Cruise Report

RRS Charles Darwin Cruise 111

20th April - 15th May, 1998

Principal Scientist

K.S. Black

To go to sea is to go to prison,
With the added chance of drowning at that
SAMUEL JOHNSON

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Contents

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CD 111A

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P. LAMONT	DML
O. PEPPE	DML
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R. LAMPITT	SOC
J. COPLEY	SOC
J. HUNTER.	MLA
J. DUNN	MLA
H. KENNEDY	BANGOR
S. MOWBRAY	EDINBURGH
B. NGWENYA	EDINBURGH
R. LLOYD	RVS
J. JONES	RVS
R. PHIPPS	RVS
D. REES	RVS
J. WYNAR	RVS
P. TAYLOR	RVS

CD 111B

K.S. BLACK (Principal Scientist)	DML
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G. RUDDY	PML
J. DIXON	PML
S. LLOYD	RVS
J. JONES	RVS

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M. GREAVES	CAMBRIDGE
E. GOOD	EDINBURGH
G. COWIE	EDINBURGH
M.WILLIAMS	DML
P. LAMONT	DML
D. MERCER	DML

Ship's Company

G. LONG (Master)
P. NEWTON
R. WARNER
P. OLDFIELD
N. MACASKILL
A. ADAMS
B. MACDONALD
J. ROYSTON
K. CONNOR
G. POOK
K. LUCKHURST
M. WYNESS
J. DALE
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R. BELL
P. LYNCH
C. DILLON
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R. STEPHENS
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1. INTRODUCTION

BENBO is a recent UK Natural Environment Research Council (NERC) Thematic initiative to investigate the biophysical and biogeochemical processes occurring at the deep ocean bed as a result of the sedimentation of marine snow. The principal objective is to quantify sediment and solute fluxes, energy flows and the biological response at this important interface. BENBO began in May, 1997, and is to run for three years. This cruise report is the second in a series of three field reports, and describes the scientific activities on the 111th voyage of the *RRS Charles Darwin*. CD 107 (August, 1997) was the first BENBO cruise . CD 111 is the first of two subsequent process cruises (the other is CD 113, July-August, 1998), and was undertaken to sample the water column and the seabed prior to the surface ocean spring phytoplankton bloom. The cruise was divided into two legs on account of the pressure for berths. The vessel sailed initially from Southampton to Fairlie on the estuary of the Clyde, before departure to the Atlantic ocean. It sailed first to site C, then to site B and then continued south to site A. This leg is referred to as CD 111A. The ship then sailed to Galway port to exchange scientific personnel. A return trip around the three experimental sites in the reverse order was completed before returning to Fairlie. This leg is referred to as CD 111B.

Acknowledgements
CD111 was an ambitious undertaking by all, not least due to the large number of scientists wishing to do some work on board the ship, the wide variety of work schedules planned, and the rather large amount of equipment going to sea. The author would like to extend his thanks to all the scientists for their co-operation and help, both prior to and during the cruise. I would also like to extend thanks to Captain Geoff Long and his crew for contributing to such an enjoyable experience, and all those land-based people who continually work to ensure a smooth running of the cruise for all. The guys and girls in the kitchen, and their remarkable ability to produce four star meals in the worst of weather, shall not escape our thanks either. The author also gratefully acknowledges on behalf of the scientific party the loan of various items of equipment by Dr Brian Bett (SOC).

This cruise provided the first opportunity for BENBO to field test the new 'benthic Lander' in the deep ocean. This Lander, constructed in collaboration with a Danish manufacturer, is the first autonomous free-fall

research rig of it's type in the UK. Field tests were conducted at all three BENBO sites.

2. ITINERARY

Sailed Southampton	20th April, 1998
Galway scientific personnel transfer	4th May, 1998
Arrived Fairlie	15th May, 1998

3. OBJECTIVES

The objectives of the cruise may only be broadly defined due to the multi-disciplinary and multi-institutional nature of the cruise. In general terms, the objectives were to undertake to a satisfactory extent the major proposed research activities of the individual research groups. A major core objective was to collect oxygen consumption and diffusion data using the new benthic Lander for the BENBO community as a whole at each of the three experimental sites. Moorings at each of the study sites were to be turned around, and the bottom-mounted ADCP instrument at site B was to be recovered permanently. Throughout the cruise, satellite imagery of sea surface colour and temperature was obtained routinely to assess the nature and extent of the upper ocean phytoplankton bloom.

4. SURVEY DESIGN

Three areas of seabed, around the Rockall Trough region in the north-east Atlantic, were selected as the field study area (Fig. 1) The locations of these sites are as follows:

		Water depth/m
Site A Mouth of Rockall Trough	52.918°N 16.917°W	3580
Site B Hatton-Rockall Basin	57.425°N 15.683°W	1100
Site C Flank of Feni Drift	57.100° N 12.515°W	1920

Fig. 1. Location of BENBO study sites

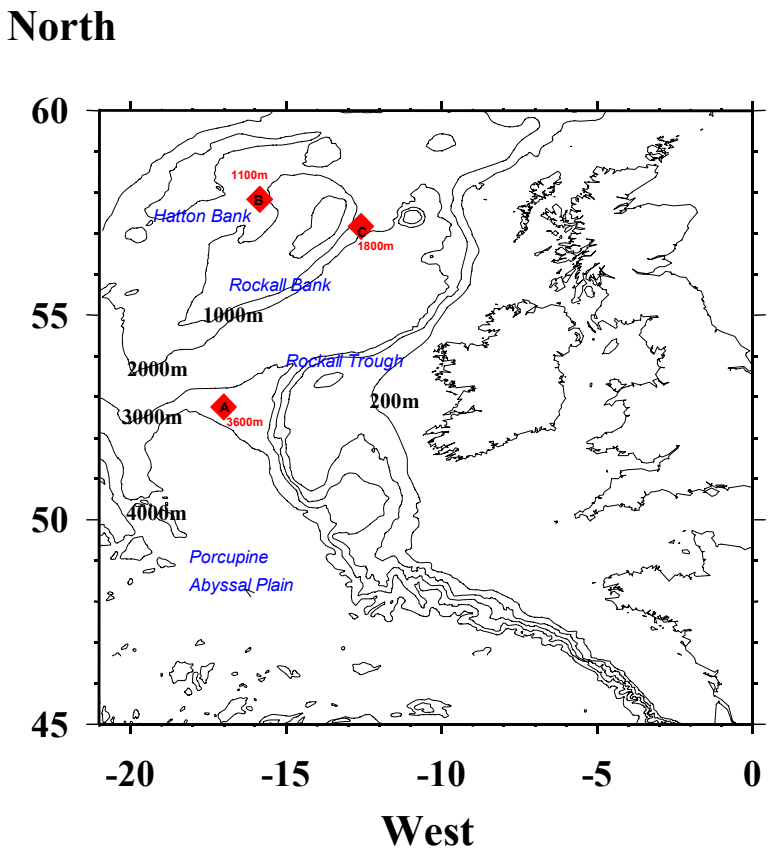

Diagram courtesy of Dr. R. Lampitt (SOC)

The cruise track is given in Figure 2. The overall scheme of operations was to complete two full circuits of the sites, with an exchange of scientific personnel mid-cruise in Galway, Ireland. The sites were visited in logical order following departure from Fairlie during the first leg (CD 111A): site C → site B → site A, and then in the reverse order during Leg B following departure from Galway (site A → site B → site C). Weather throughout the cruise was surprisingly good, and the ship completed two circuits without any major

problems. There were two short spells of bad weather, however the sampling programme was not delayed substantially due to a considerable in-built bad weather contingency.

5. DIARY OF EVENTS

Compiled by Ship's Master, Geoff Long

The RRS Charles Darwin sailed from Southampton at 1200 hrs on 20th April some three hours late due to delays in the final mobilisation and securing of scientific equipment. The pilot disembarked at 1320 and the ship proceeded on passage to Fairlie via the Needles Channel.

22 April

1930 Berthed Fairlie to load further scientific equipment
1800 Completed loading equipment.
1920 Various spares etc for scientists arrived from Ship Chandler
2200 Sailed Fairlie for scientific work area.

23 April
On passage.

24 April

0330 On Station C in area of 57.05N 12.35W commenced a series of CTD, box cores, towed sledges, and mooring recovery etc.
2200 Weather deteriorated wind increased to gale force work abandoned for the night.

25 April

0600 Weather improved after passage of frontal weather system resumed scientific program including recovery of current meter mooring.

26 April
Continued scientific program in excellent weather conditions

1550 Completed work at station C on passage to station B

27 April

0300 On Station B in area of 57.26N 15.42W. Resumed CTD work, box coring towed sledges, recovery and deployment of moorings etc. in excellent weather conditions.

28 April
Continued CTD work, coring, and towing sledges.

29 April
Re-deployed moorings etc

1600 On passage to Station A

30 April

1530 On station A in area of 52.53N 16.52W
1700 Recovered current meter mooring, resumed deployment of various rigs and nets. Overnight problem with slack turns on coring winch (problem resolved).

01 May
0400 Resumed deployment of nets etc.

02 May
Continued sampling with nets, sledges, corers etc.

03 May
0700 completed scientific programme for Leg A on passage to Galway for boat transfer of scientists.

04 May
1030 Arrive Galway Pilot Station
1100 Nine scientists disembarked to pilot boat and nine scientists embarked
1130 Full away returning to work area

05 May
On passage to work area, westerly gales

06 May
On Passage to work area, weather improving.
1230 On Station; coring in area of 52.54N 16.54W

07 May Coring and recovering of Lander.

08 May Coring.
2150 completed station – on passage

09 May
On passage
2330 On Station, deploying Lander, coring etc in area of 57.25N 15.43W

10 May
On Station. Coring. No work overnight ship remains on station

11 May
1100 Resumed coring and CTD stations
1630 Ceased overboard work for the day

12 May
0430 resumed coring
0630 Recovered Lander on passage to last station
1630 On station in area, resumed caring and deployment of Lander

13 May

Coring and CTD stations

1030 Recovered Lander. Resumed coring and CTD Stations

2300 Completed scientific programme. On Passage to Fairlie

l4 May
Passage

15 May

0900 All fast alongside equipment Fairlie. Commenced discharge of scientific equipment

Voyage Totals

Berth-Berth	*596.9 hrs*
Tot. scientific	*462.3 hrs*
Bad weather	*7.9 hrs*
Winch failure	*6.0 hrs*
Harbour steaming	*6.0 hrs*
Fairlei port call	*7.7 hrs*

6. SAMPLING PROTOCOL CD 111A

The following notes comprise the reports of sediment sampling and processing activities undertaken by scientists during Legs A and B. Wherever possible these have been split into those relating to CD 111A and CD 111B, however where this may interrupt the flow of information they have been included together. A detailed record of the scientific sampling activities may be found in Appendix I.

6.1. Leg 111A

6.1.1. H Kennedy and D Thomas (University of Wales, Bangor; report for CD111A & B)

'Carbon cycling in the benthic boundary'

The aim of this project is to develop a better understanding of carbon mineralisation in the benthic boundary layer. As a result of bacterial remineralisation of organic carbon in the sediments (SOC), the concentration of dissolved organic (DOC) and inorganic carbon (DOC) increase with depth in the sediment pore-waters. The concentration gradients of DIC and DOC in the pore-waters can maintain diffusive fluxes of carbon across the sediment

water interface into bottom waters. However the steady state distribution of DIC and DOC in the pore-waters is governed by a balance of diffusion and reaction, where the main reactions are bacterially mediated. During the cruise a number of techniques have been used to investigate the role of bacteria in the production and utilisation of carbon and the magnitude of the diffusive fluxes of DOC and DIC across the sediment water interface.

6.1.1.1. Pore-water sampling

To determine interfacial gradients , pore-water was sampled for DOC, nutrients, $^{\delta 13}$C-DIC and $^{\delta 13}$C-DOC by sectioning mega-cores under a N_2 atmosphere (Table I).

The resolution of surface sectioning of the cores was 0.5 cm, grading up to 2 cm sections towards the bottom of the core. The sediment was centrifuged and the pore-waters filtered. Pore-waters for ammonium analysis were filtered under a nitrogen atmosphere and analysed directly on board ship.

$^{\delta}$13C-DIC samples were poisoned with mercuric chloride and sealed in glass ampoules. Nutrient, DOC and $^{\delta 13}$C-DOC samples were stored frozen.

Table I. *Summary sampling information relating to pore-water determinations*

Date	Lat.	Long.	Site	Station#	Samples
25/04/98	57° 05'.30'	12° 18.13'	C	54401#10	DOC, nutr.
27/04/98	57° 26.18'	15° 41.35'	B	54402#7	DOC, nutr.
30/04/98	57° 55.11'	16° 55.12'	A	54403#2	DOC, nutr.
07/05/98	57° 55.21'	16° 53.00'	A	54404#8	δ^{13}C-DIC
10/05/98	57° 25.25'	15° 44.05'	B	54407#3	δ^{13}C-DIC
11/05/98	57° 24.57'	15° 41.00'	B	54407#13	δ^{13}C-DOC
12/05/98	57° 05.27'	12° 29.45'	C	54409#2	δ^{13}C-DIC, δ^{13}C-DOC

6.1.1.2. Lander deployments

Benthic incubations during Lander deployments allow the determination of *in situ* fluxes across the sediment-water interface. The Lander consists of a square benthic chamber of 30 litre capacity and has 15 syringe attachments to allow a time-course of samples to be withdrawn or injected. An initial deployment was made at site A to test the general function of the syringes and some in-line glass bulbs during sample withdrawal. All sampled efficiently but the dilution of the withdrawn sample (with fluid used to charge the system during deployment) was large and variable in the glass bulbs and so further collections were made using the syringes alone. At Site A the Lander was deployed for 4 days. Nine syringe samples were sampled for nutrients, DOC and δ^{13}C-DIC .

