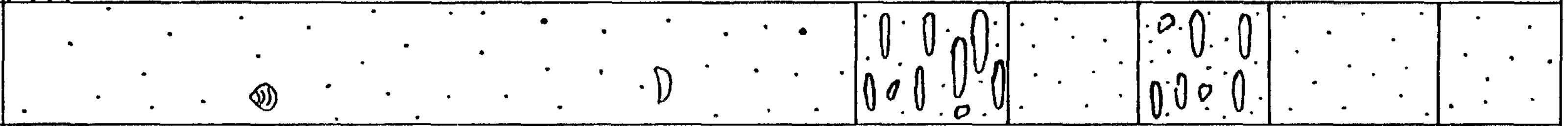
LOG SHEET CORE NO- 039 SPLIT- 19 SEPT 1992 T-NO. B-NO.

SITE- WB13 TIME- 2247 LGTH- 107.5cm Lat- 33 48.65 Long- 151 28.46 DATE- 19/9/92 DEPTH- 125m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 3/2 5Y 4/1
SORTING/ ROUNDNESS	poorly sorted subangular/angular poorly sorted subangular/well rounded
CARBONATE%	+ +++ +++ +
FOSSILS	forams pectins, bivalves forams pectins, bivalves, gastropods urchine spines, forams
SEDIMENTARY STRUCTURES	||| |||
REMARKS	20mm olive mud drape 0 - 35cm fine olive quartz sand, 50% fine subangular, non-iron stained quartz 30% subangular, iron stained carbonate, 15% fine organic rich mud 5% glauconite filled foram tests. 15% fine organic rich mud 35 - 45cm shelly band, consisting of bivalve and pectin fragments 45 - 64cm medium/fine sand, 50% fine, non-iron stained, subangular quartz 50% medium, well rounded, lightly iron stained carbonate trace fines and glauconite filled foram tests. 64 - 95cm poorly sorted carbonate rich sandy/gravel, 90% gravel to fine sand sized angular carbonate, 10% fine well rounded quartz sand, trace mud abundant forams 95 - 107.5cm medium/coarse carbonate rich sand. 60% coarse carbonate (30% forams) 15% glauconite filled foram tests. 10-15% mud, 10% very fine quartz no iron staining

LOG SHEET CORE NO- 040 SPLIT- 25/9/92 T-NO. B-NO.

SITE- 13 TIME- 2306 LGTH- 136cm Lat- 33 48.66 Long- 151 28.47 DATE- 19/9/92 DEPTH- 124m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/2 5Y 4/1 5Y 4/1 5Y 4/1 5Y 3/1
SORTING/ ROUNDNESS	poor angular/subangular poor subrounded/subangular moderate/well subangular
CARBONATE%	++ ++ ++ +++ +++ +++
FOSSILS	worm tubes bivalve bivalve gastropods pectin echinoid spines foraminifera
SEDIMENTARY STRUCTURES	¦¦¦ ¦¦¦ ¦¦¦ ¦¦¦ ¦
REMARKS	0-65cm fine to coarse carbonate sand. 50% carbonate, 20% quartz, 20% mud, 10% lithics. Egg shaped mud balls of about 0.5mm in size scattered throughout this facies. May be faecal pellets? 65-95cm fine to coarse quartz sand. Some iron staining of carbonate component. 50% quartz, 40% carbonate, 10% lithics. Some large shell fragments scattered between 65-75cm and 85-95cm. 95-100cm fine to medium quartz sand. 60% quartz, 30% carbonate and 10% lithics. 100-109cm fine to medium quartz sand. 70% quartz, 20% carbonate and 10% lithics. 109-120cm fine to coarse quartz sand. 50% quartz, 30% carbonate, 10% lithics and 10% mud. Poorly sorted, subangular to subrounded material.

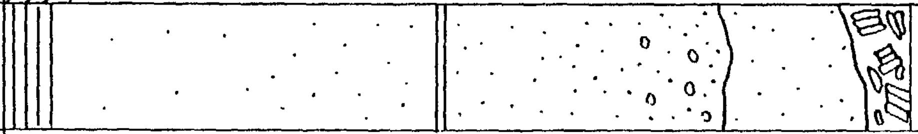
LOG SHEET CORE NO- 040A SPLIT- 25/9/92 T-NO. B-NO.

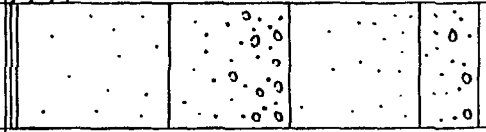
SITE- 13 TIME- 2306 LGTH- 136cm Lat- 33 48.66 Long- 151 28.47 DATE- 19/9/92 DEPTH- 124

LENGTH (MM)	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SUB-SAMPLE											
VISUAL LOG	⁘										
COLOR	5Y 4/1										
SORTING/ ROUNDNESS	poor subangular										
CARBONATE%	+++										
FOSSILS	forams.										
SEDIMENTARY STRUCTURES	¦¦										
REMARKS	120-138cm fine to medium carbonate sand. 50% carbonate, 20% quartz, 20% mud and 10% lithics.										

LOG SHEET CORE NO- 042 SPLIT- 24 SEPT 1992 T-NO. B-NO.

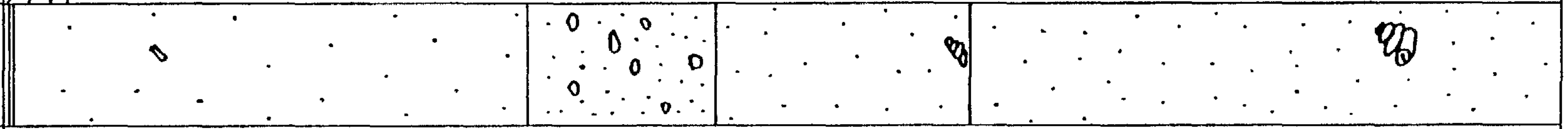
SITE- WB10 TIME- 0134 LGTH- 69cm Lat- 33 48.65 Long- 151 38.60 DATE- 21/9/92 DEPTH- 148m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 6/3 10YR 5/3 5Y 6/3 5Y 5/1-2
SORTING/ ROUNDNESS	very well sorted subangular poorly sorted angular/subangular
CARBONATE%	+++ +++ +++ +++
FOSSILS	gastropods, forams molluscs bivalves, coral forams, pectins
SEDIMENTARY STRUCTURES	<------------------------------------¦ fining up
REMARKS	40mm mud drape 4 - 35cm well sorted, medium carbonate sand, 60% iron stained carbonate 30% iron coated quartz, 10% lithics, trace mud 35cm white clay/sand band 35 - 55cm fine/coarse sand, 90% carbonate, 5% lithics, 5% mud, no quartz 55 - 63cm fine/coarse carbonate sand, 95% iron stained carbonate, 5% mud 63 - 69cm cemented carbonate blocks and coarse pectin fragments.

LOG SHEET	CORE NO- 043 SPLIT- 25/9/92 T-NO. B-NO.
SITE- 10	TIME- 0156 LGTH- 36.5cm Lat- 33 48.66 Long- 151 38.60 DATE- 21/9/92 DEPTH- 149m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	2.5Y 10YR 10YR 10YR 4/2 3/3 4/4 4/3
SORTING/ ROUNDNESS	well poor well well
CARBONATE%	+++ +++ +++ +++
FOSSILS	foraminifera sponge spicules
SEDIMENTARY STRUCTURES	<---------------¦<--------¦ fining ¦ fining ¦
REMARKS	2mm thick mud drape on surface of core. 0.2-13cm fine carbonate sand. 60% carbonate, 30% quartz, 10% lithics. Well sorted, subangular to subrounded. 13-22cm medium to coarse carbonate sand. 90% carbonate, 9% quartz, 1% lithics. Poorly sorted, angular to subangular. 22-32cm fine carbonate sand. 70% carbonate, 20% quartz, 10% lithics. Well sorted, angular to subangular. 32-36.5cm medium to coarse carbonate sand. 90% carbonate, 9% quartz, 1% lithics. Well sorted, angular to subangular.

LOG SHEET CORE NO- 045 SPLIT- 24 SEPT 1992 T-NO. B-NO.

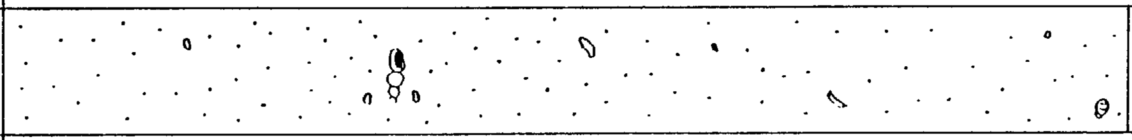
SITE- WB9 TIME- 0205 LGTH- 202cm Lat- 33 48.67 Long- 151 41.98 DATE- 21/9/92 DEPTH- 182m

LENGTH (MM)		100	200	300	400	500	600	700	800	900	1000	1100
SUB-SAMPLE	▨											
VISUAL LOG												
COLOR	5Y 5/2	5Y 4/2				10YR 4/3	5Y 6/3			5Y 4/1		5Y 4/1
SORTING/ ROUNDNESS	poorly sorted subround/subangular			poorly sorted angular/subangular			mod. sorted subangular/angular					
CARBONATE%	++			++			++		+			+
FOSSILS	sponge spicules, forams, molluscs, bryozoa worm tubes, bivalves, coral, gastropods									forams, gastropods sponge spicules, bivalves		
SEDIMENTARY STRUCTURES				¦¦¦				¦¦¦				
REMARKS	2mm mud drape 0.5 - 40cm medium/coarse iron stained carbonate sand 10% quartz, 80% carbonate, 8% lithics, 2% mud, light iron staining. 40 - 55cm coarse sand/gravel 95% carbonate, 4% quartz, 1% lithics 55 - 73cm fine/medium carbonate sand, minor iron staining 90% carbonate, 10% quartz 73 - 120cm fine/medium carbonate rich sand, 70% carbonate, 5% lithics, 20% mud 5% quartz.											

1144

LOG SHEET CORE NO- 045 SPLIT-24 SEPT 1992 T-NO. B-NO.

