Cruise Report

RRS Charles Darwin Cruise 113

28th June – 22nd July, 1998

Principal Scientist

K.S. Black

'....there must still be many strange things yet to be discovered in this hidden realm, and it really is not so very far away. Half a day's steaming to the west of Ireland or Scotland and the ocean floor will be more than three thousand feet below us; in but a few hours it will be over a mile deep'

SIR ALASTAIR HARDY (1956)

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Scientific Party

CD 113A

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A HARRIS	SOC
M GREAVES	Cambridge Uni
M WILLIAMS	DML
S MOWBRAY	Edinburgh Uni
E GOOD	Edinburgh Uni
D HUGHES	DML
O PEPPE	DML
I BENTALEB	UWB
G FONES	Lancaster Uni
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CD 113B

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R ROBERTS	RVS
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R PHIPPS	RVS
J WYNAR	RVS

Ship's Company

R. CHAMBERLAIN (Master)
A MACKAY
S SYKES
M HOOD
B RANT
I BENNETT
B MACDONALD
R PERRIAM
D LUTEY
T POOK
K LUCKHURST
B JOHNSON
J DALE
M SQUIBB
S DAY
R BELL
P LYNCH
C DILLON
A DUNCAN
S SHIELDS
P SEARLE

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 third in a series of three field reports and describes the scientific activities on the 113th voyage of the *RRS Charles Darwin*.

CD 113 was mounted during June-July, 1997, and was designed to sample the ocean water column and the seabed subsequent to the spring surface ocean phytoplankton bloom. This cruise therefore complements CD111, which was mounted just prior to the bloom period, and indeed the scientific activities on each of these mission is much the same. The cruise was divided into two legs on account of the pressure for berths. The vessel sailed from, and returned to, Fairlie on the estuary of the Clyde. It sailed first to site C, then to site B and then continued south to site A. This leg is referred to as CD 113A. The ship then sailed to Galway port to exchange scientific personnel. A return trip around the three experimental sites in the order site A – site C – site B was completed before returning to Fairlie. This leg is referred to as CD 113B.

Acknowledgements
CD113, like it's sister cruise, was a busy affair owing 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 once again 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 Roger Chamberlain and his crew for contributing to the success of the final process cruise of BENBO. The guys and girls in the kitchen, and their remarkable ability to produce four star meals in the worst of weather (which we experienced), 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).

2. ITINERARY

Sailed Fairlie	28th June, 1998
Galway scientific personnel transfer	12th July, 1998
Arrived Fairlie	22nd July, 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. The first Leg of CD113 was devoted to oxygen micro-profile and gel work, and the second Leg devoted to chamber work. The mooring at site C only was 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