The spade to the box core had not closed and so it was not possible to estimate the volume of water overlying the sediment during the incubation. Thus these samples can only be used to give a qualitative estimate of the time required for subsequent Lander deployments at this site.

Although the external and internal oxygen electrodes logged data throughout the experiment, the output was noisy and the electrodes required a long equilibration time to attain constant output. At Site B the Lander was deployed for two days. This time a chemical tracer was injected into the chamber during the incubation to determine the volume of the overlying water and thus maintain the integrity of the samples even if the spade did not close. This deployment collected 13 syringe samples and a sediment core. When the Lander was retrieved there was no overlying water left in the chamber and the surface sediment had been strongly disturbed. To investigate whether the stirrer could be a possible source of the noise in the output of the oxygen electrodes a short final Lander deployment was made at Site C. The stirrer was switched on and off over two hour periods during the deployment and an intact sediment with overlying water was collected.

Table II. *Summary sampling information relating to Lander deployments*

Start Date	Finish date	Latitude	Longitude	Site	Station#	Samples
1/5/98	1/5/98	52° 54.26'	16° 54.42	A	54403#3	Test run
3/5/98	7/5/98	52° 54.15'	16° 54.24	A	54404#6	Nutrients, DOC, δ^{13}C-DIC
10/5/98	12/5/98	52° 23.18'	16° 42.53	B	54409#17	Nutrients, DOC, δ^{13}C-DIC
12/5/98	13/5/98			C		Test run

6.1.1.3. Laboratory incubated cores

To provide comparative data with the Lander deployments, shipboard incubation of sediment cores at *in situ* temperatures was undertaken over extended periods. The majority of the water overlying a mega-core was siphoned off leaving a small volume *(*approximately 500 cm^3) in which the change of concentration of nutrients, DOC, and $^{\delta 13}$C-DIC, could be monitored.

Table III. *Summary sampling information relating to laboratory incubated cores*

StartDate	Finish Date	Lat.	Long	Site	Station#	Samples
2/5/98	6/5/98			A	54403#13	nutrients, DOC
7/5/98	14/5/98	52° 55.21'	16° 53.00'	A	54404#8	nutrients, DOC, δ^{13}C-DIC .
10/5/98	14/5/98	57° 25.25'	15° 44.05'	B	54407#3	nutrients, DOC, δ^{13}C-DIC

6.1.1.4. Bacterial decomposition experiment

In collaboration with Carol Turley and colleagues (PML) the role of bacteria in the production of DOC and DIC in the sediment pore-waters has been investigated. Fluff collected from CD 107and albumin was incubated with sediment from Site A to determine bacterial responses to pulses of

organic material settling on the sea floor. An incubation of water overlying a mega-core with pore-water derived from Site A was also made to determine the rate at which bacteria in bottom waters can oxidise DOC.

6.2. Peter Lamont (CD 111 A & B; Dunstaffnage Marine Laboratory; John Gage, PI)

'Benthic community activity and biomass in biogeochemical processes at the deep ocean bed'

One aim of the biological sampling for S.A.M.S. partners on this cruise was to acquire sufficient data to assess biomass of all size classes of the benthic biota at the three BENBO sites. Mega-fauna was collected by means of the SOC epibenthic sled which was also fitted with a camera to provide images to relate to the fauna collected. These methods and results are reported in Dr. Richard Lampitt's contribution elsewhere in this report. Macro-fauna was collected chiefly with the USNEL box-core but augmented by mega-cores (100 mm diameter). Meio-fauna samples were collected with the Barnett-Watson multi-core but additional mega-core samples were also taken for this purpose. A second aim was to attempt to quantify bioturbation. For this purpose, burrows, where encountered were sampled. Sediment was removed to glass vials, sealed with foil and frozen at –10 to –20° C in the chest freezers on the ship then transferred to a –70° C freezer on arrival in Oban. In most cases these burrows were also photographed and notes of diameter and depth in the sediment were made.

A number of box-cores were prepared with clean cut faces and slices of the cores obtained for X-ray analysis. This was accomplished by pressing a plastic tray into the vertical sediment face then separating off a slice by drawing a taut wire through the sediment along the edges of the tray The tray was then tilted back to separate the slab from the rest of the core. SAMS trays were 335 x 435 mm. Slices were also taken by Dr. Greg Cowie on smaller trays measuring 145 x 295 mm.

All samples taken and their processing are listed in chronological order in Table I, and sample fate and purpose in Table II.

Table I. *S.A.M.S samples list and processing*

Station	Gear	Site	Sample Description	Processing
54401#1	MGC	C	hydroid (Acanella ?) specimen	c. 6 cms @ 250
54401#7	ES(IOS)	C	megafauna, small catch c. 20 L including 26 rat-tails	inverts formalin, fish frozen
54401#10	MGC	C	4 cores : macro/meio, meio+chem, macro, macro	(a) 1,1,1,2,5,5,5; (b) 1,1 1+ 1-10 frozen;(c&d) 0-10 @ 250
54401#11	ES(IOS)	C	good catch, corals, scaphopod (1@6"), acanella (octopus)+ camera	inverts formalin, fish frozen
54402#1	SBC	B	o/l water lost on deck, good core with many surface tubes	sliced 1,2,2,5,5,5 cms, 0-10 @ 250, >10 @ 300
54402#5	ES(IOS)	B	megafauna (sponges dominant) + camera	inverts - formalin; fish frozen
54402#7	MGC	B	1 core sponge, 1 core sponge & polychaete	(a&b) 1-10 cms @ 250 micron
54402#8	MGC	B	1 meio + pigments (8 cms); 3 cores ex Kennedy, preserved 9.V.98	(a, b & c) sediment 0,1,1,1,1 cms formalin
54402#11	ES(IOS)	B	megafauna (many sponges) + camera	inverts - formalin; fish frozen
54402#12	MGC	B	6 cores macrofauna (10 cms)	1-10 cms @ 250 micron after probe sampling (Fones)
54402#13	MGC	B	1 core macrofauna	1-10 cms @ 250 micron
54402#15	SBC	B	good core, o/l water lost, KB frozen surface sample c 6 cm dia.	sliced 1,2,2,5,5,5 cms; frozen surface s/s (Black)
54403#7	MGC	A	(a) little on surface, (b) + ophiuroid & copepods	(a) 0,1,2,3,4 formalin; s/s 0-10 frozen; (b) 1-10 + P's
54403#9	MGC	A	cores 9,6,10 & 20 incubated with probes afterwards taken for macrofauna	all four 1- 10 cms @ 250 + some P's
54403#11	SBC	A	good core with shallow mound & some Pelosina, o/l water lost	1,2,2,5,5 @ 250 + P's from sieves
54403#16	ES(IOS)	A	varied catch, small feather star sp. Dominating	inverts formalin, fish frozen
54404#7	SBC	A	good core, o/l water washed out through gap, P's = perforated tubes & Pelosina	sliced 1,9 &10 cms + 2 vert. sections (SAMS frozen)
54404#8	MGC	A	1 core with tube c 10 mm above surface - U tube extracted	1-10 cms @ 250 + extracted tube in separate 1 L pot
54404#8	MGC	A	incubated core (5 days) ex. Kennedy, preserved 14.V.98	sediment in formalin
54404#10	MC	A	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54404#11	MC	A	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54404#12	MC	A	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54404#13	SBC	A	good core with slight slumping, o/l water retained, KB frozen surface sample (6 cm)	1, 9 @ 250 ; >10 @ 1mm; Cowie + SAMS vert sections @ 6°

54407#4	SBC	B	o/l water slowly lost on deck through large burrows (excavated), good core	1, 9 @ 250 ; >10 @ 1mm; burrow photos + sediment frozen
54407#12	MGC	B	1 core with cirratulid (?)	0-10 @250
54407#15	SBC	B	o/l water intact, good core, small surface (?) forams like fir trees	1, 9 @ 250 ; >10 @ 1mm; burrow photos
54409#1	SBC	C	o/l water intact, very good core, 2-3 mm burrows observed at c 18 cm depth	1, 9 @ 250; > 10 discarded; vert. sections @ 6°, Cowie & SAMS
54409#3	Ldr	C	Lander core, o/l water lost, disturbed surface	c.1, c6 @ 250, >7 discarded
54409#4	MC	C	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54409#6	MC	C	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54409#9	SBC	C	good core, o/l water intact, ? faecal pellets on surface, Pelosina + tubes	1, 9 @ 250 ; >10 @ 1mm; burrow sediment frozen + photos
54409#10	MC	C	1 core to 4 cms meioF, 2nd core frozen whole	surface, 1,1,1,1 in formalin; whole core frozen
54409#13	SBC	C	good core with o/l water, small ophiuroid , surface burrows, some to 28 cms depth	sliced 1,9 @250 + 1 vert. section (SAMS) frozen (> 10 discarded)

1 MGC = 0.007857 m^2
1 Lander core = 0.087 m^2
1 SBC = 0.25 m^2 = 32 mega-cores or 2.87 Lander cores
Note: all box core mud surfaces were photographed before processing
s/s = sub-sample
P's = pickings, organic material picked off sieve or core with brush or tweezer

Table II. *S.A.M.S sample purpose and fate*

Stn	**Site**	**meio F**	**macroF**	**mega F**	**chemistry**	**photos**	**X-ray**	**Ju. day**	**date**
54401#1	C		1					114	24.IV.98
54401#7	C			1				115	25.IV.99
54401#10	C	1+ part core	3		part core			116	26.IV.98
54401#11	C			1		film		116	26.IV.98
54402#1	B		0.25 m^2					117	27.IV.98
54402#5	B			1		film		117	27.IV.98
54402#7	B		2					117	27.IV.98
54402#8	B	part core	3 ex Kennedy		part core	ea. surface		117	27.IV.98
54402#11	B			1		film		118	28.IV.98
54402#12	B		6 ex Fones`					118	28.IV.98
54402#13	B		1					118	28.IV.98
54402#15	B		0.25 m^2					118	28.IV.98

54403#7	A	1	1					121	1.V.98
54403#9	A		4 ex Fones					121	1.V.98
54403#11	A		0.25 m²					122	2.V.98
54403#16	A			1		film		123	3.V.98
54404#7	A		0.25 m²				1@-10°		
54404#8	A		1			yes			9.V.98
54404#8	A		1 ex Kennedy						9.V.98
54404#10	A	1			1			127	7.V.98
54404#11	A	1			1			128	8.V.98
54404#12	A	1			1			128	8.V.98
54404#13	A		0.25 m²			yes	2@+6°	128	8.V.98
54407#4	B		0.25 m²		burrows	yes		130	10.V.98
54407#12	B		1			worm *in situ*		131	11.V.98
54407#15	B		0.25 m²			surface &burrows		131	11.V.98
54409#1	C		0.25 m²		yes	surface &burrow	2@ +6°	132	12.V.98
54409#3	C		0.087 m²					132	12.V.98
54409#4	C	1			1			132	12.V.98
54409#6	C							133	13.V.98
54409#9	C		0.25 m²				1@ +6°	133	13.V.98
54409#10	C							133	13.V.98
54409#13	C		0.25 m²				1@ -10°	133	13.V.98

Some mega-cores (from Fones and Kennedy) were taken after incubation for several days to provide macro-fauna data which might be related to the chemistry results. The surfaces of some of these mega-cores were photographed prior to sieving and preserving after 12 days incubation at 4° C in an attempt to relate surface features to burrowing fauna.

All box-core sediment surfaces were photographed after removal of surface water. Box-core sediments were always sieved on 250 microns to 10 cm depth and either 250, 300 microns or 1 mm for deeper layers. The Bengal procedure of horizontal slicing in layers of 1, 2, 2, 5, 5 and 5 cm was attempted for the first four cores obtained but was found to be impractical when burrows were being simultaneously investigated. In these latter cores horizontal slicing was confined to the 0-1 and 1-10 cm layers with deeper sediment being

sieved on 1 mm. There was insufficient time to process the deeper sediments from the last three box-cores (at station 'A'), however little had been found in those layers from other cores.

Mega-cores taken for macro-fauna were sliced at 10 cms sediment depth and either sieved at 250 microns or preserved whole. For meio-fauna some mega-cores were sliced at 1 cm intervals to 4 cms and the sediment preserved whole, part of each layer being collected in vials for chemical analysis. Fish from trawls were frozen for Dr. J Gordon, SAMS.

Observations

Station A at 3500 m exhibited little bioturbation below the top grey layer of about 10-12 cms. The deeper sediment at this station comprised of a dense, red, sticky clay which was difficult to sieve and in which no significant fauna was found, neither were there clear indications of burrows in X-rays of two box-core slabs taken. The foraminifer *Pelosina* was common on cores and although sipunculids occurred in the trawls, surface burrows observed on cores were small (<c2 mm diameter). A species of small feather star predominated numerically in the trawled megafauna.

Station B at 1100 m was dominated by sponges whose spicules were present throughout the sediment causing it to be difficult to cut through. A slice for X-ray was obtained with the small tray (Cowie) but not attempted for the larger tray size. Some larger burrows and tubes up to 6 and 8 mm diameter were encountered on the core surfaces and some worms recovered during the first leg appeared to have green gut contents but lack of time prevented microscopic examination. One sipunculid was found in a box-core burrow at 10 cm sediment depth. Trawled sponges were numerous and tended to be spherical and up to 60 mm in diameter.

Station C, at 1900 m, showed the densest burrow activity in X-rays of box-core slabs. Surface burrows of 6 – 8 mm were common in addition to many smaller tubes and burrows. Sediments were softer, lacking

reinforcement from sponge spicules and burrows of 2-3 mm were observed at up to 27 cms sediment depth in box-cores. The hydroid *Acanella* and solitary corals were common in the trawled catches.