SITE- WB9 TIME- 0205 LGTH- 202cm Lat- 33 48.67 Long- 151 41.98 DATE- 21/9/92 DEPTH- 182m

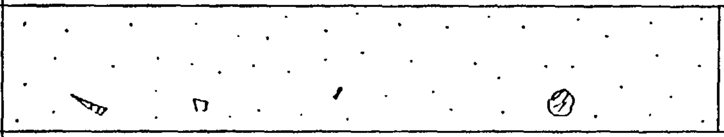
LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/1 … 5Y 4/1
SORTING/ ROUNDNESS	moderately sorted subround poorly sorted subangular/angular
CARBONATE%	+++ +++ +++
FOSSILS	echnoids, sponge spicules worm tubes, large gastropod. echnoid spines, forams gastropods, coral
SEDIMENTARY STRUCTURES	
REMARKS	fine/medium quartz sand, 50% quartz, 15% mud, 5% lithics, 20% carbonate slight iron staining of some quartz grains grades to; fine/medium carbonate sand, 75% carbonate, 10% quartz, 15% mud. foram rich

1/50

LOG SHEET CORE NO- 046 SPLIT- 26/9/92 T-NO. B-NO.	
SITE- 9 TIME- 0225 LGTH- 174cm Lat- 33 48.66 Long- 151 41.98 DATE- 21/9/92 DEPTH- 182m	
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/1 10YR 4/4 5Y 4/2
SORTING/ ROUNDNESS	moderate/poor subrounded moderate/poor subangular/angular moderate/poor subrounded/subangular
CARBONATE%	+++ +++ +++ +++
FOSSILS	foraminifera, sponge spicules, echinoid spines gastrpods, foraminifera bryozoa, echinoid spines foraminifera, sponge spicules, echinoid spines
SEDIMENTARY STRUCTURES	<------- fining
REMARKS	0-1cm olive coloured mud drape. 1-30cm fine to medium carbonate sand. Foraminifera rich. 80% carbonate, 10% quartz, 5% lithics, 5% mud. Quartz weakly ironstained. 30-80cm medium carbonate sand. Carbonate weakly iron stained. 80% carbonate, 10% quartz, 5% lithics, 5% white clay. 80-120cm muddy, silty, fine quartz sand. 40% quartz, 35% carbonate, 15% mud and 10% lithics. Carbonate weakly iron stained.

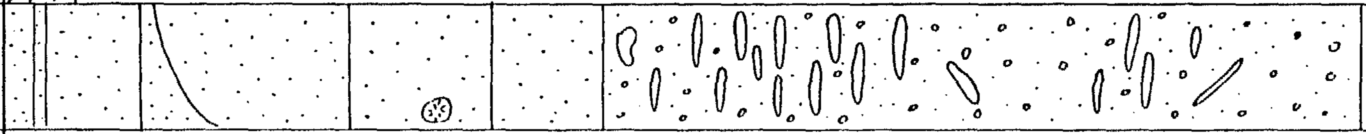
LOG SHEET CORE NO- 046A SPLIT- 26/9/92 T-NO. B-NO.

SITE- 9 TIME- 0225 LGTH- 174cm Lat- 33 48.66 Long- 151 41.98 DATE- 21/9/92 DEPTH- 182m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 5/1 5Y 5/1
SORTING/ ROUNDNESS	moderate/poor subround/subangular moderate/well subrounded
CARBONATE%	+++ +++ +++
FOSSILS	gastropods, foraminifera, bivalves, echinoid spines, sponge spicules.
SEDIMENTARY STRUCTURES	
REMARKS	120-140cm fine to medium carbonate sand. 60% carbonate, 35% quartz, 5% lithics and a trace of mud. Little or no iron staining. Scattered shell fragments. 140-174cm fine carbonate sand . 60% carbonate, 35% quartz, 5% lithics and a mud trace. Sediment generally finer than 120-140cm section with larger carbonate fragments missing.

LOG SHEET CORE NO- 047 SPLIT- 24 SEPT 1992 T-NO. B-NO.

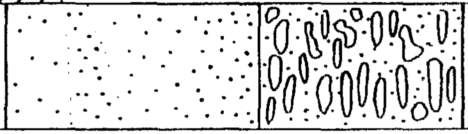
SITE- WB8 TIME- 0522 LGTH- 100cm Lat- 33 37.45 Long- 151 47.16 DATE- 21/9/92 DEPTH- 146m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 6/2 5YR 6/2 10YR 7/3 10YR 4/4
SORTING/ ROUNDNESS	Mod. sorted subangular/subround poorly sorted subangular/subround poorly sorted subangular/subround
CARBONATE%	+++ +++ +++ +++ +++ +++
FOSSILS	forams pectins forams forams, coral echinoid spines pectins, coral forams
SEDIMENTARY STRUCTURES	||| ||| |||
REMARKS	0 - 3cm fine/medium carbonate sand, 80% iron stained carbonate, 10% quartz, 10% mud (10YR 6/2) 3 - 4cm medium/coarse carbonate sand, 80% carbonate, 20% quartz (10YR 4/3) 10 - 15cm fine/medium carbonate sand, 90% carbonate, 10% quartz (5Y 4/1) 30 - 45cm fine/medium ironed stained carbonate sand. 90% carbonate, 5% quartz, 5% mud (10YR 7/3) 45 - 100cm medium/coarse carbonate sand/gravel, 25% quartz, 75% carbonate carbonate cemented together to form coarse 1 - 2mm particles

LOG SHEET	CORE NO- 048	SPLIT- 24 SEPT 1992	T-NO.	B-NO.

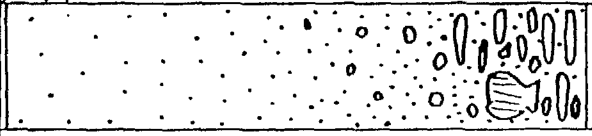
SITE- WB8	TIME- 0541	LGTH- 109.5cm	Lat- 33 37.45	Long- 151 47.19	DATE- 21/9/92	DEPTH- 146m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/3 5Y 6/2 5Y 6/2 10YR 5/8 5Y 6/2
SORTING/ ROUNDNESS	mod. sorted subround/subangular mod. poorly sorted subround/subangular poorly sorted subround/subangular
CARBONATE%	++ ++ +++ +++ +++
FOSSILS	forams bryozoa molluscs
SEDIMENTARY STRUCTURES	
REMARKS	2mm mud drape 0 - 45cm fine/medium carbonate sand, 85% carbonate, 10% lithics, 5% quartz trace mud, non/weakly iron stained, mineralised forams Three pale bands, 5 - 6cm, 30 - 31cm, 40 - 41cm (5Y 6/2) 80% carbonate, up to 15% quartz, 5% lithics, and 5% white clay quartz - iron coated, and carbonate slightly iron stained. 45 - 110cm coarse sand/gravel, carbonate rich. 85% carbonate (coarser fraction) 15% quartz (finer fraction) trace lithics, trace clay

LOG SHEET	CORE NO- 049 SPLIT- 24 SEPT 1992 T-NO. B-NO.
SITE- WB7	TIME- 0638 LGTH- 35cm Lat- 33 37.45 Long- 151 43.80 DATE- 21/9/92 DEPTH- 140m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5Y 10YR 4/1 4/3 3/3
SORTING/ ROUNDNESS	Mod. poor sorting poorly sorted subangular-well round angular
CARBONATE%	+++ +++ +++
FOSSILS	forams forams, spicules, pectins scaphopod, bivalves
SEDIMENTARY STRUCTURES	<-------------¦ fining up
REMARKS	0 - 8cm very fine carbonate sand, 75% carbonate, 15% quartz, 10% lithics carbonate iron stained, no fines. Mottled layer at 8cm (5YR 4/3). 8 - 20cm same composition as above but coarser and better sorted. 20 - 35cm coarse gravel sized shell hash, mainly pectins and bivalves, minor matrix of well rounded medium quartz grains.

LOG SHEET CORE NO- 050 SPLIT- 26/9/92 T-NO. B-NO.

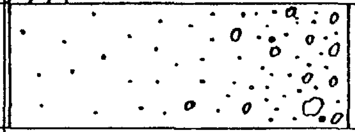
SITE- 7 TIME- 0658 LGTH- 45cm Lat- 33 37.45 Long- 151 43.80 DATE- 21/9/92 DEPTH- 140m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 5/2 10YR 4/4
SORTING/ ROUNDNESS	moderate/well angular poor subrounded
CARBONATE%	+ ++ +++ +++
FOSSILS	foraminifera, gastropods, sponge spicules, bivalves.
SEDIMENTARY STRUCTURES	<------------------------------¦ fining upwards
REMARKS	0-0.2cm mud drape. 0.2-15cm fine carbonate sand. Carbonate component weakly iron stained. 50% carbonate, 30% quartz, 10% mud and 5% lithics. 15-30cm coarse carbonate sand. Carbonate and quartz iron stained. 80% carbonate, 20% quartz. 30-45cm coarse carbonate gravel composed of shell hash, primarily pectins, bivalves, worm tubes and gastropods.

LOG SHEET CORE NO- 051 SPLIT- 25/9/92 T-NO. B-NO.

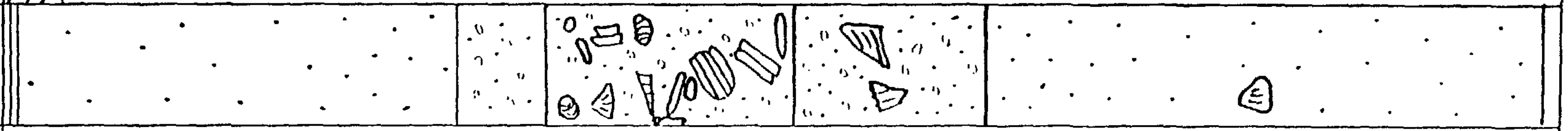
SITE- 6 TIME- 0751 LGTH- 26cm Lat- 33 37.43 Long- 151 40.48 DATE- 21/9/92 DEPTH- 134m

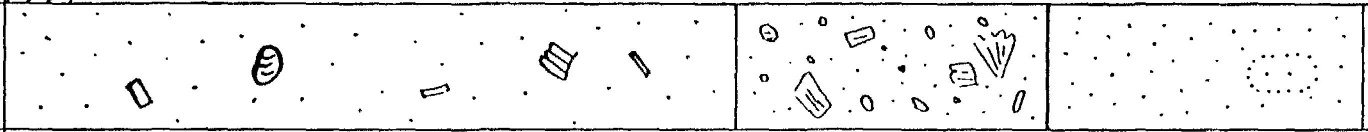
LENGTH (MM)	100	200	300	400	500	600	700	800	900	1000	1100

SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 5/3 10YR 3/3
SORTING/ ROUNDNESS	well moderate poor angular subrounded
CARBONATE%	+++ +++
FOSSILS	foraminifera sponge spicules
SEDIMENTARY STRUCTURES	<-----------------¦ fining upwards ¦
REMARKS	0.3cm mud drape at top of core. 0.3-20cm medium carbonate sand. 80% carbonate (shell fragments) 15% quartz, 5% lithics. Some iron staining of carbonates. 20-26cm medium to coarse sand. 60% carbonate (shell fragments) 30% quartz, 10% lithics. Some iron staining of carbonates.