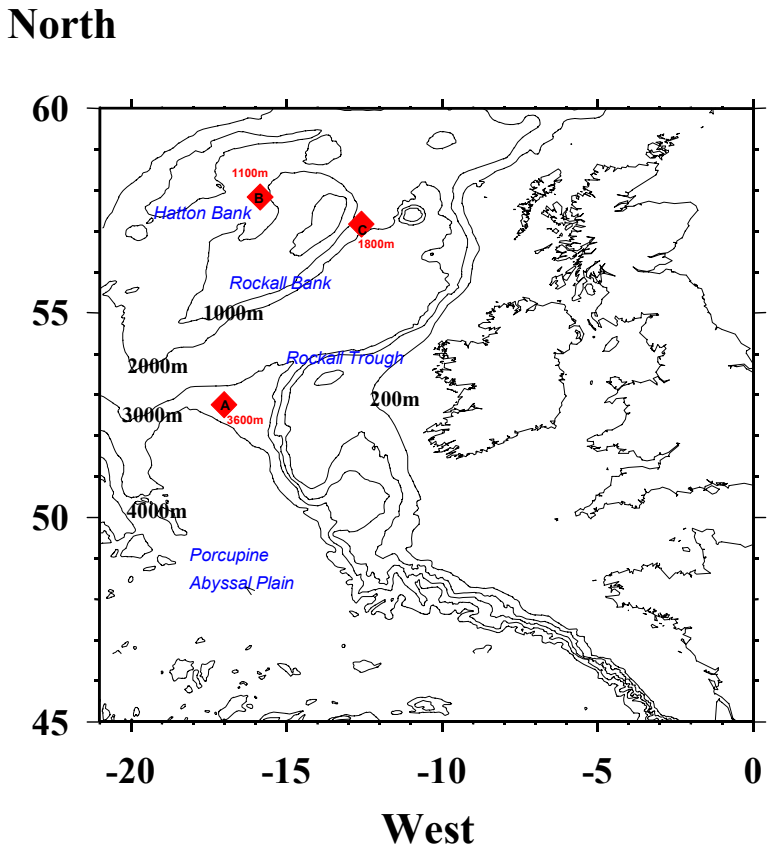

Diagram courtesy of Dr. R. Lampitt (SOC)

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). However, periodically bad weather, lost seatime associated with the loss of the MLA/SOC ARIES instrument and some riding problems with the main winch altered the site visitations on Leg B to site A → site C → site A.

5. DIARY OF EVENTS

Compiled by Ship's Master, R. Chamberlain

Date	Time BST	Events	Approx. Position
28/06/98	0900	Safety familiarisation briefing of scientific personnel.	
28/06/98	1359	*Sailed Fairlie* - clear of the berth.	
	1430	Clear of Hunterston Channel - Full ahead on passage.	
	1600-20	Emergency muster and Survival craft drill for all personnel.	
29/06/98	0500	Reduced revs due to head on seas.	
	0935-1000	Streaming cable for tightening purposes	
30/06/98	0156	Lander slipped	57 01N 012 30W
	0912-1118	Current Meter Mooring "C" recovered	57 06N 012 30W
	1218-30	Interrogating lander	
	1542	PES Fish deployed	
	1628-1810	CTD cast outboard Station	57 05N 012 30W
	1909-2057	Mega-corer cast outboard	
	2146-2334	Mega-corer cast outboard	
	2349-0136/01	Mega-corer cast outboard	
01/07/98	0229-0415	Boxcorer cast outboard	
	0438-0606	Mega-corer cast outboard	
	0915-1008	Lander recovered	
	1125-1538	Aries cast outboard	
	1717-1921	CTD cast outboard	
	2009	Lander slipped	57 04N 012 29W
	2129-2240	Current Meter Mooring deployed	57 02.4N 012 28.9W
	2340-0217/02	Camera cast outboard	57 03N 012 32W
02/07/98	0440-0531	Lander recovered	
	0531-1638	Steaming to site "B"	
	1640-1811	Camera cast outboard Stn	57 25N 015 44W
	1906	Lander slipped	57 24N 015 45W
	1951-2058	Mega-corer cast outboard	
	2116-2218	Mega-corer cast outboard	
	2311-0157/03	Aries cast outboard	
03/07/98	0419-28	Sorting out riding turns on winch	
	0547-0632	Lander recovered	
	0714-0804	Boxcorer cast outboard	
	0841-0950	Mega-corer cast outboard	
	1019-1124	Mega-corer cast outboard	
	1230-1526	Aries cast outboard	
	1603-55	CTD cast outboard	
	1727-1819	Mega-corer cast outboard	
03/07/98	1904	Lander slipped	
04/07/98	1010-1114	CTD cast outboard	
	1239	Aries cast outboard	
	1411	Indications that WE HAVE LOST ARIES	
	1514	Positive proof - NO ARIES	
	1530-1910	Searching for ARIES	
	1910-0430/05	A series of Ground wire/grapnel casts to recover ARIES.	
05/07/98	0511-53	Lander recovery	
	0626-1145	2 Further attempts to recover ARIES	