6.3. B. Ngwenya and S. Mowbray (University of Edinburgh)

'Bacterial decomposition of labile organic matter during resuspension events: high pressure incubation experiments'

The purpose of this work was to conduct high pressure incubation experiments on board the ship. The experiments were designed to simulate the extent to which resuspension events bring organic materials into contact with free-living bacteria in the nepheloid layer. The rationale behind such experiments is to test the hypothesis that labile organic materials, which are preserved in the sedimentary record primarily due to their close association with minerals surfaces and hence protected from bacterial mineralisation, are desorbed during resuspension events. Thus by simulating organic matter desorption and incubating the desorbed materials with bacterial innocula from the nepheloid layer, we should see an increase in the rate of mineralisation.

6.3.1. Procedure

Two types of experiments were conducted. In the first type, we exhaustively desorbed labile organic matter from surficial sediments and then incubated the desorbed organic matter with an innoculum at pressure and temperature to measure the rate of remineralisation. In the second type, short duration (6 days) slurries of surficial sediments were incubated in the same pressure vessels as the desorption experiments in order to measure the rate of desorption of labile organic matter from mineral particles. For these, the particle to liquid ratio was varied to simulate particle concentration at different levels in the nepheloid layer. Some of the slurry experiments were repeated on a longer term basis by our colleagues (Gregory Cowie & Emily Good) during CD111B.

We used at least two mega-cores from each station. Upon receiving the core, the overlying water was siphoned off until only 7-8 cm of water column was left. The remaining water was collected into a plastic bag and pressurised to preserve the bacteria. This water was later filtered and used to innoculate our desorption experiments. Our experimental protocol was as follows:

1. The top 5 mm of sediments from each core was extruded and collected into a 1 litre beaker. All the sediment from the two cores were mixed with water from the overlying column and used to make a slurry. After mixing and homogenisation using a magnetic stirrer, the slurry was sub-sampled into a pre-weighed glass vial. This sample was preserved by freezing and will later be dried and weighed so that we can quantify the mass of solids in the slurry. This is necessary for us to be able to calculate partition coefficients from our experimental data.

2. Between 25 and 35 ml of the slurry was then transferred into each centrifuge tube and centriguged at 5,000 rpm. At least sixteen tubes were required altogether.

3. The supernatant from all sixteen tubes was decanted into a beaker, mixed and filtered before sampling it for DOC, DON, dissolved amino acids and nutrients. Natural adsorption (distribution) coefficients could thus be determined by analysing the concentration of particulate organic carbon and amino acids on the solid phase (step 1).

4. Four of the tubes containing the solid phase were then treated with UV-irradiated seawater in order to desorb as much of the adsorbed organic matter as possible. This was done by adding between 20 and 30 ml of UV-irradiated seawater to the cake and bringing the cake into solution. The resulting slurry was then mixed and agitated on a vortexor for 30 minutes. The mixture was centrifuged, and the supernatant decanted into a volumetric flask/beaker. This process was repeated about 4 to 5 times to collect enough volume of desorbed organic matter for incubation experiments.

5. 45 ml of the desorbed organic matter was then transferred into a plastic bag and 5 ml of the preserved and filtered bottom water was added to the solution. The bag was sealed and incubated at pressure and temperature equivalent to those recorded at the benthic boundary layer at each station.

6. The rest of the centrifuge tubes were used for slurry experiments. In these, the solid was transferred from centrifuge tubes into plastic bags by adding small amounts of UV-irradiated seawater (10-20 ml), shaking the mixture and decanting it into the plastic bag. The resulting slurry (50 and 200 ml) was then incubated at pressure and temperature in the same pressure

vessels as the desorption experiments.

7. Six pressure vessels, each corresponding to a separate time point, were used at each station. These represented 5 time points (5 vessels) plus a control vessel that contained two time points for the desorption experiment and one time point for each of the slurries. The number of time points and controls was limited by the amount of UV-irradiated seawater available.

8. The pressure vessels were then popped at regular intervals (12 to 24 hour intervals) and sampled for analysis of DOC, DON, dissolved amino acids and nutrients. Samples of the solid phase from slurries were also collected on pre-weighed filters for analysis of particulate organic carbon and particulate amino acids so that partition coefficients for the desorption process could be determined.

9. For the dissolved analytes, fluid samples were treated with 100 :l of a saturated mercuric chloride solution to stop bacterial activity, and then frozen for later analysis in the lab.

6.4. Mark Williams (Dunstaffange Marine Laboratory)

'Organic and inorganic transformations at the benthic boundary layer'

The aim of the work for Leg A of the cruise was to acquire particulate and dissolved samples from the three BENBO sites A, B and C in the N.E. Atlantic. The sites were chosen to give a variation in depth and hydrodynamic conditions, from which a comparison could be made. A later cruise, after expected bloom conditions, will provide two contrasting benthic environments at each site. All the samples were obtained from the benthic region. These samples will be analysed for a variety of trace metals selected for their geochemical (e.g. Fe, Mn), anthropogenic (e.g. Pb) and biogenic (e.g. Cu) importance. Additional analysis will be performed examining the isotopes of Pb (e.g. ^{206}Pb, ^{207}Pb, ^{210}Pb) to assist in the interpretation of processes occurring within the benthic boundary layer.

6.4.1 Sediment

Sediment cores were obtained from mega-corer deployments (A#7; B#8; C#2). The sediment core was immediately transferred to a constant temperature room held at the temperature of the bottom water, typically about 4°C, where a visual description of the core was recorded. The core was extruded under nitrogen to prevent oxidation of the sub-oxic layers and to retain the integrity of the core. The core was extruded and sliced at intervals

of between 0.5 – 2cm. The higher slicing intervals were performed deeper in the core. The overlying water was removed and stored as it contained fine particles resuspended during manipulation of the core tube. This material will be shared with colleagues from the University of Wales, Bangor, who will provide analysis of the organic carbon content. Part of each slice (~50 ml) was centrifuged at 4000 rpm for 20 min and after separation the pore-waters were acidified. The remainder of the slice was kept for determination of water content.

Table I. *Summary sampling information relating to pore-water determinations from core slicing*

Site	Depth/ m	Estd. depth of redox boundary/ cm	Core length/ cm	No. slices	Typical pore-water volume/ ml
A	3572	18.5	40.0	24	5.0
B	1103	6.0	14.5	13	10.
C	1942	8.0	25.0	16	7.0

Total number of sediment samples = 53
Total number of pore-water samples = 53
Total number of surficial water samples = 3

6.4.2 Suspended Particulate Matter

Samples from the water column at each site, approximately 5-10 m above the seabed, were taken using trace metal clean, externally rigged Niskin bottles. The water from these bottles were filtered using acid cleaned pre-weighed Nuclepore filters. It was found that after filtration of approximately 10 l the filters became blocked by the fine particles and subsequent filtration was very time consuming. After filtration typically ~30 l, a coating of fine light green material was observed on the filters. For each site multiple filtrations (x5) were performed to allow for a selected digestion to be performed on each filter. The digest will allow an examination of the phase

association of the trace metals with different particle coatings. Differentiation of the particle population into two operationally defined particle fractions was achieved using 10 μm and 0.4 μm pore size filters in series. Samples of filtered water were retained for analysis of dissolved trace metals. Further samples of filtered water were taken, for colleagues from the University of Cambridge and the Southampton Oceanography centre. The calculated weights of SPM filtered will provide assistance for calibration of instrumentation used by colleagues at the Southampton Oceanography Centre.

Table II. *Summary sampling information relating to suspended particulate phase determinations from seawater filtration*

Site	Depth/m	Bottom water temp./°C	No. 0.4 μm filters	No. 10 μm filters	Dissolved sample volume/ml	Volume filtered/ml
A	3577	2.75	5	1	0.5	148
B	1083	5.05	5	1	0.5	143
C	2084	3.15	5	1	0.5	143

Total number of 0.4μm filtered samples = 15

6.4.3. Summary

Leg A of the cruise has successfully provided the basic samples to parameterise the benthic boundary layer in terms of trace metal concentrations. A number of problems have been identified, particularly the length of time required to filter the bottom water. These will need to be addressed in some measure prior to the next cruise.

6.5. Gary Fones (Lancaster University)

'High resolution concentration gradients and fluxes of trace metals, major ions and nutrients at the benthic boundary layer'

The general undertaking of this work is to conduct DET and DGT measurement programmes at two principal spatial scales: 1-2 mm (high resolution or HR) and 100-200 μm (ultra-high resolution or UHR). HR work is relatively quick, straightforward and inexpensive. UHR work is

technologically more demanding and requires expensive beam time. HR and UHR will be used as appropriate. HR will be used for most experiments and heterogeneity studies. UHR will establish the ultimate concentration gradients and fluxes and the separation of individual element processes. The objectives will be met by (i) undertaking instrumental and methodological development work, (ii) performing field and laboratory experiments and (iii) mathematically modelling concentration and flux data. Different thickness DGT devices will be used during deployments. The resulting information will be used to assess whether the metals in the pore-waters are well buffered by the solid phases or only partially or insignificantly re-supplied. These results will allow interpretation either as concentrations or in situ fluxes from solid phases to solution. DGT assemblies will be deployed in sediment cores for various times up to two weeks. The results will determine the capacity of the solid phases to re-supply locally depleted metal.

With increasing spatial resolution there is an increased likelihood that measured concentration gradients may not be representative. Replicate DET and DGT deployments within cores will assess horizontal variability on the cm scale. Between core and in situ deployment will examine the m scale. Horizontal variability within a gel (measured by LA-ICP-MS) will assess the 100 μm scale (already shown to be important in freshwater systems).

During Leg A all on-board core deployments were undertaken apart from the last 6 probes due to the depth at station A and also the unreliability of the mega-corer. On board analysis was undertaken using flow injection analysis (FIA) for ammonia and ΣCO_2. Results showed no ammonia in the cores apart from the very base, due to the oxic nature of the sediment. The ΣCO_2 values increased only very slightly from the overlying water into the sediment.

6.5.1 Site summaries

Station C: 24th April

5 mega-cores retrieved. 6 gel probes inserted into the cores to determine pore-water values at high spatial resolution for a suite of determinants. Trace metals, major cations, major anions and nutrients. Probes left in sediment for 24 – 32 hours.

Station C: 26th April

4 mega-cores retrieved. 5 gel probes inserted into the cores to determine pore-water values at high spatial resolution for a suite of determinants. Trace metals, major cations, major anions and nutrients. Probes left in sediment for 24 – 32 hours.

Station B: 28th April

6 mega-cores retrieved from first drop and 3 from second drop. 12 gel probes inserted into the cores to determine pore-water values at high spatial resolution for a suite of determinants. Trace metals, major cations, major anions and nutrients. Probes left in sediment for 24 – 32 hours.

Station A: 1st May

2 mega-cores retrieved. 3 gel probes inserted into the cores to determine pore-water values at high spatial resolution for a suite of determinants. Trace metals and major cations. Probes left in sediment for 24 – 32 hours.

Station A: 2nd May

4 mega-cores retrieved. 4 gel probes inserted into the cores to determine pore-water values at high spatial resolution for a suite of determinants. Major cations, major anions and nutrients. Probes left in sediment for 24 – 32 hours.

Other Work

The Lander was used to deploy the gel probes *in situ* at station B on 27th April (57° 26° 90.57′ N; 15° 41° 51.21′ W). In logistical terms the deployment was successful and the Lander was recovered after 35 hours. However, the

drive motor which pushes the probe units into the mud cut out early, due to the unusually stiff sediment (principally due to the high density of broken silica sponge spicules). This problem will be overcome between cruises by changing the torque on the motor. Other successful deployments of the Lander included a micro-electrode deployment which may yield some useful oxygen data, however 2-3 of the electrodes were broken. It is not certain if this was upon deployment or retrieval or during the profiling stage.

6.6. Richard Lampitt (Southampton Oceanography Centre) and Peter Lamont (Dunstaffnage Marine Laboratory)

'Biogeochemical studies on the benthic nepheloid layer'

6.6.1 Benthic Megafauna

The benthic megafauna were examined on five occasions using the IOS benthic sledge which had both a single benthic net with mesh size 4mm and an IOS MkIV camera loaded with colour film. Apart from a torn net during one haul (54401#11) and an upside down sledge during the later part of another (54403#16), no technical problems were encountered. The film has however yet to be developed. Preliminary comments on the catch follow:

54401#7

small catch c 20 L (including 26 rat-tails)

54401#11

good catch; 54 rat-tails, 11 synapthobranchid eels, 1 incertae 1 octopus, several spp. stars including brisinga sp., phormosoma - 5 or 6 small specimens, acanella common, several solitary corals, one specimen with associated sponge and polychaete, one 150 mm scaphopod, 3 geryon crabs

54402#5

good haul dominated by sponges and sponge fragments, c 8 L of sponges, holothurians c 3 spp, some molluscs (one *philine* ?), 6 squat lobsters, c 8 asteroids, two with gelatinous dorsal surfaces: - 3 frozen for PCR, fecampid (Turbellaria) cocoon, 2 anemones
several spp. of fish - frozen

54402#11

haul dominated by sponges, 3 X 10 L tubs sponge fragments plus invertebrates

1 X 10 tub of discrete complete sponges, 1 X 5 L gelatinous pink tissue (stars ?) plus sponge fragments, 1 X 5 L assorted invertebrates, c 14 L fish, squat lobsters of all sizes
1 phormosoma, 1 anenome, several small eels

54403#16
3 squat lobsters, 1 hermit, small stones with attached fauna, sipunculids, 1 X 2.5 L tub of small assorted fauna: feather star predominating (small sp. C 10 mm disc diameter), scaphopods (many with associated anenome), c 6 pycnogonids, several large holothurians, one large cushion star (one small asteroid frozen), 3 phormosoma, large & different species from other sites. Small fish catch - 3 fish and one eel. many small stones.