LOG SHEET CORE NO- 052 SPLIT- 25/9/92 T-NO. B-NO.

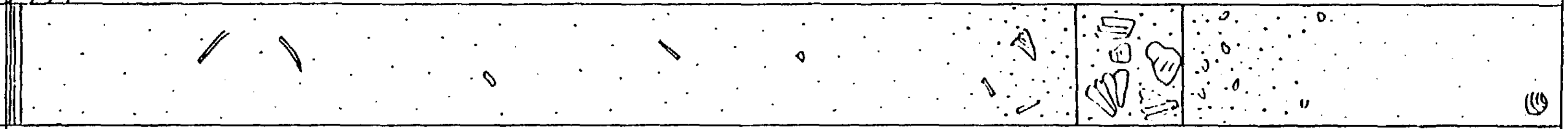
SITE- 6 TIME- 0811 LGTH- 128cm Lat- 33 37.42 Long- 151 40.48 DATE- 21/9/92 DEPTH- 134m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 7.5YR 5/4 10YR 6/3 7.5YR 5/4 10YR 5/3 5Y 4/1
SORTING/ ROUNDNESS	moderate/well subround/subangular poor angular poor angular moderate/well subrounded/subangular
CARBONATE%	+++ +++ +++ +++ +++ +++
FOSSILS	foraminifera sponge spicules pectins, bivalves gastropods foraminifera sponge spicules
SEDIMENTARY STRUCTURES	¦¦¦ ¦¦¦ ¦¦¦
REMARKS	0-2cm olive coloured mud drape. 2-35cm olive coloured muddy fine carbonate sand. 40% carbonate, 30% quartz, 20% mud, 10% lithics (sandstone fragments). Carbonate fraction composed of shell fragments. Approximately 50% of quartz fraction iron stained and well rounded. 35-43cm coarse shell grit and quartz sand matrix. 43-62cm cemented calcareous shell fragments (pectins and bivalves mainly). 62-75cm coarse shell grit as well as whole pectin and bivalve shells. Similar to the 43-62cm facies except that material is not cemented together. 75-117cm fine to medium carbonate sand. 60% carbonate composed of shell fragments and foraminifera, 30% quartz, 5% lithics and 5% mud. 30% of quartz iron stained, remainder clear. Quartz grains subrounded, carbonate grains subangular. 117-128cm fine to medium carbonate sand as for 75-117cm except that a greater percentage of lithics (20%) present and a smaller percentage of carbonate (45%). N.B. The last 8cm is absent from the visual log, but a full description is given.

LOG SHEET	CORE NO- 054 SPLIT- 24 SEPT 1992 T-NO. B-NO.
SITE- WB5	TIME- 0926.40 LGTH- 100cm Lat- 33 37.46 Long- 151 37.17 DATE- 21/9/92 DEPTH- 128m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/3 2.5Y 7/6 5Y 4/3 5Y 4/3
SORTING/ ROUNDNESS	mod. sorted subangular/angular mod. sorted subangular/angular
CARBONATE%	++ ++ +++ +++ +++
FOSSILS	worm tubes, bivalves forams, spicules, crab fragments. bryozoa, pectin, mollusc forams, molluscs; bioturb.- worm tube
SEDIMENTARY STRUCTURES	¦¦¦ ¦¦¦
REMARKS	0 - 55cm fine olive quartz muddy sand, 50% quartz - minor iron staining 25% lithics 20% mud 5% carbonate, no forams 55 - 77cm coarser and poorer sorted quartz sand; large shell fragments, coarse quartz grains (to 1mm) and large sandstone clasts in a medium quartz sand similar in composition to 0 - 55cm. 77 - 100cm coarse carbonate sand, 50% carbonate 40% quartz 10 - 15% lithics <5% mud minor iron staining 95cm worm cast, and mottled area surrounding.

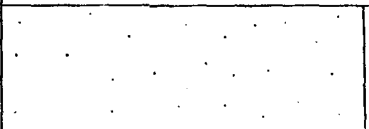
LOG SHEET	CORE NO- 055	SPLIT- 26/9/92	T-NO.	B-NO.

SITE- 5 TIME- 0945 LGTH- 148cm Lat- 33 37.47 Long- 151 37.18 DATE- 21/9/92 DEPTH- 128m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 2.5Y 5/2 2.5Y 5/4
SORTING/ ROUNDNESS	moderate/poor rounded angular poor angular moderate/well subrounded/ang
CARBONATE%	+ + ++ +++ +++ +++
FOSSILS	foraminifera,gastropods bryozoa, worm tubes, sponge spicules pectin,bryozoa gastropods
SEDIMENTARY STRUCTURES	<--------| fining |------> fining
REMARKS	0-1.5cm mud drape, very high water content. 1.5-82cm muddy fine sand. 30% quartz, 20% carbonate, 20% lithics and 30% organic rich mud. Presence of mica-like fragments. Carbonate consists of angular shell fragments and foraminifera. 30% Of the quartz is iron stained and well rounded, the remainder is angular and free of iron staining. 82-88cm coarse shelly gravel band. Very coarse grains of sandstone conglomerate and glauconite filled foraminifera tests. Quartz in this band consists of medium sand, 30% is clear and angular, 70% is more rounded and iron stained. 88-120cm fine to medium quartz sand. 70% quartz, 25% lithics, 5% carbonate. Carbonate component made up of shell fragments. Some minor iron staining of quartz. No mud.

LOG SHEET CORE NO- 055A SPLIT- 26/9/92 T-NO. B-NO.

SITE- 5 TIME- 0945 LGTH- 148cm Lat- 33 37.47 Long- 151 37.18 DATE- 21/9/92 DEPTH- 128m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	2.5Y 5/4
SORTING/ ROUNDNESS	moderate/well subround/angular
CARBONATE%	++ ++
FOSSILS	foraminifera sponge spicules
SEDIMENTARY STRUCTURES	
REMARKS	120-148cm fine to medium quartz sand. 70% quartz, 25% lithics, 5% carbonate. Carbonate component made up of shell fragments. Glauconite filled foraminifera tests occur. Some minor iron staining of quartz. No mud.

LOG SHEET CORE NO- 056 SPLIT- 26 Sept 1992 T-NO. B-NO.

SITE- WB 4 TIME- 1032.50 LGTH-129 Lat- 33 37.48 Long- 151 33.86 DATE- 21/9/92 DEPTH- 118

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/2
SORTING/ ROUNDNESS	Mod. sorted subangular/subround Mod.sorted Subangular/subround
CARBONATE%	+ + + + +
FOSSILS	Forams
SEDIMENTARY STRUCTURES	<-- Fining up
REMARKS	0-10cm silty mud, visible lithics and carbonate material-20%, remainder mud. 10-100cm fine to medium quartz sand 70% quartz 20% carbonate 10% lithics Mud-balls 0.5mm in size

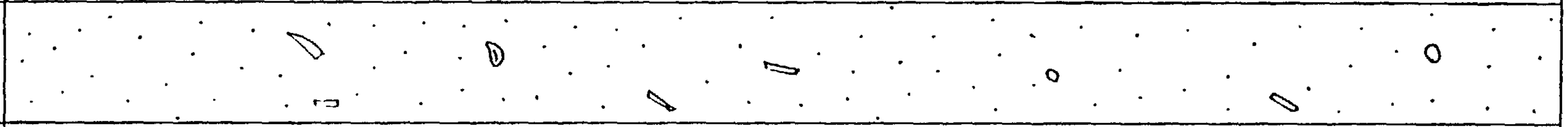
LOG SHEET CORE NO- 056 SPLIT- 26 Sept 1992 T-NO. B-NO.

SITE-WB 4 TIME- 1032.50 LGTH-129CM Lat- 33 37.48 Long- 151 33.86 DATE- 21/9/92 DEPTH- 118

LENGTH (MM)	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SUB-SAMPLE											
VISUAL LOG											
COLOR	5Y 4/2										
SORTING/ ROUNDNESS	Mod sorted subangular/subround										
CARBONATE%	++										
FOSSILS	Forams										
SEDIMENTARY STRUCTURES	-----¦										
REMARKS	Fine to medium quartz sand 70% quartz 20% carbonate 10% lithics Mud balls to 0.5cm Core Bottom 129.0cm										

LOG SHEET CORE NO- 057 SPLIT- 25/9/92 T-NO. B-NO.

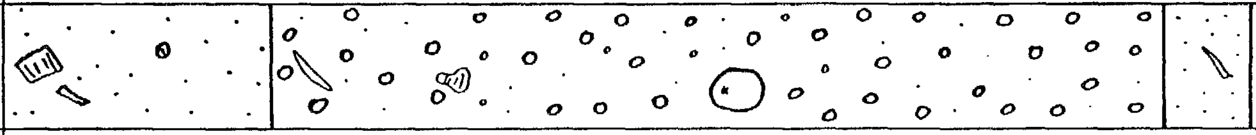
SITE- 4 TIME- 1053 LGTH- 211.5cm Lat- 33 37.46 Long- 151 33.89 DATE- 21/9/92 DEPTH- 118m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/1 5Y 4/1
SORTING/ ROUNDNESS	moderate angular/subrounded poor angular/subrounded well/moderate subangular/angular
CARBONATE%	+ + + + +
FOSSILS	foraminifera scaphopods worm tubes bivalves foraminifera worm tubes foraminifera bivalves sponge spicules
SEDIMENTARY STRUCTURES	
REMARKS	0-65cm muddy fine to medium quartz sand. Olive colour. Carbonate slightly iron stained, quartz not stained. 50% quartz, 40% carbonate, 5% mud and 5% lithics. Quartz well rounded while carbonate angular to subangular. 65-85cm fine to medium quartz sand. 50% quartz, 40% carbonate, 10% mud. Otherwise similar to 0-65cm. 85-115cm medium quartz sand. 50% quartz, 40% carbonate, 10% mud. carbonate slightly iron stained, angular to subangular in shape. Quartz not iron stained and well rounded in shape. 115-120cm silty fine carbonate sand. Quartz well sorted and angular in shape. Carbonate component poorly sorted and subangular. 40% carbonate, 30% quartz, 30% silt. No iron staining.