	1148-1400/06	Steaming to site "A"		
06/07/98	1441-1727	Mega-corer cast outboard Stn	52 54N	016 54W
	1612-1700	Avon Searider launched for off-ship sampling		
	1753	Lander released		
	1950-2213	CTD cast outboard		
	2228-0157/07	Camera cast outboard		
07/07/98	0440-0552	Lander recovery		
	0617-0917	Mega-corer cast outboard		
	1022	Lander released		
	1102-1416	Boxcorer cast outboard		
	1530-2055	Aries cast outboard		
	2131-0026/08	Multi-corer cast outboard		
08/07/98	0158-0445	CTD cast outboard		
	0548-0854	Mega-corer cast outboard		
	1026-1319	CTD cast outboard		
	1403-1908	Aries cast outboard		
	2010-2134	Lander recovery		
	2205-0122/09	Mega-corer cast outboard		
09/07/98	0138-0449	Mega-corer cast outboard		
	0741	Lander released		
	0854	PES Fish inboard		
	0900	Set Course for Galway Full ahead	52 55N	016 55W
10/07/98	1045	Approaching Galway		
	1300	Hove to awaiting transfer of personnel		
	1337	Boat transfer of personnel & equipment completed		
	1348	Outward bound full ahead		
	1715	Vessel labouring - reduced speed in heavy weather.		
11/07/98	0000-2359	Steaming to stn "A" in heavy seas - vessel labouring		
12/07/98	0000-0400	Hove to in heavy weather		
	0400-1118	Laboured steaming to stn "A"		
	1120	PES fish outboard		
12/07/98	1205-1514	CTD cast outboard	52 55N	016 55W
cont.....	1756-2054	CTD cast outboard		
	2123-0025/13	Boxcorer cast outboard		
13/07/98	0059-0419	Boxcorer cast outboard		
	0516-0810	Multi-corer cast outboard		
	0850-1135	Multi-corer cast outboard		
	1204-1500	Multi-corer cast outboard		
	1529-1808	Multi-corer cast outboard		
	1917-2227	Mega-corer cast outboard		
	2337-0708/14	SAPS cast outboard		
14/07/98	0751-1055	Boxcorer cast outboard		
	1154-1442	Multi-corer cast outboard		
	1516-1755	Multi-corer cast outboard		
	1730-1838	Lander recovery		
	1915-2329	Bed-hop camera cast outboard		
	2330	Steaming to next site		
15/07/98	0000-2400	Vessel steaming to next site.		
16/07/98	0430	Lander released	57 05N	012 30W

	0535-0710	Mega-corer cast outboard		
	0758-0943	Mega-corer cast outboard		
	1016-1158	Mega-corer cast outboard		
	1212-1349	Boxcorer cast outboard		
	1426-1607	CTD cast outboard		
	1641-1810	Multi-corer cast outboard		
	1849-2027	Multi-corer cast outboard		
	2138-2326	Boxcorer cast outboard		
17/07/98	0005-0247	Bed-hop camera cast outboard		
	0338-0931	Agazziz Trawl cast outboard		
	0948-2400	Labouring to Site B in rough weather		
18/07/98	0000-0836	Improved steaming to B		
	0843-0950	ADCP recovered	57 25N	015 41W
	1103-1205	Mega-corer cast outboard		
	1235-1340	Mega-corer cast outboard		
	1400-52	Mega-corer cast outboard		
	1510-1601	Boxcorer cast outboard		
	1637-1731	Multi-corer cast outboard		
	1756-1849	Multi-corer cast outboard		
	1912-2005	Multi-corer cast outboard		
	2040-2231	Bed-hop camera cast outboard		
	2247-2344	CTD cast outboard		
19/07/98	0000-0603	SAPS cast outboard		
	0713-59	Kasten Core cast outboard		
19/07/98	0843-0943	Boxcorer cast outboard		
cont.....	1001-1144	Bed-hop camera cast outboard		
	1200-57	Mega-corer cast outboard		
	1325-1424	CTD cast outboard		
	1541-1639	Boxcorer cast outboard		
	1701-57	Boxcorer cast outboard		
	1806	Set course for site C		
20/07/98	0000-2100	Hove to due to inclement weather		
	2100-0700/21	Making as much E ly departure as is practicable.		
21/07/98	0700	Hove to on Lander site.	57 04N	012 30W
	0848-52	Lander grappled and brought aboard		
	0907	PES Fish inboard		
	0918	Full ahead for Fairlie		
22/07/98	1300	*Arrival Fairlie*		

6. SAMPLING PROTOCOL CD 113A

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 113A and CD 113B, 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 113A

6.1.1. Ihlem Bentaleb, Hilary Kennedy and David Thomas (University of Wales, Bangor; report for CD113A & B)

'Carbon cycling in the benthic boundary'