6.6.2 Mid-water and Near-Bottom Zooplankton (Richard Lampitt SOC, J.Dunn Marine Laboratory Aberdeen [MLA], J.Copley SOC, J.Hunter MLA)

Zooplankton were collected using both the MLA ARIES system and the supra-benthic net of the IOS benthic sledge. Mesh sizes of both were 200 μm . In addition to this, both systems carried a Focal technologies Inc. optical plankton counter one of which had been specially manufactured to a depth rating of 4000m. Data were stored *in situ* on MLA OPC loggers providing counts of plankton in each of 136 size bins from 100 μm to 5.5mm (bin width 40 μm) every 30 seconds. These data were subsequently merged with *in situ* pressure and flow rates and shipboard navigational and echo-sounder data.

The ARIES system carries a carousel of 110 cod ends which rotates at preset time intervals below a preset depth as well as a Seabird CTD, fluorometer and transmissometer. 60 water bottles of 125ml are closed simultaneous with the first 60 net samples. In addition, two nets (200 μm and 95 μm mesh size) collect single integrated samples from the entire deployment. ARIES was fitted with an IOS acoustic altimeter and net monitor for precise altitude measurement telemetered in real time and visualised on the shipboard waterfall display. Five deployments of ARIES were made during the cruise, two at station C when the altimeter malfunctioned, two at station B during which the altimeter only worked once and once at station A at which the ARIES net motor drive jammed. The OPC and MLA loggers performed faultlessly on all deployments. In addition insufficient towing warp was available at station A to reach the near-bottom zone.

The benthic sledge was fitted with opening/closing mechanism, acoustic monitor and a new design of supra-benthic net (Spartel Ltd). No odometer was fitted. Five deployments were carried out all of which apart from the first also carried the OPC and its data logger. The OPC was fitted with a concentrating funnel potentially providing a seven-fold increase in flow rate (calibration and fume tests of funnel still to be completed). The camera flash monitor proved to be a good indicator of excess warp on the seabed by the consequent reduction in signal and in spite of care to avoid this, the supra-benthic net was usually heavily contaminated with sediment. All deployments were free of technical problems although near the end of the last tow (station A), the sledge weak link broke and it turned over, recovery being accomplished on the safety strops. The photographic record may indicate the cause of this.

Preliminary examination of the OPC data indicates that near-bottom enhancement of biomass occurs very close to the seabed and was not readily detected above 15m of the seabed. The elevation noted from the sledge appeared to be heavily dominated by organisms greater than 2 mm diameter with a marked shift in the size spectrum in the bottom 10 m. During the subsequent BENBO cruise (CD113) attempts will be made to fish ARIES closer to the seabed than the 15 m possible with the existing altimeter.

Table I. Sledge station details

ARIES station details

		Start					Finish				
Station	OPC data #	Date	time	North	West	Sounding	Date	time	North	West	Sounding
54401 # 8		25/04/98	16:54:43	57.0888	-12.676	1905	25/04/98	21:11:38	57.146	-12.356	1930
54401#12	C05M004.DAT	26/04/98	06:42:43	57.087	-12.637	1906	26/04/98	10:12:21	57.174	-12.315	1929
54402#10	C05M006.DAT	27/04/98	22:49:37	57.490	-15.666	1099	28/04/98	01:15:43	57.384	-15.665	1090
54402#17	C05M008.DAT	28/04/98	15:01:47	57.485	-15.665	1093	28/04/98	19:32:27	57.230	-15.721	1093
54403#4	C05M009.DAT	01/05/98	03:58:32	53.046	-16.879	3558	01/05/98	10:51:18	52.711	-16.901	3558

6.6.3 Downward Particle Flux (Richard Lampitt, SOC)

Deep water flux was measured at sites A and B using Parflux 21 cup sediment traps. With a mouth opening of 0.5m^2, these traps collect settling material during pre-set time intervals which in this case ranged from 7 to 28 days (see report for Charles Darwin cruise 107 for details). These were deployed in September 1997 to provide primary flux to the sediment (i.e. flux just above the benthic nepheloid layer) and flux within the resuspension zone at 100 m above bottom. Both moorings were successfully recovered and apart from the lower trap at site B where the carousel jammed with cup 16 beneath the cone, all operated well. The failure of this trap was due to a faulty "Duracell" within the battery pack. Associated with the traps were current meters and transmissometers.

Both moorings were re-deployed successfully during the cruise at the same locations and with similar configurations for recovery in 1999. However as no recovery cruise dates are presently available, a date had to be assumed and the timing schedule of the trap carousel may well turn out to be less than satisfactory. Cup time intervals were the same for all four traps and ranged from 14 to 56 days with longer intervals at times of expected low flux. As usual, cups were filled with previously collected deep water spiked with 2% borax buffered formaldehyde and sodium chloride to give 5 ppt excess salinity.

Table I. Summary location information for the Parflux sediment trap deployments

Site:	A	B
Position:	52 54.97 N	57 25.32 N
	16 56.33W	15 42.08 W
St Dep. #	XXIV	XXIII
Station:	54403#14	54402#21
Deployment date:	02/05/98	29/04/98
Sounding:	3581 m	1104 m

Table II. Summary sampling information for the Parflux sediment trap deployments

Cup No.	Open Date at 1200h	Open duration (d)

1	03/05/98	14
2	17/05/98	14
3	31/05/98	14
4	14/06/98	14
5	28/06/98	14
6	12/07/98	14
7	26/07/98	14
8	09/08/98	14
9	23/08/98	14
10	06/09/98	14
11	20/09/98	28
12	18/10/98	28
13	15/11/98	56
14	10/01/99	56
15	07/03/99	28
16	04/04/99	14
17	18/04/99	14
18	02/05/99	14
19	16/05/99	14
20	30/05/99	14
21	13/06/99	14
	27/06/99	close

7. SAMPLING PROTOCOL CD 111B

7.1 Alan Hughes (Southampton Oceanography Centre)

'Foraminiferal shell chemistry and faunal characteristics as proxies for benthic organic matter flux and ocean circulation in the palaeoceanographic record: the role of benthic boundary layer processes'

All samples taken for the study of benthic Foraminifera were taken using the Watson-Barnett SMBA multi-corer (internal core diameter 62 mm). From each site three cores were taken for the quantitative analysis of benthic Foraminifera, each from a separate deployment of the multi-corer. These cores were sliced in 0.5 cm sections down to 2 cm sediment depth and in 1 cm sections below this. One core from each station was sectioned to 10-15 cm sediment depth, while the other two replicates were sectioned to 5 cm sediment depth. The surface 1 cm was retained from additional cores to

provide material for taxonomic studies. These samples were all fixed in 4% buffered formalin.

Sections from one core at each site were taken for Transmission Electron Microscopy studies. These sections were fixed in 4% gluteraldehyde buffered with sodium cacodylate.

At Site B the surface sediment (0-1 cm) was retained from 5 cores. This material was stored in filtered seawater in the Constant Temperature room and has been returned to Southampton Oceanography Centre for prelimnary studies on the viability of culturing deep-sea foraminifera at 1 atmosphere pressure.

Table I. Summary sampling information for site A (7/5/98)

Sample	Position	Depth	Notes
54404#10	52° 54.10714' N 16° 55.27299' W	3576.5 m	One core sectioned to 13 cm.
54404#11	52° 54.62150' N 16° 54.80408' W	3576.5 m	One core sectioned to 5 cm. 0-1 & 3-4 cm sections of second core fixed in gluteraldehyde.
54404#12	52° 55.26049' N 16° 54.60615' W	3576.5 m	One core sectioned to 5 cm. 0-1 cm sections were retained from two additional cores.

Table II. Summary sampling information for site B (10/5/98)

Sample	Position	Depth	Notes
54407#7	57° 25.02640' N 15° 44.54865' W	1116 m	One core sectioned to 6 cm. 0-1 cm section was retained from second core.
54407#8	57° 24.67105 N	1114 m	One core sectioned to 10 cm.

	15° 44.06419 W		0-1 cm section was retained from second core.
54407#9	57° 25.13879 N 15° 43.84518 W	1114 m	One core sectioned to 5 cm. 0-1 cm section was retained from second core. 0-0.5 & 3-4 cm sections of third core fixed in gluteraldehyde. The top 1 cm of sediment was removed from a further 5 cores to provide living foraminifera for laboratory studies.

Table III. Summary sampling information for site C (12-13/5/98)

Sample	Position	Depth	Notes
54408#4	57° 07.35.10' N 12° 30.05.20' W	1906 m	One core sectioned to 15 cm. 0-1 cm section was retained from second core.
54408#6	57° 07.42.55' N 12° 30.36.01' W	1906 m	One core sectioned to 5 cm. 0-1 cm section was retained from second core. 0-0.5 & 3-4 cm sections of third core fixed in gluteraldehyde.
54408#10	57° 07.35.01' N 12° 29.35.03' W	1909 m	One core sectioned to 5 cm. 0-1 cm section was retained from second core.

7.2 . Ros Rickaby and Mervyn Greaves (Cambridge University)

'Foraminiferal shell chemistry and faunal characteristics as proxies for benthic organic matter flux and ocean circulation in the palaeoceanographic record: the role of benthic boundary layer processes'

7.2.1. Pore-Water Sampling

The pore-waters were sampled from two mega-cores at each of the three stations to compliment the foram chemistry work performed in conjunction with A. Hughes and A. Gooday. Two similar and undisturbed mega-cores were selected from the same deployment and immediately taken to the controlled temperature laboratory which was maintained at the bottom water temperature of each site. The cores were then extruded and sectioned, using only plastic tools, in 0.5 cm sections down to 2 cm and every cm from 2-8 cm. To obtain sufficient pore-water for both Cd and nutrient analyses it was necessary to amalgamate the sediments from the two cores. All the sectioning was performed in an inert atmosphere provided by a glove bag filled with N_2

and monitored at less than 0.1% O_2. The sediment samples were centrifuged for 20 mins at 2600 rpm in a refrigerated centrifuge at the bottom water temperature. The samples were then returned to the glove bag and the supernatant water drawn into an acid-cleaned 20 ml syringe. The water was filtered through a 0.4um acid-cleaned nuclepore filter. 4ml was subsampled and frozen for nutrient (principally phosphate) analysis and the remaining 15ml was acidified with 10 μl of concentrated HNO_3 and stored for Cd analysis.

7.2.2. Plankton Sampling

Two methods were employed on this cruise to collect planktonic foraminifera. The first was an on-going filtering of the non-toxic supply through a 100 μm polypropylene mesh. The filter was changed every 24 hours and examined for planktonic forams with a microscope. *G.bulloides* and *N.pachyderma (dextral)* dominated the assemblages. The filters collected over the first four days in the vicinity of station A were slightly stained with organic matter. However, on transit to station B (Day 129-130) the mesh collected a very thick layer of green-brown matter, consistent with a doubling of the fluorimetry index noted on the surface log. Moreover the low-resolution satellite images suggest the presence of high chlorophyll concentrations in this area so it is possible that the spring bloom was already starting. The second method of plankton collection involved deploying a 100 μm mesh plankon net on the CTD wire at each of the 3 stations down to 100 m depth. The net was then rinsed down and the effluent collected and frozen.

In each case the forams will be picked according to species and analysed for Cd/Ca, $\delta^{18}O$ and $\delta^{13}C$. It is hoped that the $\delta^{18}O$ analyses, in conjunction with the $\delta^{18}O$ of the CTD samples will allow a control on the depth at which these planktonic forams are adding the majority of their calcite.

Table I. Summary sampling information relating to suspended plankton

Sample	**Day**	**Start Time**	**Lat °N**	**Long °W**
PF1	125-126	08.28	52° 58	12° 59

PF2	126-127	07.52	52° 55	16° 05
PF3	127-128	07.39	52° 54	16° 53
PF4	128-129	07.10	52° 54	16° 54
PF5	129-130	09.17	55° 04	16° 22
PF6	130-131	08.05	57° 25	15° 43
PF7	132-133	06.30	57° 25	15° 43
PF8	133-134	06.27	57° 07	12° 30
PN1	127	17.33	52° 53	16° 54
PN2 (*2)	130	10.30	57° 25	15° 43
PN3	131	15.01	57° 25	15° 39
PN4	133	16.59	57° 07	12° 29

7.2.3. Water Sampling

Surface water samples were collected underway from the bow of the ship using a trace metal clean water sampler consisting of a weighted PVC bucket containing an acid cleaned 1 litre bottle. During sample collection the ship was moving at approximately 1 knot to minimise contamination from the hull. At each station water samples were collected through the thermocline using the CTD/Rosette and 1 litre sub-samples were taken from the Niskin bottles. The water samples were processed as follows.

Cd Samples: (working in the clean container)125 ml water was filtered through a 0.4 μm acid-cleaned nuclepore filter and acidified with 100 μl of QD HNO_3.

$\delta^{13}C$ Samples: A 10ml soda glass ampule was completely flushed with N_2. 10 ml of water was filtered through a 0.4 μm nuclepore filter into the ampule and poisoned with 10 μl $HgCl_2$. The ampule was sealed with a blow torch.

PO_4 Samples: A 250 ml borosilicate glass bottle was filled with unfiltered water and poisoned with 250 μl $HgCl_2$.

$\delta^{18}O$ Samples: Only the CTD samples are to be analysed for $^{\delta 18}O$. 20 ml glass bottles were filled to overflowing with unfiltered water and sealed.