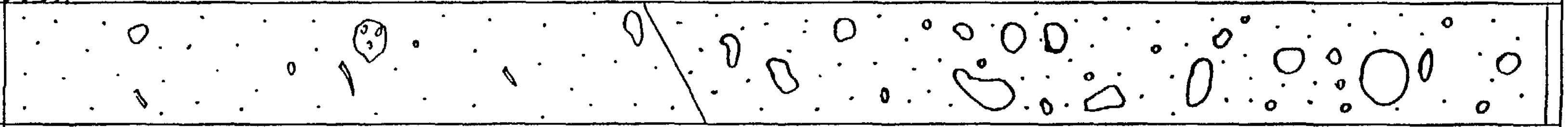
1164

LOG SHEET CORE NO- 057A SPLIT- 25/9/92 T-NO. B-NO.

SITE- 4 TIME- 1053 LGTH- 211.5cm Lat- 33 37.46 Long- 151 33.89 DATE- 21/9/92 DEPTH- 118m

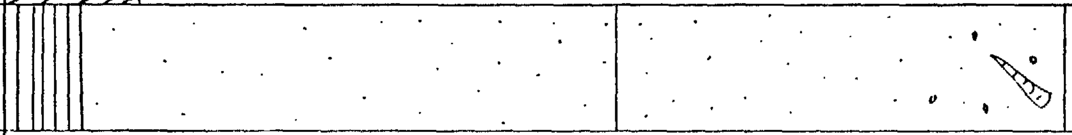
LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	5Y 4/1 5Y 4/1 5Y 4/1
SORTING/ ROUNDNESS	well/moderate angular/subangular poor rounded poor subangular
CARBONATE%	+ + ++ ++ ++ +
FOSSILS	foraminifera sponge spicules pectin bivalve crab shell sponge spicules
SEDIMENTARY STRUCTURES	¦¦ ¦¦
REMARKS	120-140cm silty fine carbonate sand. Quartz well sorted and angular in shape. Carbonate component poorly sorted and subangular. 40% carbonate, 30% quartz, 30% silt. No iron staining. 140-205cm well rounded gravel up to 4cm in diameter with average diameter of about 1cm. Gravel made up of carbonate, quartz and sandstone, all with a white clay coating. 205-211cm fine to medium quartz sand. 50% quartz, 15% poorly sorted carbonate, 15% lithics and 20% mud. Presence of mica-like material noted.

1165

LOG SHEET	CORE NO- 059 SPLIT- 25 SEPT 1992 T-NO. B-NO.
SITE- WB3	TIME- 1520 LGTH- 118.5cm Lat- 33 37.46 Long- 151 30.57 DATE- 21/9/92 DEPTH- 89.3m
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 4/2 5Y 7/3
SORTING/ ROUNDNESS	mod. poorly sorted subangular/round subangular poorly sorted well round/subangular
CARBONATE%	+ + ++ ++ ++
FOSSILS	bivalve gastropod echinoid gastropod remains
SEDIMENTARY STRUCTURES	
REMARKS	0 -50cm fine grained, olive muddy quartz sand. 65% very fine non-iron stained quartz 30% olive mud, 5% subangular carbonate, trace lithics, no forams 50 - 118.5cm large river pebbles in a coarse sandy matrix, angular/subangular, non-iron stained, sand/gravel sized quartz. Pebbles consisted of sandstones, quartzites and basalts up to 50mm in diameter.

LOG SHEET CORE NO- 060 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB3 TIME- 1552 LGTH- 78cm Lat- 33 37.46 Long- 151 30.57 DATE- 21/9/92 DEPTH- 89.5m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/2 5Y 3/2
SORTING/ ROUNDNESS	mod. poorly sorted subangular/subround poorly sorted subangular/angular
CARBONATE%	++ +++ +++ ++
FOSSILS	forams, sponge spicules worm tubes, gastropods gastropod coral
SEDIMENTARY STRUCTURES	<---| fining upwards
REMARKS	0 - 5cm olive 'fluidised' mud. 5 - 45cm olive calcarous, muddy fine sand. 10% fine sand/silt sized quartz 70% non-iron stained carbonate 10% lithics 10% mud 45 - 78cm same composition as above, but coarser and therefore more poorly sorted generally larger non-iron stained quartz and biogenic shell fragments. no fossils Note: This core was allowed to settle for several days before capping and splitting.

LOG SHEET CORE NO- 061 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB2 TIME- 1704 LGTH- 220cm Lat- 33 37.47 Long- 151 26.28 DATE- 21/9/92 DEPTH- 47.4

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 5/2(M.D.) 10YR 6/4
SORTING/ ROUNDNESS	well sorted subround
CARBONATE%	+ + + +
FOSSILS	
SEDIMENTARY STRUCTURES	
REMARKS	3mm mud drape medium, well sorted quartz sand, 95% quartz, 5% carbonate, trace lithics iron staining of carbonates only. consistant down core

1166

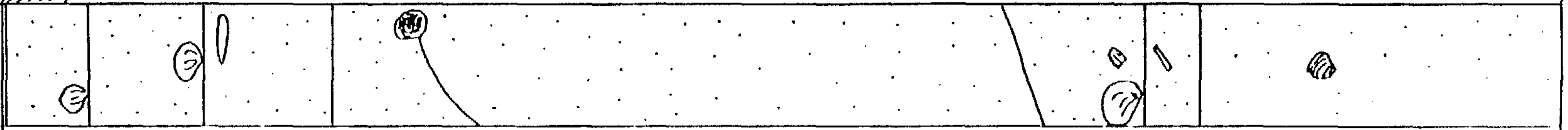
LOG SHEET CORE NO- 061 SPLIT- 25 SEPT 1992 T-NO. B-NO.	
SITE- WB2 TIME- 1704 LGTH- 220cm Lat- 33 37.47 Long- 151 26.28 DATE- 21/9/92 DEPTH- 47.4m	
LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
SUB-SAMPLE	
VISUAL LOG	
COLOR	10YR 6/4 … 10YR 6/4 · 10YR 4/3 · 10YR 6/8
SORTING/ ROUNDNESS	well sorted subangular … poor sorting round-angular … well sorted subangular
CARBONATE%	+ + + +
FOSSILS	scaphopod … pectins … pectins, bivalves gastropods
SEDIMENTARY STRUCTURES	
REMARKS	medium quartz sand to 185cm. 95% quartz, 5% carbonate, slight iron staining 185 - 195cm large shell hash. 195 - 205cm large rounded river stones of igneous origin. 205 - 220cm similar to 120 - 185cm but with iron staining. mottled.

LOG SHEET CORE NO- 062 SPLIT- 24 SEPT 1992 T-NO. B-NO.

SITE- WB2 TIME- 1718.10 LGTH- 80cm Lat- 33 37.47 Long- 151 26.28 DATE- 21/9/92 DEPTH- 57.8m

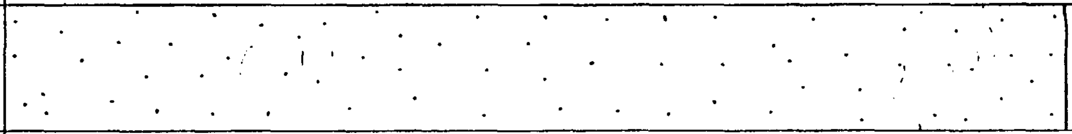
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	5Y 4/1 10YR 5/6 10YR 5/6 5Y 7/2
SORTING/ ROUNDNESS	well sorted subround well sorted subround/subangular extremely well sorted subangular/subround
CARBONATE%	++ ++
FOSSILS	echinoid spines coral gastropods, sand dollar(15cm)
SEDIMENTARY STRUCTURES	⁞⁞⁞ ⁞⁞⁞
REMARKS	1mm mud drape 0 -20cm yellow, well sorted fine/medium quartz sand 70% quartz, 30% carbonate, iron stained 20 - 50cm mottled dark patches, medium well sorted quartz sand 80% quartz, 20% carbonate 50cm large pebble 2cm in diameter 50 - 80cm well sorted medium quartz sand, 100% clean, non iron stained quartz 65cm mottling - 10YR 3/1

LOG SHEET	CORE NO- 063	SPLIT- 25 SEPT 1992	T-NO.	B-NO.	
SITE- WB1	TIME- 1826	LGTH- 198cm	Lat- 33 37.47	Long- 151 22.60	DATE- 21/9/92	DEPTH- 46.7m

LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	7.5YR 5/6 10YR 4/3 2.5YR 2/0 5Y 5/1 10YR 4/3 2.5YR 2/0 10YR 4/1
SORTING/ ROUNDNESS	well sorted sub angular mod. sorting angular well sorted subround
CARBONATE%	+ ++ ++
FOSSILS	bivalves, oyster shell bivalve
SEDIMENTARY STRUCTURES	||| ||| ||| |||
REMARKS	2mm grey mud drape 0 - 8cm medium quartz sand, non-iron stained 90% quartz, 10% carbonate trace mud, trace lithics 8 - 85cm medium/coarse quartz sand, mod. poor sorting, subangular/subround 15 - 18cm bivalves, oyster shells 30cm large pebble 2cm diameter 80 - 85cm pieces of large bivalve 90 - 100cm medium quartz sand, 95% quartz , 2% lithics, 3% mud 100 - 120cm 100% medium clear quartz sand.

LOG SHEET CORE NO- 063 SPLIT- 25 SEPT 1992 T-NO. B-NO.