The aim of this project is to develop a better understanding of organic matter mineralisation in the benthic boundary layer. As a result of bacterial remineralisation of organic matter in the sediments (SOM), the concentration of dissolved organic matter (DOM) or more specifically dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) 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 (and DOP, DON referred to dissolved organic nitrogen and phosphate), metals, nutrients, ^{13}C-DIC and ^{13}C-DOC and cadmium by sectioning mega- cores under a N_2 atmosphere. The resolution of surface sectioning of the cores was 0.5 cm , grading up to 2 cm sections towards the bottom of the core. Between 3 and 4 mega-cores were sectioned in order to obtain sufficient pore-water for the different analyses. 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. ^{13}C-DIC samples were poisoned with mercuric chloride and sealed in glass ampoules. Nutrient, DOM and ^{13}C-DOC samples were stored frozen.This work is part

of a collaboration with Cambridge (M. Greaves).

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

Stations	Operation	Date	Depth (m)	Longitude W	Latitude N
C	54701-5	29-6-98	1965	12° 29.34	57° 06.42
B	54702-8	3-7-98	1104	15° 44.31	57° 24.25
A	54703-1	6-7-98	3560	16° 54.05	52° 54.36
C	54705-2	16-7-98	1935	12° 31.15	57° 05.12
C		17-7-98	1935		
B	54706-6	18-7-98	1094	15° 41.31	57° 24.24

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 litres capacity and has 15 syringe attachments to allow a time course of samples to be withdrawn or injected. The depressed syringes are attached to the benthic chamber through teflon tubing filled with a known volume of milliQ water. An initial deployment was made at site A for 5 days. The first syringe was used to inject a super-saturated NaBr solution in the benthic chamber in order to quantify the volume of the overlying water within the benthic chamber. 14 syringe samples were sampled for triplicate nutrients, ^{13}C-DIC and carbohydrate and the 14 teflon tubes were sampled for the DOC and nutrients. Each time course has been sampled twice (see Table II). The spade to the box core had not closed and so it was not possible to sample the sediment. The O_2 electrodes broke during this deployment.

At Site C the Lander was deployed for 5 days. The same chemical tracer was injected into the chamber during the incubation to determine the volume of the overlying water. This deployment collected 14 syringe samples, 14 teflon tubings, 10 cm sediment and bottom water from external bottles attached to the lander. When the Lander was retrieved there was no overlying water left in the chamber and the surface sediment had been slightly disturbed. The 0-1 cm of sediment has been sampled for pore water analysis. Samples for DOC, DON, DOP, nutrients, ^{13}C-DOC, ^{13}C-DIC, carbohydrates have been taken. The bottom water from the external bottles was used for O_2 calibration and also for the complete set of samples we needed.

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

Station	Operation	Date	Depth (m)	Longitude W	Latitude N
A	57703#17	9-7-98	3560	16° 53.01	52° 55.47
C	54705#1	16-7-98	1935	12° 30.04	57° 04.52

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 was siphoned off leaving a small volume (approx 600 cm^3) in which the change of concentration of nutrients, DOC, ^{13}C -DIC, and carbohydrates could be monitored. In site A and C, three or four cores were running during the time course of the lander. A daily sampling has been performed. In site B, we sampled twice a day due to the shorter time schedule.

Parallel to our incubations, samples for DOC and ^{13}C -DIC were collected from mega-cores from the same locations in the incubation studies of Cowie *et al.* (Edinburgh University) that were performed under closed systems (see Cowie's cruise report).

6.1.1.4. Bacterial decomposition experiment

In collaboration with Turley *et al.* (PML) the role of bacteria in the production of DOC and DIC in the sediment pore waters was investigated. Samples will be taken at time intervals over a period of 45 days in conjunction with Turley et al..

In site A an incubation of water overlying a mega core with pore water was made to determine the rate at which bacteria in bottom waters can oxidise DOC.