Table II. Summary sampling information relating to surface water samples and CTD samples

Sample	**Depth**	**Day**	**Time**	**Lat °N**	**Long °W**
SSW 1	0	126	12.15	52° 54	16° 53
SSW 2	0	129	09.34	55° 05	16° 22
SSW 3	0	129	15.11	56° 04	16° 06
SSW 4	0	131	16.00	57° 25	15° 39
SSW 5	0	132	10.23	57° 15	14° 12
SSW 6	0	132	16.00	57° 05	12° 29
St. A					
CTD 1	497	128	19.00	52° 54	16° 53
CTD 2	251	128	19.00	52° 54	16° 53
CTD 3	101	128	19.00	52° 54	16° 53
CTD 4	52	128	19.00	52° 54	16° 53
CTD 5	25	128	19.00	52° 54	16° 53
St. B					
CTD 1	250	19.10	130	57° 25	15° 43
CTD 2	100	19.10	130	57° 25	15° 43
CTD 3	64 (max f)	19.10	130	57° 25	15° 43
CTD 4	50	19.10	130	57° 25	15° 43
CTD 5	26	19.10	130	57° 25	15° 43
St.C					
CTD 1	250	19.13	133	57° 08	12° 29
CTD 2	100	19.13	133	57° 08	12° 29
CTD 3	75	19.13	133	57° 08	12° 29
CTD 4	50	19.13	133	57° 08	12° 29
CTD 5	25	19.13	133	57° 08	12° 29

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7.3 Mark Williams (Dunstaffnage Marine Laboratory)
'Organic and inorganic transformations at the benthic boundary layer'

The aim of the work for Leg B of the cruise was to acquire bulk particulate samples from the three BENBO sites for analysis of trace metals. It was envisaged that this would be achieved by three methods. The primary technique was by deploying stand-alone pumps (SAP's) for organic (GFF filters/University of Edinburgh) and trace metal (Nuclepore filters/DML) analysis. CTD casts were used during this leg to acquire mid-depth samples and near bottom samples, and very near bed samples were to be acquired using the Lander syringe system.

7.3.1 Stand Alone Pump (SAP) Deployment

Three pairs of SAP's were deployed at sites A, B and C. One SAP pair contained a GFF and the other a Nuclepore filter, to sample particles for organic (University of Edinburgh) and trace metal (DML) analysis. The option of using a pre-filter (10 μm Nylon mesh) was available. The first two pairs of SAP's were deployed at an intended altitude above the bed of 20m and 50m, while the last pair were deployed at the depth of the sediment trap moorings for those sites. Typically the SAPS were placed at a distance of 2 m apart and the SAP's containing the Nuclepore filters was placed above the one containing the GFF filter. The first SAP was shackled between the line and weight, as no clamps were available. The plastic coated weight used at the base of the SAP's wire was not on board, a lead weight (wrapped in plastic) was used, with a distance of five meters (using a plastic coated wire) between the SAP's and the weight.

Cast 1. Site A. *Water Depth – 3572m, Distance drifted during deployment – 1.648 nm, Pumping time – 2.5h*

This was the first deployment and was characterised by a litany of difficulties. The weather was very poor and hence the SAP's were deployed in conditions of rain, wind, high swell and waves. The length of the SAP's wire (plastic coated wire) was unknown and during deployment the counting sheaf stopped working. Thus the sampling depth of the SAPS were unknown (latter deployments allowed this to be estimated). The SAP's wire was reeled without tension and after a load was placed on it, the wire started to dig into the loose winding on the drum. The wire was unreeled to its full length and then rewound under tension. The records of half of the flowmeter readings were not taken and an accurate knowledge of the volume filtered is unknown. The last pair of SAP's was set at a shallower depth (1000m a.b.), the plastic coated wire did not extend to this height above the bed and the SAP's had to be secured onto the main uncoated wire. Later examination of those filters showed possible contamination from the wire. The wire clamps on the last two SAP's were the wrong size for attachment and required changing on deck. The main winch had a number of problems during its operation, causing a delay of the full deployment of the SAP's. The combination of the delays, resulted in the SAP's pumping for 25 minutes prior to arriving at the required depth. One of the cartridge housing was lost during deployment. All the filters obtained from this deployment were badly ripped.

Table I Summary deployment information relating to deployment of Stand Alone Pumps (SAPs) at Site A

Intended Sampling Depth m	**Actual Sampling depth m**	**Filter Type**	**Prefilter – 10µm Mesh**	**Volume Filtered l**	**Flowrate l/h**	**Comments**
1000	1000	0.4µm	Yes	1638.3	655	Filter torn
1000	1000	GFF	Yes	1447.9	579	Filter torn
50	50	0.4µm	Yes	458.2	183	Filter torn
50	50	GFF	Yes	2428.5	971	Filter torn
20	20	0.4µm	Yes	N/A		Filter torn
20	20	GFF	Yes	N/A		Filter torn

<u>Cast 2. Site B.</u> *Water depth – 1114m, Distance drifted during deployment – 1.164nm, Pumping time – 3h*

The cast at site B was successful. No misfortunes occurred except that after retrieving one of the SAP's, it was found that the housing between the pump and the flowmeter had fractured. The weather was calm and only a slight swell was present. As this was at a shallower depth, all the SAP's could be placed on the SAP's wire. Due to the problems encountered at Site A, a number of changes were made to improve on the performance of the SAP's. This included the removal of the prefilter and using the mesh as a filter support to prevent the filter ripping. An attempt was made to prime the SAP's, but after water was poured into the SAP's it flowed out immediately after the tubing was removed. However, it was decided to fill the unused cartridge housings with Milli-Q to minimise the total air in the system. The SAP pair's were kept near to the surface to allow trapped air to escape, before deploying them deeper. Deployment rate was decreased from the normal 40 $mmin^{-1}$ to 20 $mmin^{-1}$. Probably the largest contribution to the successful deployment at this site was the vastly improved sea conditions.

Table II Summary deployment information relating to deployment of Stand Alone Pumps (SAPs) at Site B

Intended Sampling Depth m	**Actual Sampling depth m**	**Filter Type**	**Prefilter –10µm Mesh**	**Volume Filtered l**	**Flowrate l/h**	**Comments**
300	315	0.4µm	No	2809.5	937	Filter torn
300	315	GFF	No	2390.8	797	
50	65	0.4µm	No	1132.3	377	
50	65	GFF	No	2577.2	859	
20	35	0.4µm	No	1021.5	341	
20	35	GFF	No	-135.1	N/A	Broken Housing

<u>Cast 3. Site C.</u> *Water depth – 1800m, Distance drifted during deployment – 0.006nm, Pumping time – 2.5h*

The cast at site C was successful. It was decided that the GF/F data would not be required from this site and only Nuclepore filters were deployed

for trace metal data. As cast 2 the weather was calm and provided ideal deployment conditions.

Table II Summary deployment information relating to use of Stand Alone Pumps (SAPs) at Site C

Intended Sampling Depth m	Actual Sampling depth m	Filter Type	Prefilter –10µm Mesh	Volume Filtered l	Flowrate l/h	Comments
300	297	0.4µm	No	1149.7	460	
50	47	0.4µm	No	907.6	363	
20	17	0.4µm	No	857.0	343	

7.3.2. CTD Deployments

The CTD deployments were shared with colleagues from University of Cambridge. Typically this meant that 50 l of seawater was available. This was divided between the bottom (30 l) and the depth of the shallower SAP's pair i.e. 1000 m or 300 m (coincident with sediment trap depth), these samples would also support data from the SAP's deployments. The bottom sample will be used for major element analysis by XRF and the mid water sample will provide an indication of the material entering into the BBL, as well as contributing to the calibration of transmissometer data from sediment trap moorings.

Table III. Summary sampling information relating to dips of CTD

Site	Depth m	Bottom Water Temp °C	No 0.4µm Filters	No 10µm Filters	Dissolved Sample Volume l	Volume Filtered l
A	3570 (7m a.b.)	2.75	1	0		29.5
	2570 (1000m a.b.)		1	0	0.5	14.8
B	1112 (5m a.b.)	5.04	1	0		20
	797 (300m a.b.)		1	0	0.5	18
C	1942 (7m a.b.)	3.41	1	0		12
	1642 (300m a.b.)		1	0	0.5	19.5

7.3.3. SEM Samples

From the CTD deployments, 100 ml of water from each depth was filtered through a 25mm 0.4 μm Nuclepore filter to provide samples for SEM examination. It should be noted that no particles were visible on the surface, but if earlier estimates of the SPM concentration were correct approximately 9 μg dry weight should be present. Samples of sediment were acquired during the cruise and with these SPM samples should provide a history of particle characteristics, as the particles settle through the BBL to the sediment surface.

7.3.4. Lander Deployments

Due to time constraints and technical difficulties it was not possible to deploy the Lander for near bottom water sampling until Site C. This set up involved the use of latex free plastic syringes fitted to the Lander, configured in the incubation mode. Stronger springs were fitted and three lengths of tubing were connected, via a manifold, to the three banks of five syringes. Giving a potential total volume of 250 ml per bank. The tubing was fixed at the three heights above the sediment surface (2.0 m, 1.0 m, 0.5 m), determined by the distance from the feet of the Lander. However, after deployment the syringes had only approximately 20 ml per syringe. The samples for each bank of five syringes (representing a single depth) were combined and filtered through a 25 mm 0.4 μm Nuclepore filter. No particles were visible on the filter surface.

7.3.5. Summary

The second leg of this cruise was a reasonable success. The greatest disappointment was the lack of success of the SAP's deployment at Site A. However, some of this data will be available via CTD deployments. The sampling of near bottom water to acquire SPM for XRF is a bonus and will provide a useful comparison with the data from the sediment retrieved in Leg A. Additional samples of SPM for examination by SEM will be of interest, providing sufficient particles are present on the filter. The lack of deployment of the Lander for near bottom sampling at site A and B, and its poor performance at Site C was disappointing. This may be a more significant loss when comparisons are made with post-bloom samples from the next cruise.

7.4. Greg Cowie and Emily Good, Edinburgh University

'Organic and inorganic alteration at the benthic boundary layer'

The goals of the Edinburgh component of the above research programme are:

1. To determine the organic content and composition of sediment trap materials, suspended particles and surficial and deep sediments (representing a sampling transect across the BBL).
2. To assess the relationships between organic matter composition, surface area and mineralogy in order to characterise transformations occurring across the BBL and the role of sorptive processes in determining the fate of organic matter
3. To assess the rates of microbial decay and organic matter desorption associated with resuspension events, via laboratory simulations under quasi natural conditions (high-pressure incubations)
4. To compare these rates to *in situ* degradation rates determined via benthic Lander deployments and shipboard whole-core sediment incubations, and to rates determined in parallel enrichment studies
5. To compare organic matter compositions and decay rates (1-4) before and after the spring bloom in order to assess benthic response to a non-steady state organic input event and consequences for the quantity and nature of organic material ultimately buried.
6. To compare organic compositions and decay rates (1-5) at sites with contrasting input fluxes, depths, benthic populations, sediment accumulation and mixing rates, and bottom-water conditions (BENBO sites A-C).

7.4.1. Sample Collection:

<u>BENBO Site A</u>

a) *Mega-cores*: Two mega-cores were sampled for subsequent analyses. Both were ca. 15 cm in length and had undisturbed interfaces. The first was sampled for solid phase analyses only, at 0.5 cm intervals down to 2 cm, 1 cm intervals down to 16 cm, and 2 cm intervals below. The second core was sampled for pore-water analyses and for solid-phase lipid analyses. It was sectioned at 1 cm intervals down to 2 cm, and at 2 cm intervals below.

Pore-waters were isolated by centrifugation in teflon centrifuge tubes at 5000 rpm for 15 minutes. This was followed by filtration with glass syringes and MilliQ-pre-rinsed disposable Whatman 0.5 micron filter kits. Extrusion and sample handling were carried out in the controlled temperature room. Pore-waters and solids for lipid analyses were stored frozen in pre-combusted glass vials. Other solids were stored frozen in plastic zip-lock bags.

A further mega-core was collected for shipboard whole-core incubation studies (with H. Kennedy), from which samples were collected for analysis in Edinburgh.

b) *Multi-cores*. Eleven undisturbed multi-cores (from 3 drops) were obtained. These were also extruded in the controlled temperature room. Only the surficial 0-0.5 cm interval was collected. Materials from the 11 cores were combined to be used as a substrate in high-pressure incubation studies (see below).

c) *Suspended particles:* Attempts were made to collect suspended particles using SAPS at 3 depths; ca. 20, 50 and 1000 m off bottom, the uppermost corresponding to the sediment trap deployment depth for this site. Pairs of SAPS were deployed at each depth but with different collection filters – GF/F for organic materials, Nuclepore for trace metals (Mark Williams, DML). At the lower 2 depths, 10 μm pre-filters were incorporated for in line particle size fractionation. Rough seas and various technical difficulties led to torn filters at all three depths, although there was a clear colour change at 20 m, indicating a significant suspended load. All filters will be stored frozen until analyzed. No evidence was found for any particulate material on the prefilters at any depth.

d) *Box cores:* A vertical section was made from the opened side of a core collected with the RVS box corer. The slab was collected in a plastic tray and heat-sealed in a plastic bag. It will be refrigerated until analysed by x-radiography.