SITE- WB1 TIME- 1826 LGTH- 198cm Lat- 33 37.47 Long- 151 22.60 DATE- 21/9/92 DEPTH- 46.7m

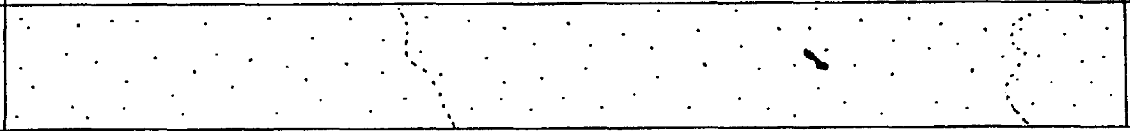
LENGTH (MM)	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SUB-SAMPLE											
VISUAL LOG											
COLOR	5Y 6/1	5Y 4/1			5Y 6/1		5Y 4/1				
SORTING/ ROUNDNESS	well sorted subangular/subround					mod. sorted subangular/subround					
CARBONATE%											
FOSSILS											
SEDIMENTARY STRUCTURES											
REMARKS	100% medium quartz sand, non iron stained. at core base trace mud, trace lithics very consistant down core with mottling at 140cm and base core barrel bent during coring										

LOG SHEET	CORE NO- 064	SPLIT- 24 Sept 1992	T-NO.	B-NO.			
SITE- WB1	TIME- 1849.1	LGTH- 202cm	Lat- 33 37.45	Long- 151 22.62	DATE- 21/9/92	DEPTH- 46m	

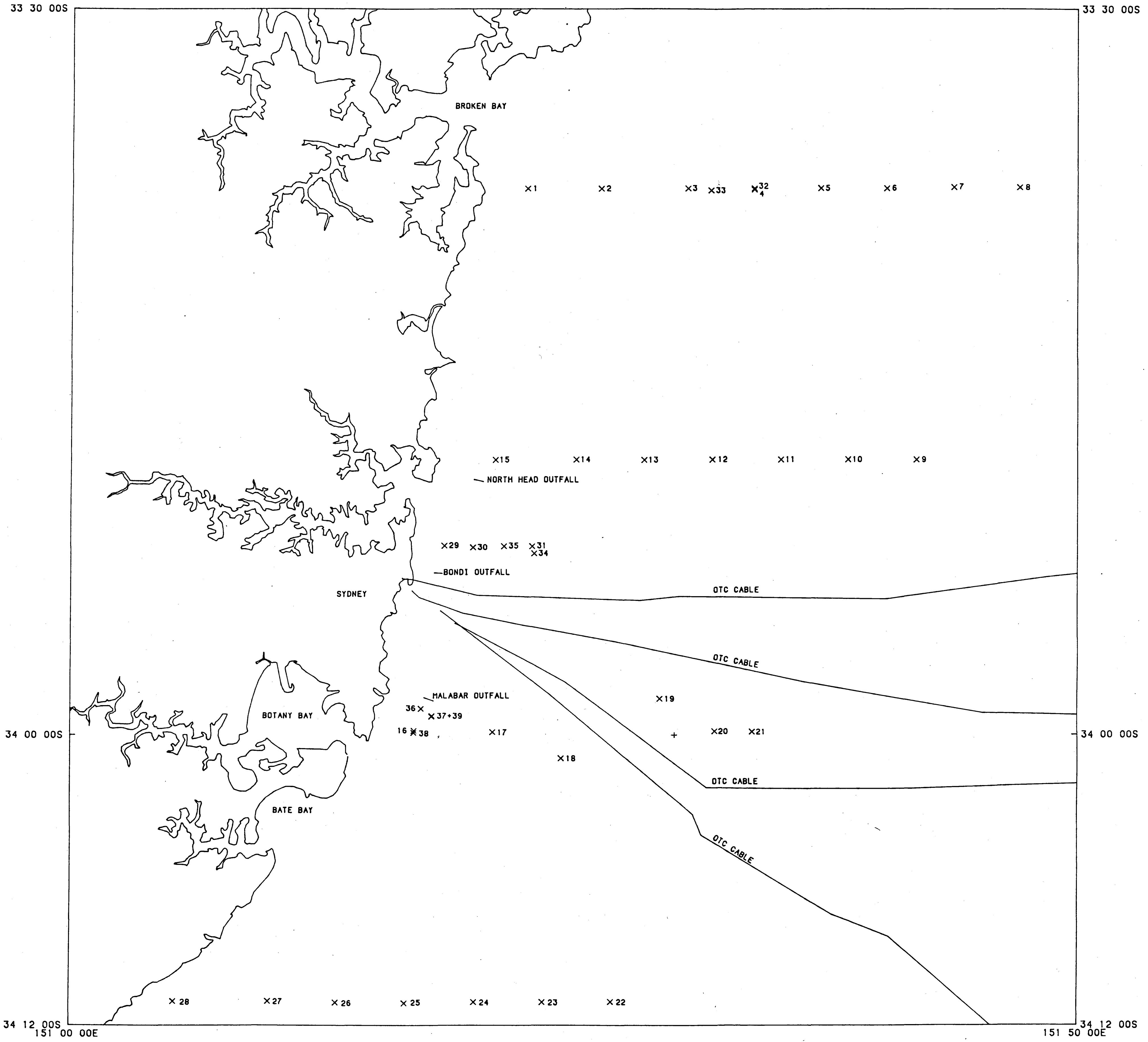
LENGTH (MM)	100 200 300 400 500 600 700 800 900 1000 1100
SUB-SAMPLE	▨
VISUAL LOG	
COLOR	10YR 3/1 10YR 5/4 10YR 6/1
SORTING/ ROUNDNESS	Mod. well sorted subangular/subround poorly sorted Angular/subangular Very well sorted Subangular/subround
CARBONATE%	+ ++
FOSSILS	Forams Molluscs Bivalves Gastropods Organic Material Organic Material
SEDIMENTARY STRUCTURES	<------------| Fining up
REMARKS	5mm olive mud cap 0.5 - 20cm medium, moderately well sorted subangular to subround quartz sand 80% iron stained quartz, 10% carbonate shell hash, 5% lithics, 5% mud 20 - 40cm Larger angular shell fragments in medium iron stained quartz sand 40 - 100cm Very well sorted medium 'clean' quartz sand, non-iron stained 99% quartz, 1% lithics (trace)

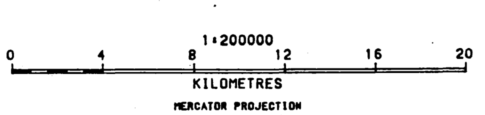
LOG SHEET CORE NO- 064 SPLIT- 24 Sept 1992 T-NO. B-NO.

SITE- WB1 TIME- 1849.10 LGTH- 202 Lat- 33 37.45 Long- 151 22.62 DATE- 21/9/1992 DEPTH- 46.0m

LENGTH (MM)	1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300		
SUB-SAMPLE			
VISUAL LOG			
COLOR	10YR 6/1	10YR 4/1	10YR 6/1
SORTING/ ROUNDNESS	Very well sorted Subangular/subround	well sorted Subangular/subround	
CARBONATE%			
FOSSILS		Organic material	
SEDIMENTARY STRUCTURES			
REMARKS	Very well sorted medium quartz sand, 99% quartz (non-iron stained), 1% lithics 150 - 190cm finer, medium quartz sand with increased mud 95% quartz, 4% mud, 1% lithics		