In site C, an overlying 'fluff' layer was collected from few cores. The fluff was incubated with sediment to determine bacterial responses to pulses of organic material settling on the sea floor. Samples were collected to complement short term hydrolytic enzyme experiments performed by Turley et al. Again these were taken at both sites (see Turley's cruise report)

6.1.2. 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'

6.1.2.1 Pore-Water and Sediment Core Sampling

Pore-water sampling on this cruise was carried out working with Ilhem Bentaleb from Bangor. Three mega-cores were sectioned at each of the three stations, the Cambridge interest being to compliment the foram chemistry work we are doing in conjunction with A.Hughes and A.Gooday. Three similar and undisturbed mega-cores were selected, where possible from the same deployment, and immediately taken to the CT lab which was maintained at the bottom water temperature of each site. The cores were extruded and sectioned in a glove-bag under nitrogen, the oxygen concentration being maintained at less than 0.1%. Using plastic tools, 0.5cm sections were taken down to 3cm depth, then 1cm sections down to 10cm and 2cm sections below. To obtain sufficient pore-water for the analyses the sediments from the three cores were amalgamated. The sediment samples were centrifuged for 20mins at 4500rpm in a centrifuge cooled to the bottom water temperature. The samples were then returned to the glove bag and the supernatant water was drawn off with a syringe appropriate to the required analysis. Sampling of the pore-waters specific to the Cambridge project is described here while samples taken for the work at Bangor are detailed elsewhere. The water for cadmium determination at Cambridge was sampled with an acid cleaned polypropylene syringe and filtered through a 0.4μm acid-cleaned nuclepore filter. After removal from the glove-bag these samples were acidified with 10μl of concentrated HNO_3 and stored ready for Cd analysis. 4ml samples were taken for nutrient determination required by both groups and stored frozen.

An additional core from each site was sectioned down to 10cm depth and the sediment stored in the coldroom. These samples will be sieved and picked for forams as required for analyses at a later date.

6.1.2.2. Plankton Sampling

Planktonic foraminifera were collected using an on-going filtering of the non-toxic supply through a 100μm polypropylene mesh. The filter was changed every 24

hours and stored for later examination. The filters collected on this cruise, after the spring bloom, contained noticeably less material than those collected on cruise CD 111B, consistent with the much lower fluorimetry index observed on the surface log. A second method involving the deployment of a 100um mesh plankon net on the CTD wire down to 100m depth was planned but was unable to be used because of time and weather constraints.

The forams will be picked according to species and analysed for Cd/Ca, $^{\delta}$18O and $^{\delta}$13C together with those collected earlier on cruise CD 111B. It is hoped that the $^{\delta}$18O analyses, in conjunction with the $^{\delta}$18O 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 table of planktonic foram sampling strategy*

SAMPLE	DAY	START TIME	LAT °N	LONG °W	LOCATION
PF1	180-181	08.10	56° 02’	08° 39’	Passage
PF2	181-182	08.05	57° 06’	12° 30’	Site C
PF3	182-183	09.45	57° 02’	12° 30’	Site C
PF4	183-184	10.25	57° 16’	14° 11’	Passage
PF5	184-185	08.25	57° 24’	15° 44’	Site B
PF6	185-186	09.05	57° 26’	15° 45’	Site B
PF7	186-187	10.20	57° 26’	15° 43’	Passage
PF8	187-188	13.30	52° 55’	16° 54’	Site A
PF9	188-189	12.30	52° 55’	16° 54’	Site A
PF10	189-190	14.50	52° 53’	16° 54’	Site A

6.1.2.3. Water Sampling

Surface water samples were collected between stations using a trace metal clean surface water sampler deployed from the bow of the ship while underway. At each station the CTD was used to collect water samples through the thermocline, together with a bottom water sample taken to complement the pore-water work. Additionally, at site A the weather permitted collection of a trace metal clean surface water sample away from the ship using the inflatable boat.

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

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

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

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

Table II *Summary table of pore-water sampling strategy*

SAMPLE	DEPTH	DAY	TIME	LAT °N	LONG°W
SSW 1	0	180	09.00	56° 04’	08° 45’
SSW 2	0	183	10.00	57° 15’	14° 07’
SSW 3	0	186	13.00	57° 03’	15° 51’
SSW 4	0	187	09.40	53° 32’	16° 45’
SSW 5	0	187	16.00	52° 54’	16° 54’
Site C	**1951**	**181**	**15.30**	**57° 05’**	**12° 30’**
CTD 1	Bottom +5m				
CTD 2	251				
CTD 3	101				
CTD 4	52				
Site B	**1106**	**184**	**15.03**	**57° 26’**	**15° 44’**
CTD 1	Bottom +5m				
CTD 2	300				
CTD 3	200				
CTD 4	100				
CTD 5	75				
CTD 6	50				
CTD 7	25				