BENBO Site B

a). *Mega-cores*: Eight undisturbed mega-cores were collected from two drops. Two were sectioned for solids and pore-waters (see description for Site A). Three were sectioned only for the surficial 0.5 cm and these materials were combined for use as substrate in high-pressure incubation studies (see below). A further three were also used to collect the surficial 0.5 cm, the materials again being combined but then frozen for later use as substrates for desorption and incubation experiments in Edinburgh. Finally, a separate core was collected for shipboard incubation studies (H. Kennedy), from which samples were collected for analysis in Edinburgh.

b) *Suspended particles*: SAPS were deployed (as per station A) at three depths (ca. 35, 65 and 315m off bottom). One of the SAPS (35 m) broke during deployment and no material was recovered. The other filters showed little or no discolouration. No prefilters were used. A CTD cast was used to collect water at 7 m off bottom. One hundred liters were filtered through a precombusted 142 mm diameter filter. Some discolouration was observed but likely not be enough material for detailed organic analyses.

c) *Box cores:* Two box-cores were sampled for x-radiography as per site A.

BENBO Site C

Due to restricted time at this site, a reduced sampling program was attempted.

a) *Mega-cores:* Five mega-cores were collected from two drops. Two were sectioned for pore-waters and solids as per site A. The remaining three were sampled only for the surficial 0.5 cm and the combined materials were frozen for later use as substrates in incubation studies.

b*) Box cores*: Two box cores were sampled for x-radiography as per site A.

7.4.2. Incubation studies:

Two types of high-pressure incubation studies were carried out:

a. Short-term studies (as described by B. Ngwenya for CD111A)

b. Long-term studies.

These experiments involve incubation of sediments or desorbed sedimentary organic materials in slurries held at *in situ* temperatures and pressures in stainless steel high-pressure vessels. Decay rates will be compared to those determined for static sediments, either *in situ* (benthic Lander) or on the ship (whole-core incubation), or from substrate enrichment studies (Turley).

The aims of the short-term, time-series experiments (started on CD111A) are to compare, over a period of 2-3 days, the compositional changes occurring in slurries made up of surficial sediment (0-0.5 cm) mixed with different proportions of bottom waters (from mega-cores). Poisoned controls (using $HgCl_2$) are used to distinguish microbial alteration from purely physical desorption effects and to calculate partition coefficients. A separate time series focused on the rate of microbial decay of dissolved organic material desorbed from the sediments. The aim of the long-term experiments is to assess the rates of microbial organic matter decay (again with poisoned controls) using time-series sampling over a period of 6-8 weeks.

Short-term studies:

Incubations from Site A started by Ngwenya/Mowbray on CD111A were processed. This involved gradual depressurisation from 360 bars to atmospheric pressure followed by removal and opening of the heat sealed polyethylene sample bags. The samples were then homogenised and solids

and particles separated by centrifugation and filtration (precombusted GFF). All samples were stored frozen in glass.

Long-term incubations:

These time-series, high-pressure incubation studies were carried out only at sites A and B. Combined surficial sediment samples (see above) were homogenised with bottom water in a 1-liter beaker and 50-60 ml aliquots were taken and sealed in polyethylene bags. Controls were poisoned with $HgCl_2$. The bags were then placed in stainless steel pressure vessels and brought to local bottom-water pressures and temperatures (360 bar and 2 °C for site A, 110 bar and 5 °C for site B). Sediments were kept in suspension by continuous rotation of the vessels. The vessels will be sampled at ca. 1, 3 and 7 days, and ca. every week thereafter for a total of 7 weeks (sampling and storage as per short-term incubations). Duplicate samples were used at all time points.

Analyses:

Sediments, suspended particles and sediment trap materials: Both bulk materials and size-fractions will be analysed (quantities permitting) at Edinburgh for lignin (GC), carbohydrates (GC), and amino acids (HPLC) as well as bulk organic and inorganic C and N. Further analyses will include $^{\delta 13}C_{org}$ (SURRC), surface area (BET, University of Washington), grain size distributions (Edinburgh) and XRD (Edinburgh). Selected samples, time and quantity permitting, will also be analysed for pigments and selected lipids.

Pore-waters: These will be analysed for DON (DML), dissolved amino acids (Edinburgh), and nutrients (DML). These will parallel and complement DOC (University of Wales, Bangor) and trace-metal (DML) analyses. Sample permitting, total dissolved carbohydrate will also be determined (Edinburgh).

Incubation samples: Solids will be analysed for POC, PIC and PON, amino acids, and, in selected cases, carbohydrates (Edinburgh). Liquids will be analysed for DOC (Universty of Wales, Bangor), DON and nutrients (DML), dissolved amino acids (free and combined, Edinburgh) and, in selected cased, total dissolved carbohydrate.

7.5. Joanna Dixon (Plymouth Marine Laboratory)

'Trace metal subsidiary of the microbial investigations'

A small number of seawater and sediment samples were taken for the analysis (time and funding permitted) of the trace metals, Cu, Cd and Pb.

Table I. Summary sampling information for trace metal investigations

Station	Date	Location	Depth (m)	Samples taken			
				MC[1]	Pore water[2]	MC water[3]	SPM[4]
A	7/5/98	52°55'02.28N 16°54'59.28W	3576	✓ (54404#11	✓	✓	✓
B	10/5/98	57°25'13.87N 15°43'84.52W	1115	✓ (54407#9)	✓	✓	✓
C	12/5/98	57°07'56.14N 12°30'22.15W	1913	✓ (54409#4)		✓	

[1]sectioned multi-core every 1cm, stored frozen;
[2]Pore-water obtained by centrifugation in teflon tubes from the top 1 cm sediment, 0.2 μm filtered;
[3]Overlying bottom water siphoned from the collected multi-core and 0.2 μm filtered;
[4]Suspended particulate matter (>0.2 μm) from filtration of the MC water.

The core sections will undergo a three stage sequential leach to determine the carbonate, organic and residual fractions of the particle bound metals, with subsequent analysis by Graphite furnace atomic adsorption spectrophotometry (GFAAS). Seawater samples (i.e. 0.2 μm filtered pore-waters and overlying multi-core water) were sub-sampled as follows;

a) between 20-30 ml were acidified (1:1 HCl, AristaR) and stored in pre-acid cleaned test tubes in the dark at 4°C for the analysis of total dissolved metals (Cu, Cd & Pb) by cathodic stripping voltammetry (CSV),
b) between 20-30 mls were stored frozen in pre-acid cleaned test tubes for the determination of the dissolved organically complexed trace metals by CSV and
c) the remainder of the sample (20-60 ml) was also stored frozen for a complexing capacity titration to determine the complexing capacity (i.e. the stability constant, K) of the sampled seawater

Additionally, sub-samples of the sediment slurry (1:1 with filtered overlying multi-core water) used in the microbiological studies were taken

from each site and stored frozen to investigate the effect of slurrying on the trace metal distributions between the dissolved and particulate phases.

7.6. Carol Turley, Gavin Ruddy and Joanna Dixon (Plymouth Marine Laboratory)

'Estimation of microbial production and decomposition rates in surficial deep-sea sediments'

7.6.1. Introduction

The top 2 cm of five mega-cores were removed and 3 ml samples taken for dry weight and CHN analysis. Further 260 ml volumes of sediment were removed and made into a 1:1 slurry with 0.2 μm filtered seawater overlying the cores for each of the following incubations used in the decomposition experiment: C unenriched, E1 enriched with fluff collected from station C on CD 107, E2 enriched with albumen. Filtered water (FMC) was also incubated as a control. Pore-water, extracted from stations A and B was added (1:1) with overlying water (unfiltered), was also incubated to follow any DOC enrichment from pore-waters. Incubation conditions were at *in situ* pressure (360 atmospheres) and temperature (2-3^{o}C) and times were around 0, 2, 5, 10, 15, 20, 30 days. At each sampling time sub-samples were removed from experiments C, E1 and E2 for bacterial numbers, bacterial DNA synthesis, bacterial protein synthesis, a- and b- glucosidase, amino peptidase and esterase exoenzyme activities, POC, PON, DOC (H Kennedy), DIC (H Kennedy), carbohydrates (G Cowie) and amino acids (G Cowie). FMC was used as a control for exo-enzymatic activities. DOC, DIC, bacterial numbers and DNA synthesis was measured at each sampling time in the Pore-water enrichment experiments. The experiment was carried out at the deepest station A (3570m; 54404#15 and #16; 52^{o}54'67.36 N; 16^{o}53' 42.89 W) prior to a "fluff" fall. Incubations up to 5 days were carried out on board the ship (✓). Those incubations beyond 5 days were carried out at PML after transportation in a refrigerated van from Fairlie (*).

Table 1: Summary of experimental plan and sample volumes. C = unenriched, E1= enriched with fluff collected from station C on CD 107, E2 = enriched with albumen. FMC = Filtered mega-core water, P = pore-water enriched with mega-core water.

Incubation duration		C (1 x 65ml bag) unenriched	E1-fluff (1 x 65ml bag) enriched	E2-albumen (1 x 65ml bag) enriched	FMC water (1 x 5ml bag)	P-Pore-water (1 x 50ml bag)
T=0	day 0	✓	✓	✓	✓	✓
T=1	day 2	✓	✓	✓	✓	✓
T=2	day 5	✓	✓	✓	✓	✓
T=3	day 10	*	*	*	*	*
T=4	day 15	*	*	*	*	*
T=5	day 20	*	*	*	*	*
T=6	day 30	*	*	*	*	*

7.6.2. Effect of pressure on microbial rate measurements

These experiments were carried out at all 3 sites (A: 54404#4; 3572 m; 52°54'19.04 N; 16°53'21.76 W, B: 54407#3; 1115 m; 57°25'24.61 N; 15°44'05.49 W and C: 54409#2;1913 m; 57°05'26.86 N; 12°29'44.67 W) because of their depth variation. The aim was to investigate the effect of pressure on the microbial activity of bacteria in the surficial sediments at the three sites. The top 1 cm of two mega-cores was removed and 3ml samples taken for dry weight, CHN and phospholipid analyses. The sediment was slurried 1:1 with 0.2μm filtered seawater overlying the cores and dispensed into sterile polyethylene bags for replicate measurements of bacterial numbers (AODC), bacterial DNA synthesis (^{3}H-thymidine incorporation), bacterial protein synthesis (^{3}H-leucine incorporation), a- and b- glucosidase, amino peptidase and esterase exoenzyme activities, POC and PON. These measurements were taken before and after 3 hour incubation at *in situ* temperatures but at pressures of 1, 100, 200, 300, and 400 atm.

Table II: Summary of experimental plan, analyses, sample volumes and replicates. Tdr = thymidine incorporation, Leu = leucine incorporation, AODC = bacterial numbers, a-gluc = a-glucosidase activity, b-gluc = b-glucosidase activity, Peptidase = leucine amino-peptidase activity, Esterase = esterase activity. R = replicate numbers, C = controls, t_0 = start of incubation, t_1 = after 3 hrs under the specified pressure.

Sediment Slurry: Bacterial Nos/Production					Bacterial Exoenzyme Activities			
		Tdr	Leu	AODC	a-gluc	b-gluc	Peptidase	Esterase

Pressure (atm)		(0.5ml slurry) 3R + 1C	(0.5ml slurry) 3R + 1C	(1ml slurry) 3R	(3R x 1ml)	(3R x 1ml)	(3R x 1ml)	(3R x 1ml)
1	t_0	N/A	N/A	✓	✓	✓	✓	✓
1	t_1	✓	✓	✓	✓	✓	✓	✓
100	t_1	✓	✓	✓	✓	✓	✓	✓
200	t_1	✓	✓	✓	✓	✓	✓	✓
300	t_1	✓	✓	✓	✓	✓	✓	✓
400	t_1	✓	✓	✓	✓	✓	✓	✓

7.6.3. Determination of free enzymatic activity in pore-waters of deep-sea sediments

This aim of this work component was to see if enzymatic activity is mainly associated with particles as suggested from results from CD 107, with little or no activity free in the pore-waters. Pore-water was extruded and a- and b- glucosidase, amino peptidase and esterase exoenzyme activities determined in 3 replicates of each. This experiment was carried out at station B (54407#13; 1115m; 57°24'56.76 N; 15°41'00.16 W) on extruded, 0.2 μm-filtered pore-water from 4 mega-cores.

7.6.4. Contribution to enzyme sediment pool by deep-sea foraminifera

The aim was to investigate potential foraminiferal contribution to the whole sediment pool of enzymatic activity. This was carried out at station B; (54407#16; 1115m; 57°23'57.11 N; 15°40'53.72 W), on foraminifera picked from the surface of the sediment or just below the surface in 6 mega-core tubes kept at *in situ* temperature. The individual foraminifera were transferred through a series of washes in filtered mega-core seawater and then one of the enzyme substrates inoculated into the filtered mega-core water surrounding the foraminifera and the a- and b- glucosidase, amino peptidase and esterase enzyme activities measured over time. Filtered mega-core water acted as the control. Twelve individuals were selected: 6 *Pelosina* sp. (*arborescens*?); 3 *Astrorhiza* sp. (*limicola*?) and 3 *Rhabdamina* sp. (*abyssorum*?). This was carried out in collaboration with Alan Hughes. Selected individuals were preserved for later confirmation of the indentification.

8. LANDER OPERATIONS, Oli Peppe & Duncan Mercer (Dunstaffnange Marine Laboratory)

8.1. Introduction

The Benbo Lander was delivered to DML several months late, and not in a fully working state. In particular the electronics and software required significant time and effort to ensure the system was in a working condition for CD111. As a result, only minimal sea trials were carried out at DML before the cruise, and no experience was gained with calibrating and using electrodes. For this reason CD111 was regarded as an opportunity for technical sea trials of the Lander, the primary purpose being to gain experience in deploying and recovering the Lander in all its different configurations. Unfortunately this resulted in the demotion of any scientific work to a relatively low priority level.

The Lander was deployed and successfully recovered seven times during CD111. The only configuration in which no data at all was obtained was the gel system. This was due to a fundamental design flaw which was not anticipated and which could not be rectified on ship. The operational experience gained should maximise the opportunity to gather a good set of scientific data during CD113.