SWB/AGSO - SAMPLE SITES

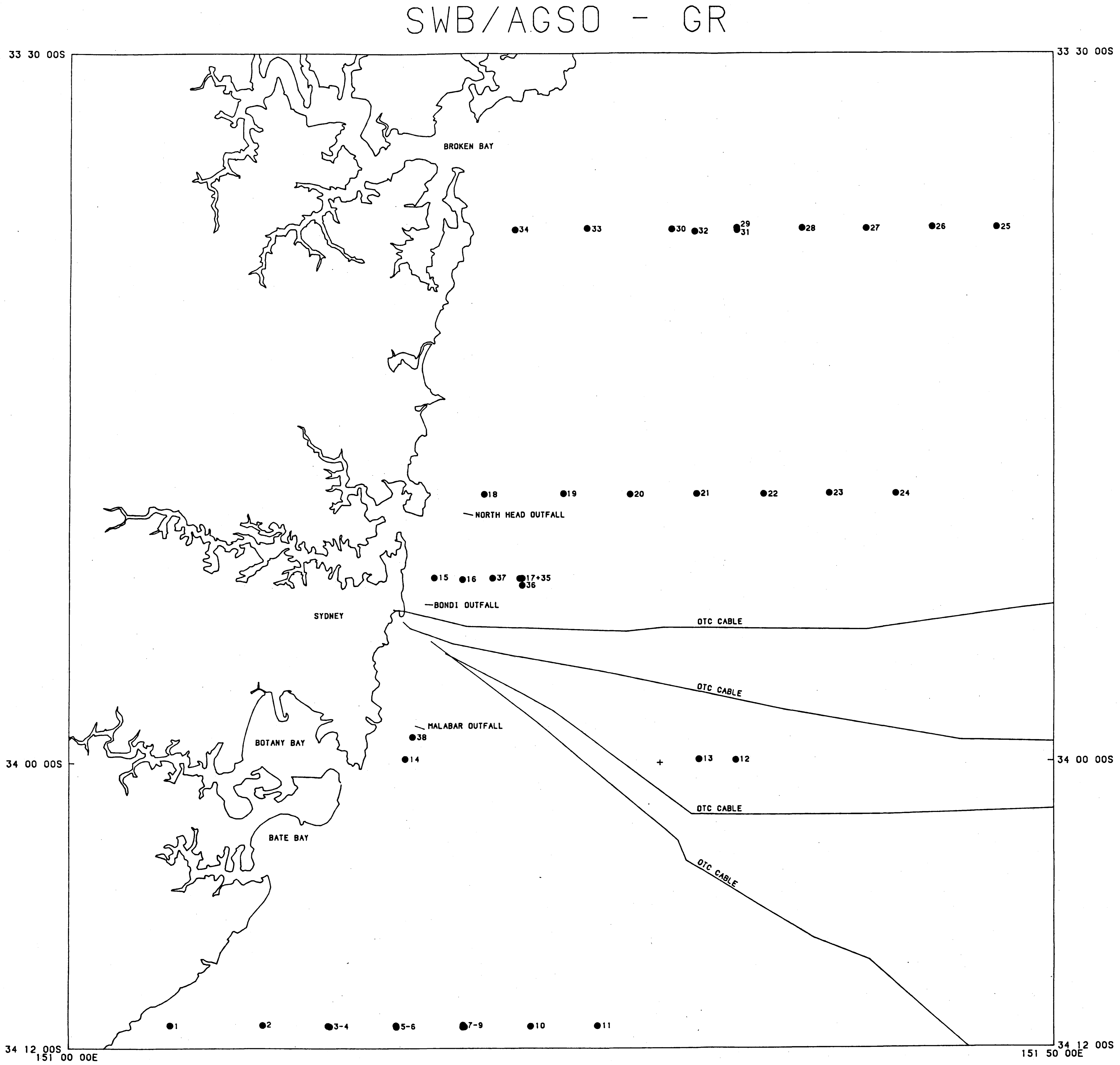




MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

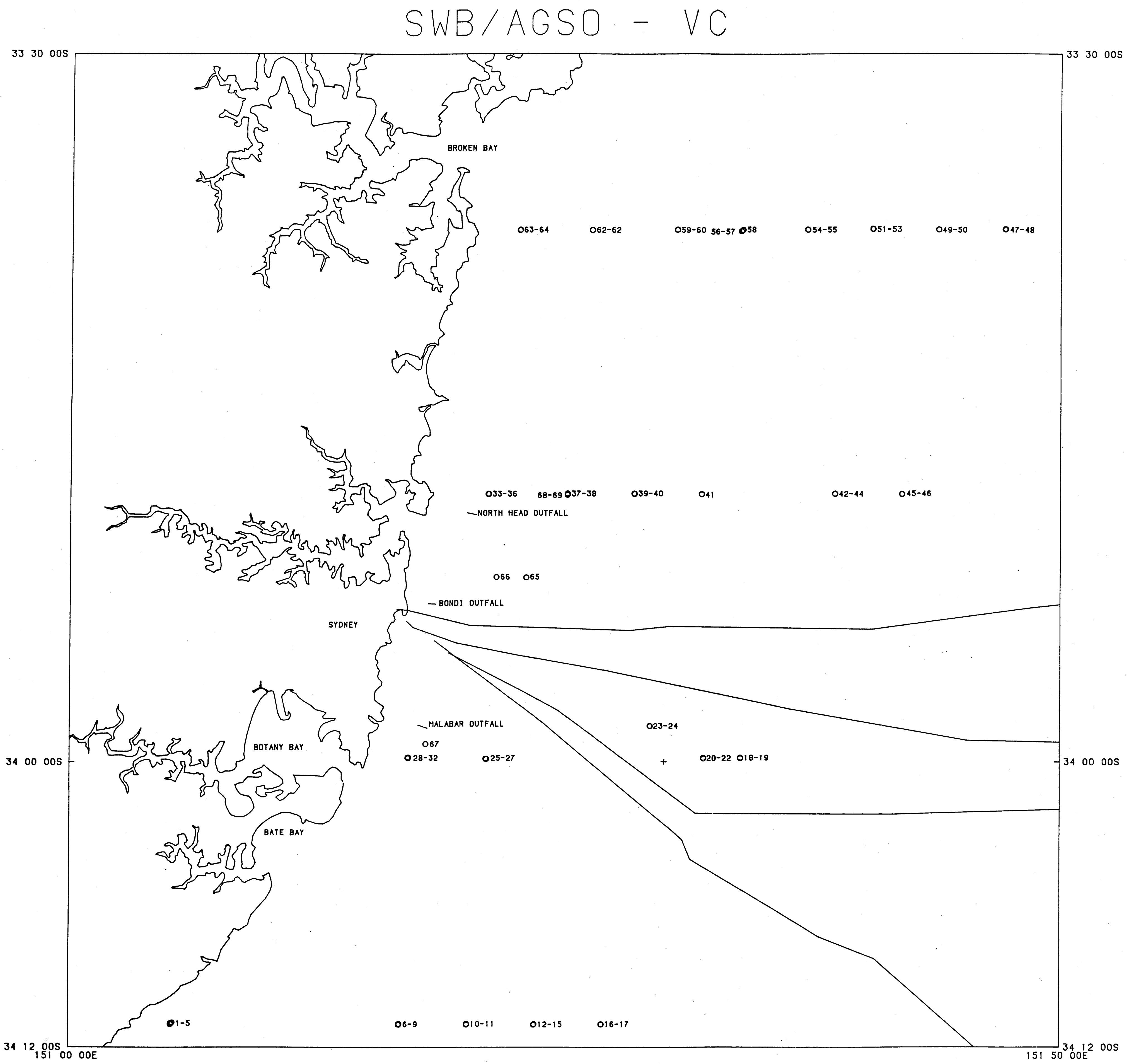
Enclosure 1 Map of the sampling sites occupied during this part of Survey 112.

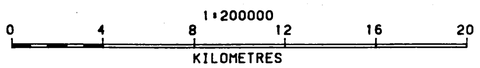
PREPARED BY JENNIFER E BEDFORD
FILE: SWBWSAMSITEST.PIC DECEMBER 1992



Enclosure 2 Map of the locations of Van Veen grab sampling stations.

PREPARED BY JENNIFER E BEDFORD
FILE: SWBVGRT.PIC DECEMBER 1992

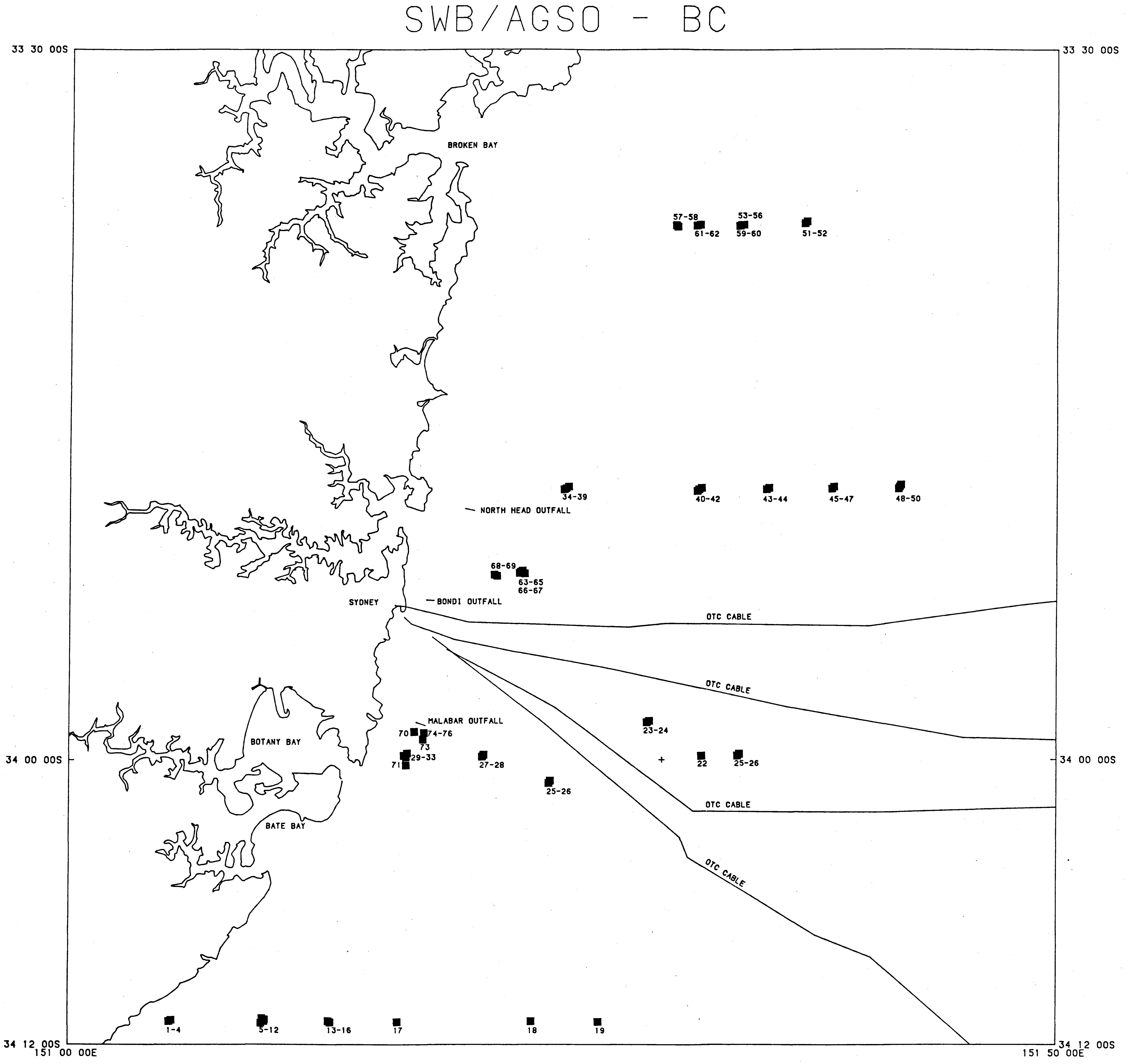




MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

Enclosure 3 Map of the locations of vibrocore sampling stations.

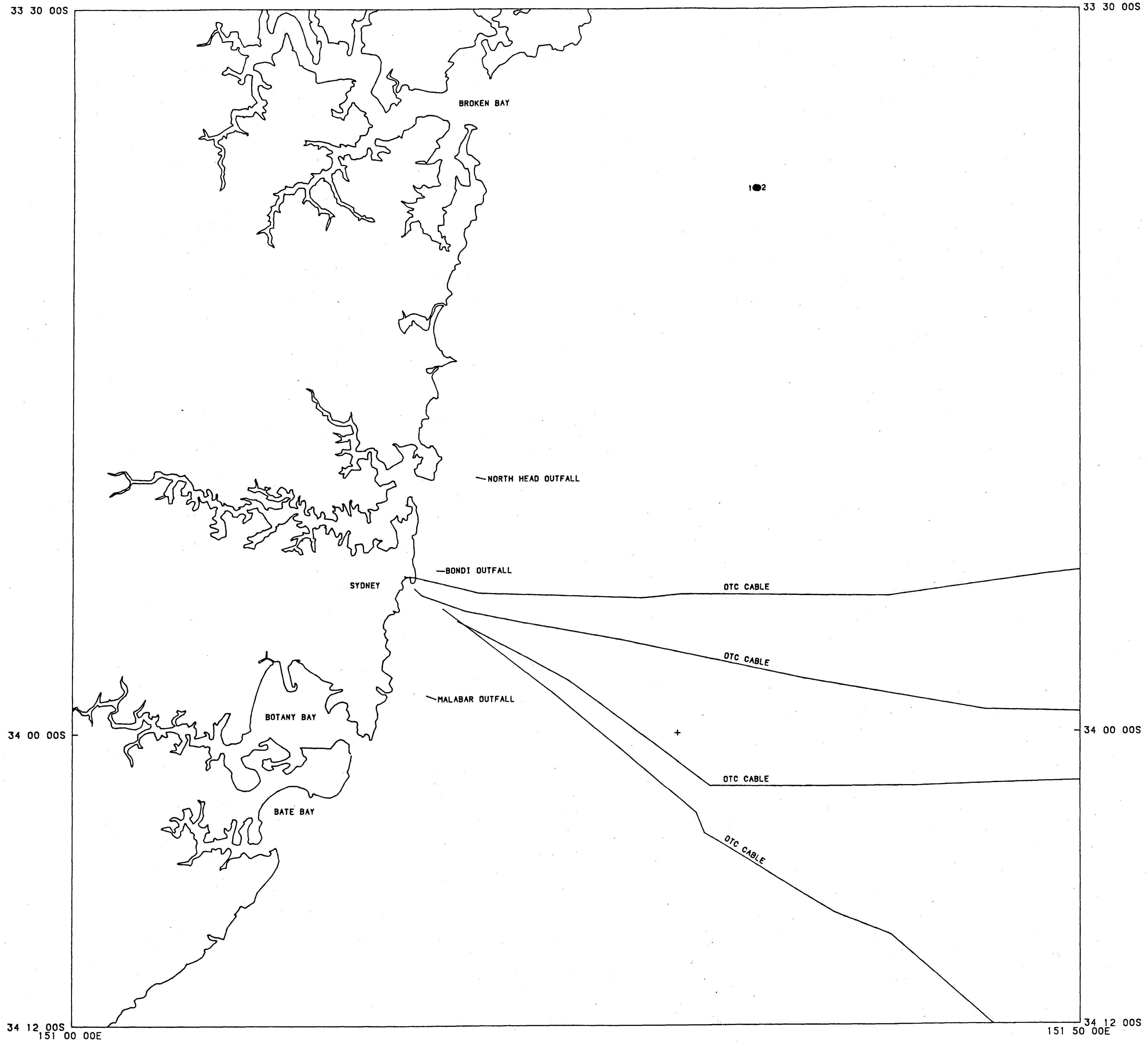
PREPARED BY JENNIFER E BEDFORD
FILE: SWBVCT.PIC DECEMBER 1992

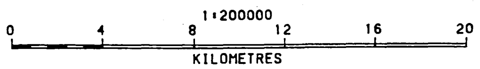


Enclosure 4. Map of the locations of box core sampling stations.

PREPARED BY JENNIFER E BEDFORD
FILE: SWBWBCT.PIC DECEMBER 1992

SWB/AGSO - GC



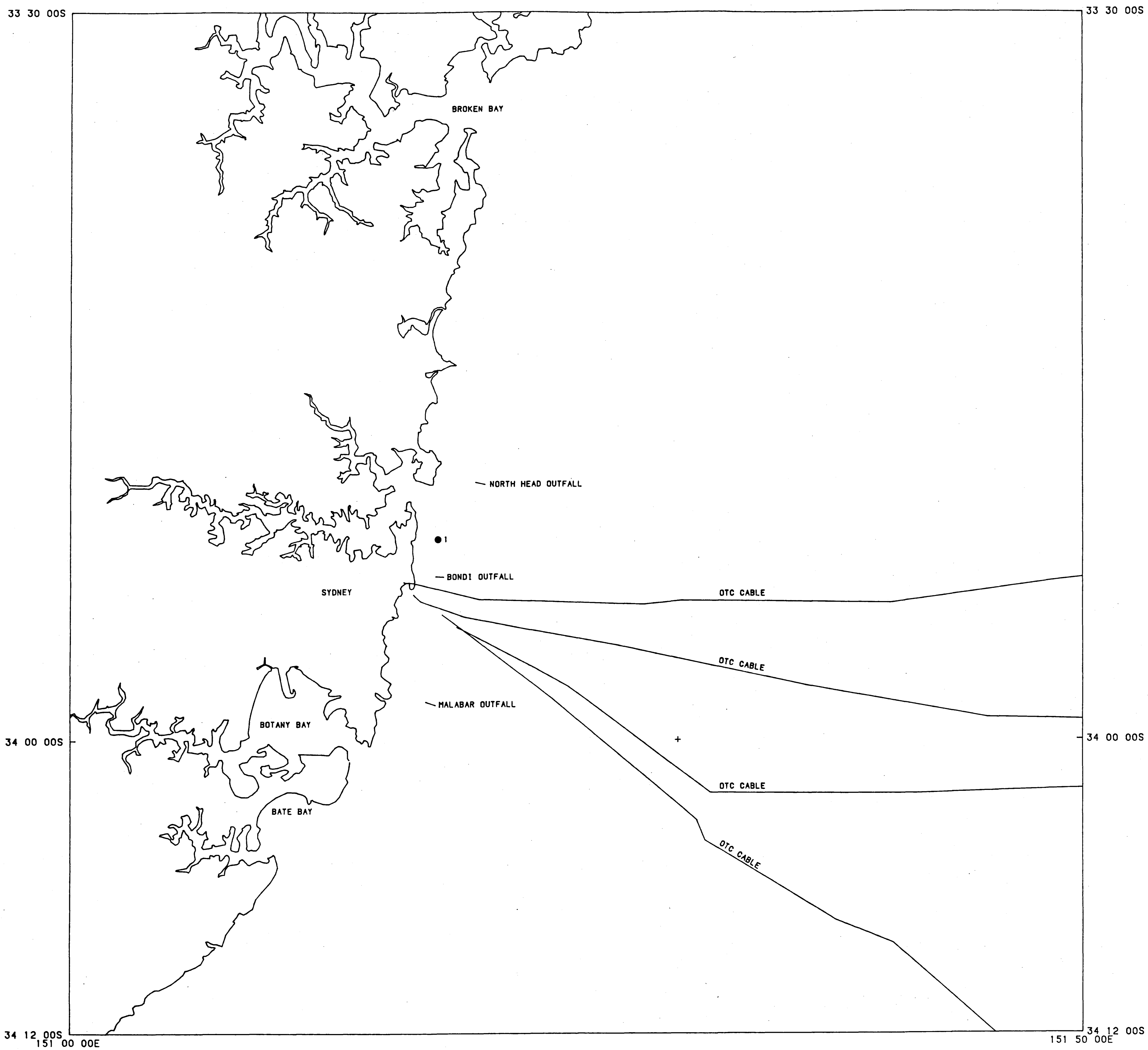


MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

Enclosure 5. Map of the locations of gravity core sampling locations.

PREPARED BY JENNIFER E BEDFORD
FILE: SWBGCT.PIC DECEMBER 1992

SWB/AGSO - HC



1:200000

0 4 8 12 16 20

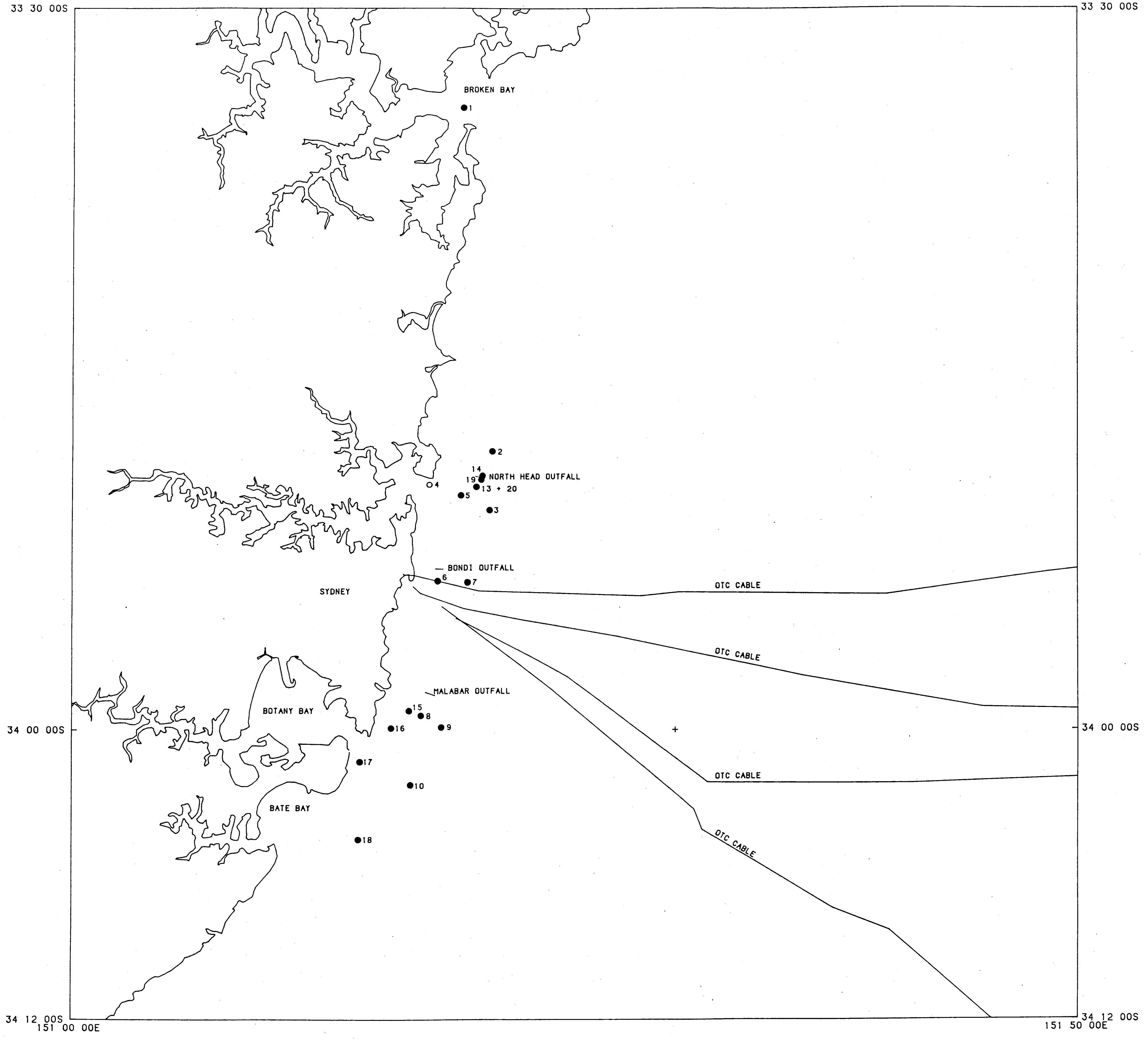
KILOMETRES

MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

PREPARED BY JENNIFER E BEDFORD
FILE: SWBWHCT.PIC DECEMBER 1992

Enclosure 6. Map of the location of the single hydrocast.