The Lander can be set up in 3 main configurations:

Profilur System designed to measure oxygen and pH concentrations in the sediment at very fine resolution (~ 250 um) using micro-electrodes.

Gel System designed to drive gel peeper units into the sediment, and retrieve them at the end of the deployment, for measuring high resolution pore-water profiles.

Elinor A chamber incubation system for measuring oxygen fluxes over long deployments, using both mini-electrodes and a syringe sampling unit. The system is also capable of retrieving a box core.

8.2. Deployment details

Deployment #001_PRF

This first free deployment was aimed purely at gaining experience in deploying and recovering the Lander, and ensuring that the system was working correctly at depth. The system was set up in the Profilur configuration, but with no electrodes fitted.

The deployment ran smoothly, and the Lander descent was tracked using the 10kHz pinger. The descent rate was very fast (roughly 75mmin^{-1}). The ballast had been made slightly on the heavy side (net Lander weight on descent ~80kg) after the wire test had indicated a very slow descent rate of roughly 20 mmin^{-1}.

The system was programmed to do a simple profiling procedure, and analysis of the height data logged indicated correct movement of the profiling rack. The burn wire had been scheduled to fire to release the Lander, but in fact the galvanic release corroded early, and thus the Lander was already on the surface when the burnwire was activated. This inaccuracy in galvanic release specifications led to the decision to rely only on acoustic release and burnwire for the remainder of deployments during CD111.

Once on the surface the Lander was easily located visually, and grappling of the pellet line was no problem. Recovery was made over the stern with the A-frame, but proved problematic due to the heave of the ship (even in the relatively small swell) and lack of recovery line attached to the Lander.

Deployment #002_PRF

Deployment of the Gel system was hoped to be the first opportunity to gather scientific data from the Lander. Making the Lander significantly lighter on descent (~50kg) resulted in a descent rate of ~ 55m/min.

The Lander was scheduled to stay on the bottom for 31 hours, allowing the gels to remain in the sediment for ~ 29 hours. This was slightly short of ideal, but was restricted by operational considerations.

Recovery of the Lander was fast and efficient, with the Lander in-board just 25 min. after being spotted on surface. However an immediate inspection indicated significant problems with the deployment program. The gel profiling rack had not returned to its zero position, and two of wires holding the gel covers had come lose.

An analysis of data logged in the computer and the position of the profiling rack at the end of the deployment indicated that the motor had not driven the gels into the sediment. It was suspected that the motor was not delivering enough force to push the gels into the sediment. This might have been exacerbated by the two gel covers not lifting up because of the wires coming free. Because it was not possible to change gearing on motor on board ship, and because of time constraints on the science schedule, it was decided not to deploy the gel system again on CD111. The motor would be upgraded between CD111 and CD113.

Deployment #003_ELI

The aim was to test all the different parts of the Elinor system in a short deployment not aimed at performing any incubation experiment. The leg height was set conservatively high to ensure that the chamber didn't penetrate too far and stick the Lander on the bottom. The net buoyancy on ascent was also set high at ~100kg. The syringe sampler was set up in two configurations. One, used on 4 ports, drew the sample into glass vials, in line with the syringes. The other, used on the remaining ports, drew the sample directly into the syringes. Oxygen mini-electrodes were also fitted, though only for practise, as no change would be seen over such a short deployment.

After a bottom time of roughly 10 hours, the Lander was recovered. No sediment was in the chamber on retrieval, but this was thought to be due to insufficient penetration into firm layer of sediment. The shovel had released correctly before the Lander lifted off the sea-bed. A problem was also identified with respect to the timing of the syringe sampler (thought to be pressure effects)
which will have to be compensated for in subsequent deployments.

Deployment #004_PRF

Another attempt to obtain some scientific data. The first deployment of Profilur system with electrodes attached was blessed with perfect conditions and a good crane driver!

During bottom program, the system profiled in 250 μm steps, over a total distance of 7 cm. On recovery, after ~ 9 hours on bottom, one electrode was found to be broken. Others appeared intact. Initial analysis of data indicate good results from two oxygen electrodes, and show clearly that one oxygen electrode was broken during

profiling. pH electrodes indicate a constant signal, though one electrode was known to be faulty at beginning of deployment.

Deployment #005_ELI

A long term deployment of the Elinor system at Site A to attempt the first incubation experiment, leaving the Lander *in-situ* during the personnel change over in Galway. This would enable a bottom time of ~4 days which should be sufficient to see a change in oxygen concentrations.

The syringe sampling system was set up without any of the glass vials used in #003_ELI, which had not proved a success. It was decided that the Teflon tubing between syringes and chamber would provide sufficient volume for samples which couldn't be taken from plastic syringes. The legs were set 5 cm lower than #003_ELI in an attempt to insert the chamber deeper into the sediment.

Recovery was in the worst conditions experienced during Lander operations so far, but went without serious mishap. The Argos beacon antenna was again broken. Unfortunately the securing twine on the shovel had failed to break, so no core had been retrieved. Initial analysis of electrode data indicates a decreasing O_2 signal in chamber over duration of deployment, but there was a worrying increase in signal of both chamber and external electrodes over the initial 20 hours.

Deployment #006_ELI

An incubation experiment at site B. Because shallower than site A, shorter deployment time of ~ 2 days planned. A different method of securing the shovel with twine was devised to avoid a repetition of the failure during #005_ELI.

Recovered after 54 hours on the bottom. The core had successfully been retrieved for the first time, but the surface was very disturbed, evidently due to folds caused by shovel action. Initial analysis of the electrode data shows a decrease in chamber O_2 signal during deployment (again), but also the rise in both electrode signals over initial 20 hours, as seen in #005_ELI.

Deployment #007_ELI

A short deployment at Site C principally to obtain near bottom water samples for trace metal analysis using the syringe sampler and tubing rigged at different heights on the Lander frame. It was initially hoped to achieve this as a wire

deployment, but it was decided that it would be too difficult to leave Lander on sea-bed on a wire for sufficient time for any sediment disturbance to settle.

Syringes used were without rubber bungs, which would contaminate the samples. Stronger springs were fitted to syringe sampler to compensate for the lack of bungs, which ease the syringe movement.

After a bottom time of 12 hours, Lander recovered without mishap. Unfortunately the new springs had not proved strong enough to draw samples, and each 60ml syringe only contained ~18mm. However good undisturbed sediment core with overlying water was retrieved. Also some experimentation with electrodes indicated that there maybe a problem with interference on the signals from the stirrer motor.

Table 1. *Summary of Lander deployments*

Dep. #	**001_PRF**	**002_GEL**	**003_ELI**	**004_PRF**	**005_ELI**	**006_ELI**	**007_ELI**
Site	B	B	A	A	A	B	C
Station #	54402 #4	54402 #9	54403 #3	54403 #8	54403 #13	54407 #1	54409 #3
Config.	Profilur	Gel	Elinor	Profilur	Elinor incubation	Elinor incubation	Elinor trace metals
Dep. date	27/04/98	27/04/98	01/05/98	01/05/98	03/05/98	09/05/98	12/05/98
Dep. time	1120	2135	0200	2220	0440	2245	1945
Dep. Pos.	57.44834 N 15.69205 W	57.44822 N 15.69205 W	52.90757 N 16.91362 W	52.90689 N 16.91274 W	52.90655N 16.90927 W	57.38861N 15.71028W	57.12111 N 12.50000W
Dep. Water depth (m)	1102	1102	3570	3573	3570	1103	1905
Rec. date	27/04/98	29/04/98	01/05/98	02/05/98	07/05/98	12/05/98	13/05/98
Rec. time	1600	0550	1410	1025	0905	0545	0920
Rec. pos.	57.74630 N 15.70553 W	57.44844 N 15.68671 W	52.89624 N 16.90557 W	52.90503 N 16.90503 W	52.89861N 16.90778 W		57.13056N 12.49833W
Time on bottom	<3.5	31	9.3	9.5	98	54	12

(hrs)							
Weight on descent (kg)	80	49	52	40	52	48	67
Weight on ascent (kg)	-82	-75	-99	-82	-99	-99	-93
Descent spd (m/min)	75	55	56	54	63	63	68
Ascent speed (m/min)	?	69	73	67	71	64	66
Electrodes fitted	None	N/A	2 O_2 only	4 O_2 2 pH +ref.	2 O_2 only	2 O_2 and pH + ref.	2 O_2 and pH + ref.

Dep. time: time system reset prior to deployment
Dep. pos.: position of ship when Lander released
Rec. time: time Lander completely in-board
Rec. pos.: position of ship when Lander grappled

9. CTD OPERATIONS, RVS Technical staff

The CTD unit on board was a 24 bottle Neil Brown Mkllc Rosette: GO 1016, although we used a 12 bottle frame throughout the cruise. Ten CTD dips were carried out in total. These were primarily to assess the water column properties (in particular the presence/absence of a bottom nepheloid layer) but also to retrieve water samples and samples of suspended particulate material for various scientists. No systematic survey using the CDT was undertaken. Table I below summarises the CTD deployment programme.

The CTD and rosette both worked reliably throughout the cruise with no significant problems. Samples were taken, usually from the first bottle as this was fitted with two reversing thermometers, and the temperatures noted to keep a check on the conductivity and any other errors of the CTD. No appreciable errors were detected.

Table I. *CD 111 CTD Log*

	#	*Date*	*Time (GMT)*	*Depth (m)*	*Co-ord-inates (N/W)*
CD111 A					
Site A	54403#6	01/05/9814:40	3577 m	52 54.3	16 54.6
	54403#15	02/05/9818.46	3576 m	52 54.7	

					16 54.9
Site B	54402#6	27/04/9817:20	1147 m	57 25.5	15 41.3
	54402#18	28/04/9822:24	1100 m	------	
Site C	54401#4	24/04/9816:20	2093 m	57 02.3	16 16.8
	54401#9	25/04/9821:45	1949 m	57 08.4	12 20.9
CD111 B					
Site B	54407#10	10/05/9818:22	1115 m	57 25.2	15 43.2
	54407#11	11/05/9811:00	1118 m	57 25.8	15 43.7
Site C	54409#11	13/05/9817:31	1894 m	57 08.5	12 29.0

Example data for each site is given in Figure 3. The water column structure clearly differs between sites. Site A (deep site) has essentially a two layer structure, with a steep reduction in temperature between 500-1200 m. The other two site display a gradual almost linear reduction in temperature with depth. Of most relevance to many of the BENBO scientists is the between site difference in bottom water temperature. These bottom water temperatures are:

Site A 2.15°C
Site B 6.05°C
Site C 3.12°C.

Figure 4. shows the raw voltage output from the light backscatter instruments mounted on the CTD. A bottom nepheloid layer is evident at all three study sites, usually within the lower-most 50-100 m. The nepheloid layer is more pronounced at site C, with a greater concentration of suspended particulate matter and a thicker nepheloid layer.

10. MOORING OPERATIONS, RVS Technical staff

During the first leg of CD 111, all four moorings at the three sites were recovered, the data down-loaded from the respective loggers, and the

moorings re-deployed having carried out any required maintenance. The sites were visited in reverse order i.e. site C being inspected first.

Site C

The mooring at this station was approximately 320 m long and in 1900 m of water. It comprised of two RCM8 current meters, two transmissometer and marine monitor (MMT) combinations, an acoustic release, and associated buoyancy. It was recovered at 0949Z on the 24/4/98. The lower of the two RCM8's (at a depth of 1875 m) had flooded and there was therefore no data re-coverable from this instrument. The upper MMT (300 m off bottom) had stopped recording on initial deployment, but then re-commenced logging again on the 10/3/98. The lower MMT (50 m off bottom) had a full data record over the whole deployment period, although some of the connectors had corroded badly.
The mooring was re-deployed at 1416Z on the 26/4/98 in a water depth of 1920 m having replaced both MMTs with factory modified ones, and the flooded RCM8.

Site B

At this site there were two moorings; an SC-ADCP in a bottom frame, and a 330 m long single point mooring consisting of two 21-bottle sediment traps, two S4 current meters, two MMT and transmissometer combinations, a release and buoyancy. The single point mooring was recovered at 0715Z on the 27/4/98. The upper MMT (285 m off bottom) had stopped logging immediately on entering the water and had recorded no useful data. The lower MMT (48 m off bottom) had recorded for the full deployment period, but again the connectors were found to be badly corroded. Both sediment traps had complete samples as recorded by their respective schedules. Both S4s had also operated successfully and contained full data sets. The mooring was deployed at 1040Z on the 29/4/98 in a depth of 1104 m.The sediment traps had been serviced, the S4s replaced with RCM8s for operational reasons, and the MMTs replaced with modified ones.

The self-contained ADCP was recovered at 1000Z on the 27/4/98. This had operated reliably and the data set downloaded and the instrument readied for re-deployment. It was re-deployed at 1415Z on the 29/4/98 in a depth of 1100 m.

Site A

This mooring was recovered on the 30/4/98 at 1545Z and was approx. 1000 m long. It included two 21-bottle sediment traps, an RCM8, one S4D, one MMT and transmissometer combination, and a release and buoyancy. The MMT had stopped recording after entering the water. Only one sediment trap had a full set of samples, the lower of the two having stopped operating about half-way through the deployment period. Both the S4D and the RCM8 had successfully collected data. The fault with the sediment trap was investigated and repaired.

The MMT was replaced with a modified one and another MMT and transmissometer combination deployed where planned in the original mooring design, this was not done due to equipment failure on CD107. Also, an RCM8 was substituted for the S4D, the other RCM8 being re-deployed. The mooring was deployed at 1731Z on the 2/5/98 in a water depth of 3572 m.