SWB/AGSO - VP

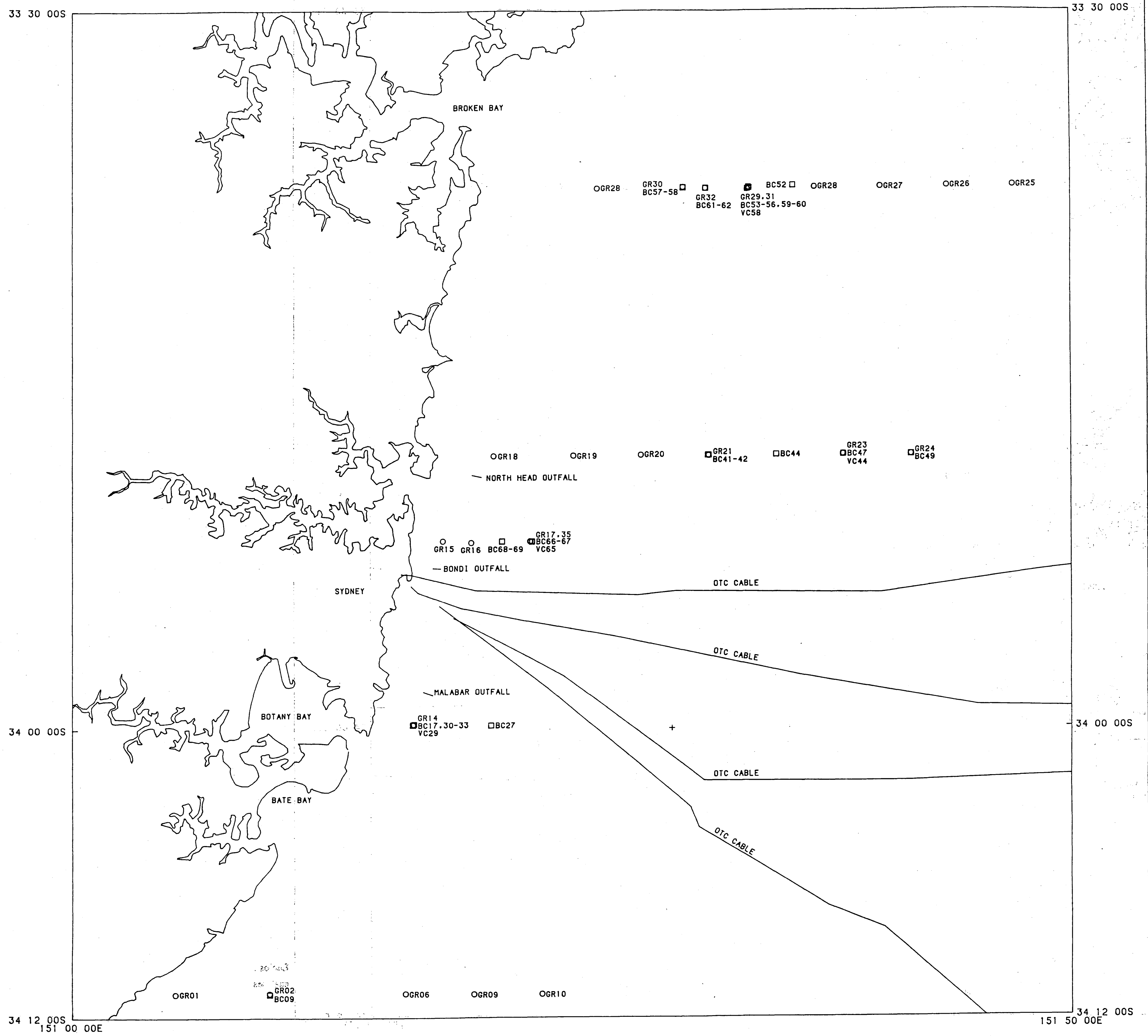


1:200000
0 4 8 12 16 20
KILOMETRES
MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

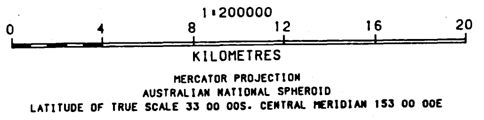
Enclosure 7. Map of the locations of vertical profiles conducted in the coastal zone.

PREPARED BY JENNIFER E BEDFORD
FILE: SWBWYPT.PIC DECEMBER 1992

SWB/AGSO - LHC SITES

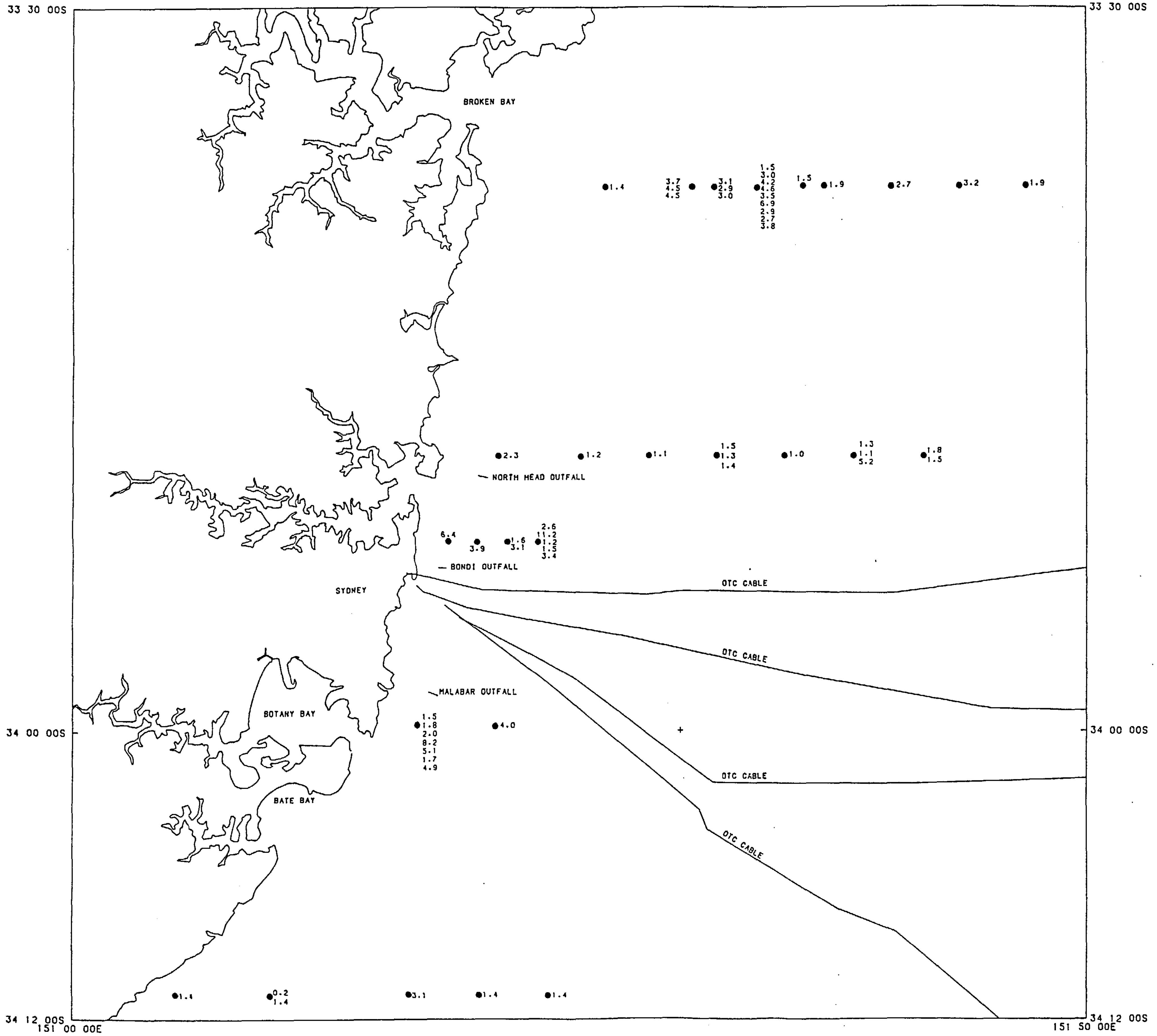


PREPARED BY JENNIFER E BEDFORD
FILE: SWBLHCT.PIC DECEMBER 1992



Enclosure 8. Map of the locations of sediments sampled for light hydrocarbon analyses.

SWB/AGSO - SUM C1+C2+C3+C4



1:200000
0 4 8 12 16 20
KILOMETRES
MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID
LATITUDE OF TRUE SCALE 33 00 00S. CENTRAL MERIDIAN 153 00 00E

Enclosure 9. Posted value plot of THC (total light hydrocarbans) in sediments.

PREPARED BY JENNIFER E BEDFORD
FILE: SWBVC1C4T.PIC DECEMBER 1992