11. SATELLITE DATA

Processed data from the NASA SeaWiFS satellite indicating surface ocean chlorophyll *a* concentration was received by the *RRS Charles Darwin* in near-real time throughout the duration of CD111. The data is sent by the Ocean Colour Group (Dr. S. Groom & Dr. S. Lavender) at Plymouth Marine Laboratory. The areal coverage of the images was from 5-19 °W and 50-60 °N. Images were received for the following days:

30th April, 1998
7th May, 1998
8th May, 1998
9th May, 1998
10th May, 1998
11th May, 1998
12th May, 1998

Samples of the surface waters were filtered (through Whatman GF/F membranes) and stored under liquid nitrogen in order to measure the chlorophyll *a* concentration using high performance liquid chromatography. These data will be used by PML to calibrate the satellite images. Table I outlines the details of the samples.

Table I. *Sampling details relating to determination of chl a concentration by HPLC*

Sample	Date	Time GMT	Lat-Long	Source	Volume filtered (l)	Comments
I	09-May	1543	56 09 32.27 16 04 29.64	TSG	2	some fluoresence on TSG trace

II	09-May	1838	56 40 29.40 15 55 10.52	TSG	2	evening sunshine
III	10-May	900	57 25 22.22 15 43 33.96	TSG	2	At Site B, CD111B on way back
IV	10-May	1921	57 25 01.3 15 42 56.68	CTD@65m	2	chl maximum on TSG very pronounced
V	11-May	1821	57 25 24.40 15 36 27.44	TSG	2	very sunny!
VI	12-May	905	57 17 51.42 14 37 52.45	TSG	2	Cloudy; en routeSite B-C, CD111B
VII	12-May	1252	57 09 58.81 13 21 48.47	TSG	2	cloudy; scattered sunlight
VIII	13-May	1145	57 08 05.19 12 29 45 95	TSG	2	misty; no sun!
IV	15-May	1913	57 08 39.20 12 29 02.33	CTD@50m	2	sampled in the chl sub-surf. maximum

12. CONCLUSIONS

CD 111 was, on the whole, a highly successful cruise. A major contributing factor to this was the remarkably good weather for the time of year. Most of the scientific activities progressed with only minor problems, and it appears that we achieved a true pre-bloom period (although surface water indications toward the end of the cruise indicate that the bloom was just starting). The cruise provided a good opportunity for scientists to fully develop and test their protocols, many of which were also to be used on CD113. Overall, the cruise was characterised by a pleasing degree of co-operation and collaboration between the different scientific groups.

The Lander was field-tested successfully, and some (limited) scientific results were forthcoming. The cruise highlighted several aspects of using such an instrument. The preparation time required to ready the Lander is of the order eight hours, and two people were needed to construct and launch any of the single models. Back-to-back change-overs from one module to another often required technical staff to work in excess of 16 hours. The cruise demonstrated the utility of the Lander, but the limited penetration of the gel

peepers into site B sediments illustrates that some preliminary idea of sediment stiffness is always useful. The cruise also enabled the scientists, technicians and ship's crew to investigate the best method of launching and retrieving the Lander. Much beneficial knowledge - scientific as well as logistical - has been gained from use of the Lander on this cruise which be of use to future users.

The moorings were successfully turned around and re-deployed. Problems were encountered during deployment of the Stand Alone Pumps (SAPS). It appeared difficult to deploy the SAPS in anything but the calmest seas, due to breakage of the filter papers. Seabed coring was generally successful, however substantial difficulties arose when attempting to use the mega-corer at our deep site (site A). Often the instrument returned empty, evidently not impacting the seabed at all. The difficulty appears to be a problem of unknown deep currents, which influence the instrument, and the difficulty in reckoning the ship's movement to compensate for this. Neither of the two common approaches of i) to let the ship drift during wire out, or ii) maintaining the ships position at a fixed site, appears to be better. In such instances, we rely heavily on the experience and ability of the ship's officers and crew. Failure to obtain bottom sediments at site A wastes much time, owing to the large water depth (corer turnaround time *c.* 3 hours). I wonder if it might be fruitful to undertake a modelling study of this phenomenon to help scientists sample in deep ocean waters with this piece of equipment? Certainly a frame-mounted, full ocean depth camera would immediately identify the cause of the mis-firing and would be extremely useful to scientists actually at sea.

This cruise builds upon the site survey work conducted on CD107, and it's success should ensure that BENBO as a whole achieves a large part of it's aims and objectives. The experimental frame of work established on this cruise has been invaluable, and should contribute to an even greater degree of success on the next BENBO cruise (CD 113).

Appendix I

Cruise Log

Date	SOC#	Activity	Time Start	Time Stop	Water depth/m	Lat-Long
CD 111A						
Station C						
24/04/98	54401#1	mega-core	03:20		1922 m	57 05 34.55 12 31 49.21
	54401#2	mega-core	05:51	07:16	1932 m	57 05 12.85 13 31 11.89
	54401#3	lander (wire test)	08:55	11:40	1970 m	
	54401#4	CTD	16:20	18:16	2093 m	57 02 20.38 12 16 56.76
25/04/98	54401#5	box-core	07:16		1923 m	57 05 36.73 12 31 38.23

	54401#6	mooring rec.	09:05	10:40	1922 m	57 06 16.17 12 29 12.20
	54401#7	sledge run	11:55	16:03		57 08 35.22 12 24 42.90
	54401#8	ARIES run	17:36	20:32	1932 m	57 08 48.47 12 23 35.56
	54401#9	CTD	21:45	23:10	1949 m	57 08 24.00 12 20 54.00
	54401#10	mega-core		20:29	2026 m	57 05 30.46 12 18 13.09
26/04/98	54401#11	sledge run	02:50	06:12	1900 m	
	54401#12	ARIES	07:00		1901 m	
	54401#13	mooring deploy.	12:00	14:16	1920 m	57 05 42.70 12 29 03.07
Station B						
27/04/98	54402#1	box-core	03:19	03:54	1100 m	57 26 52.80 15 40 45.60
	54402#2	mooring rec.	06:00	08:37	1101 m	57 27 43.70 15 41 44.20
	54402#3	ADCP rec.	10:14	10:34	1102 m	57 26 20.76 15 41 49.58
	54402#4	Lander deploy. (PRF)	11:24	15.55	1102 m	57 26 54.55 15 41 31.18
	54402#5	sledge run	12:50	15:10	1089 m	57 30 34.74 15 38 55.56
	54402#6	CTD	17:20		1147 m	57 25 28.78 15 41 19.28
	54402#7	mega-core	18:30	19:31	1145 m	57 26 18.20 15 41 34.65
	54402#8	mega-core (re-try)	21:00	20:52	1103 m	57 24 46.28 15 41 06.80
	54402#9	Lander deploy. (GEL)	21:47		1100 m	57 29 40.57 15 41 15.21
				28/04/98		

	54402#10	ARIES run	23:00	02:15	1100 m	57 29 40.20 15 39 25.14
28/04/98	54402#11	sledge run	02:42			57 29 32.22 15 39 24.26
	54402#12	mega-core		08:43	1102 m	57 25 31.83 15 40 42.12
	54402#13	mega-core	09:13	10:03	1100 m	57 25 35.85 15 40 52.87
	54402#14	box-core	11:11		1097 m	57 25 23.45 15 40 21.13
	54402#15	box-core		13:09		57 25 23.45 15 40 21.13
	54402#16	ARIES run	14:30	14:37		
	54402#17	ARIES run	15:10	19:33		
	54402#18	CTD	22:24	23:42		
			29/04/98			
	54402#19	ARIES run	00:17	00:23		57 30 07.20 15 39 34.20
29/04/98	54402#20	Lander rec.	05:10	05:50		57 26 37.24 15 41 16.11
	54402#21	mooring deploy.	10:40		1102 m	57 24 55.10 15 41 46.11
	54402#22	ADCP deploy.	14;08		1100 m	57 24 47.68 15 41 52.67
Station A						
30/04/98	54403#1	mooring rec.	15:30	17:00	3566 m	52 56 26.85 16 55 06.98
	54403#2	mega-core	18:11	20:45	3577 m	52 55 11.35 16 55 11.82
			01/05/98			
01/05/98	54403#3	lander deploy.	02:21			52 54 25.60 16 54 42.30
	54403#4	ARIES run	04:45			

	54403#5	Lander rec.	13:30			52 53 59.53 16 54 21.65
	54403#6	CTD	14:40	17:55		52 54 25.27 16 54 25.27
	54403#7	mega-core	18:14			52 54 27.44 16 54 58.32
	54403#8	lander deploy. (PRF)	22.36			52 54 24.68 16 54 46.19
	54403#9	mega-core	23:40	03:00		52 54 52 87 16 54 57.84
02/05/98	54403#10	box-core	05:25	07:30		
	54403#11	box-core	07:45	09:11		
	54403#12	Lander rec.	10:20			
	54403#13	mega-core	11:20	14:00		52 55 10.95 16 53 37.09
	54403#14	mooring deploy.	16:00	18:13		52 54 34.80 16 56 12.00
	54403#15	CTD	18:46	21:16		52 54 43.12 16 54 58.09
				03/05/98		
	54403#16	sledge run	21:55	03:23		52 54 39.90 16 55 38.40
03/05/98	54403#17	Lander deploy.	04:57			52 54 14.52 16 54 24.00

CD 111B

Station A

06/05/98	54404#1	mega-core	11:45	14:15		52 54 52.47 16 54 24.79
	54404#2	surface water sample	14:15			52 54 21.00 16 53 30.60
	54404#3	mega-core	14:48	17:28	3382 m	52 54 13.28 16 53 33.58
	54404#4	mega-core	17:50	20:12	3563 m	52 54 18.51

						16 54 38.27
				07/05/98		
	54404#5	SAPS deploy.	21:50	07:00		52 55 33.22 16 54 38.96
07/05/98	54404#6	Lander rec.		08:37		52 54 09.91 16 54 26.09
	54404#7	box-core	10:16	13:02		
	54404#8	mega-core	13:44	16:44	3576 m	52 55 20.57 16 53 00.45
	54404#9	plankton net	17:33	17:53		52 54 40.20 16 55 10.80
	54404#10	multi-core	18:10	20:45		52 53 45.28 16 54 51.07
				08/05/98		
	54404#11	multi-core	21:24	00:08	3576 m	52 55 02.28 16 54 59.28
08/05/98	54404#12	multi-core	01:05	03:55		52 55 15.60 16 54 34.80
	54404#13	box-core	04:56	07:32		
	544047#14	mega-core	08:37	11:16	3597 m	52 55 02.13 16 54 51.07
	54404#15	mega-core	11:37	14:12	3568 m	52 54 58.70 16 52.9813
	54404#16	mega-core			3570 m	52 54 40.20 16 53 25.20
	54404#17	CTD	18:20	20:45		52 54 57.00 16 55 13.80
Passage to Station B						
09/05/98	54405#1	surface water sample	09:30			55 05 19.20 16 53 29.40
	54406#1	surface water sample	15:11			56 04 00.00 16 05 31.80
Station B						

09/05/98	54407#1	Lander deploy.	22:52		1100 m	57 23 18.71 15 42 38.62
			10/05/98			
	54407#2	SAPS deploy.	00:30	07:55	1100 m	57 23 54.00 15 45 04.80
10/05/98	54407#3	mega-core	07:40		1115 m	57 25 24.61 15 44 05.49
	54407#4	box-core	09:15	10;16	1112 m	57 25 15.71 15 43 19.66
	54407#5	plankton net	10:30	11:06	1103 m	57 25 22.64 15 43 58.22
	54407#6	mega-core	11:21		1109 m	57 25 00.10 15 43 24.09
	54407#7	multi-core	13:29	14:23		57 25 01.56 15 44 32.40
	54407#8	multi-core	15:06	16:07		57 24 40.20 15 44 03.84
	54407#9	multi-core	16:30	17:30		57 25 08.40 15 43 50.40
	54407#10	CTD	18:22	19:25		57 25 10.68 15 43 11.17
11/05/98	54407#11	CTD	11:00	11:56		
	54407#12	mega-core	13:00	14:05		57 24 37.46 15 42 03.28
	54407#13	mega-core	14:25			57 24 56.76 15 41 00.16
	54407#14	plankton net	15:01	15:41		57 25 26.41 15 39 46.03
	54407#15	box-core	16:18	17:20		57 25 30.60 15 38 57.00
			12/05/98			
	54407#16	mega-core	03:40	04:50		57 23 34.20 15 40 31.80
12/05/98	54407#17	Lander rec.	05:26			57 23 17.27 15 42 53.11

Passage to Station C

12/05/98	54408#1	surface water sample	10:20			57 15 03.00 14 12 08.40

Station C

12/05/98	54409#1	box-core	15:52		1913 m	57 04 59.91 12 30 20.74
	54409#2	mega-core	17:58	19:43		57 05 26.86 12 29 44.67
	54409#3	Lander deploy.	19:51			57 07 18.45 12 29 59.65
	54409#4	multi-core	20:27	21;14		57 07 56.14 12 30 22.15
				13/05/98		
	54409#5	SAPS deploy.	11:20	05:15		
13/05/98	54409#6	multi-core	06:08	07:45		57 07 42.55 12 30 36.01
	54409#7	Lander rec.	09:08			
	54409#8	mega-core	10:26	11:19		57 07 33.88 12 29 46.71
	54409#9	box-core	11:49			
	54409#10	multi-core	14:40			
	54409#11	plankton net	17:00			57 07 23.40 12 29 16.20
	54409#12	CTD	17:31	19:12	1894 m	57 08 38.94 12 29 00.66
	54409#13	box-core	19:59	21:35		57 07 31.14 12 29 53.82