CTD 8	10				
Site A	**3563**	**189**	**00.59**	**52° 54'**	**16° 54'**
CTD 1	Bottom +5m				
CTD 2	250				
CTD 3	100				
CTD 4	50				
CTD 5	25				
CTD 6	10				

6.1.3. Emily Good and Steve Mowbray (University of Edinburgh)

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

6.1.3.1. Objective and Hypothesis

We joined RRS Charles Darwin at Fairlie on 27th June 1998 in order to conduct further high pressure incubation experiments complementing the work started on CD111A. The experiments were essentially the same as that of CD111A so that comparisons of the benthic response after seasonal deposition events could be made. 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 inocula from the nepheloid layer, we should see an increase in the rate of mineralisation.

6.1.3.2 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 inoculum at *in situ* pressure and temperature to measure the rate of remineralisation. In the second type, short duration (10 days, a slight increase from the 6 day incubations on CD111A.) 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.

We required three mega-cores from each station. Upon receiving the core, the overlying water was siphoned off until only 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 inoculate our desorption experiments.

1. The top 5 mm of sediments from each core was collected, along with any "fluff" layer present, and transferred into a 2 litre beaker. The collected material was then mixed with water from the overlying column and homogenised using a magnetic stirrer, forming a slurry. The slurry was sub-sampled into a pre-weighed glass vial and preserved by freezing. This 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 35 ml and 40 ml of the slurry was then transferred into twenty centrifuge tubes and centrifuged at 5,000 rpm.

3. The resulting supernatant from all 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 25 and 30 ml of UV-irradiated seawater to the 'cake' and bringing the 'cake' into solution. The resulting slurry was then mixed and placed in an ultrasonic bath for 20 minutes. The mixture was centrifuged, and the supernatant decanted into a beaker. This process was repeated a total of five times to exhaustively desorb any removable organic matter and to collect a sufficient 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 heat-sealed and incubated at *in situ* pressure and temperature 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 time points for the desorption experiment and for each of the slurries. The controls which were poisoned with mercuric chloride, will allow distinctions between purely physical/chemical processes and biological processes to be made. 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 (36-48 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. At the end of the sampling, the remaining solids were transferred quantitatively to a pre-weighed glass vials for particle-size and further organic studies.

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.

6.1.3.3. Summary

In summary, our participation on this cruise has been a success in the sense that we have been able to achieve all the objectives for CD113A. Much work remains to be done by way of analysis in the laboratory. Again, longer term slurry experiments will be conducted by the Edinburgh group (Gregory Cowie & Steve Mowbray) during CD113B.

6.1.4. Mark Williams, CD113 A&B (Dunstaffange Marine Laboratory)

'Organic and inorganic transformations at the benthic boundary layer'

The aim for this cruise was to acquire post bloom 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 with pre-bloom samples acquired during cruise CD111. 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.

6.1.4.1. Sediment

Sediment cores were obtained from mega-corer deployments. 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 extrude 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 Bangor who will provide analysis of the organic carbon content. Part of each slice (~50ml) was centrifuged at 4000rpm for 20min and after separation the pore-waters were acidified. The remainder of the slice was kept for determination of water content.

Sediment from site C exhibited a major fluff deposit during Leg A, however during Leg B sediment core should only a minor layer of fluff (~0.5cm). This may be due to spatial differences caused by topography of sea bed or this may indicate rapid utilisation of the fluff by benthic organisms reducing this layer within a few weeks. A further sediment core was planned to be extruded at Site C during Leg B, but foul weather prevented deployment of the mega-corer. A core was retained from Site B (CD113B) and was sectioned instead of one from Site C. Site B sediment was packed with spongy spines causing the sediment to be much stiffer, this was not observed during CD111. Site A was not significantly different compared with CD111.

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

Site	Depth m	Estimated depth of redox boundary cm	Length of Core cm	No of slices	Depth of Fluff layer cm	Typical pore-water volume ml
A	3560	11	43	20	negligible	5
B (CD113A)	1100	10	18	14	0.5	5

B (CD113B)	1100	10	14	11	negligible	4
C	1951	11.5	31	17	3	6

Total number of sediment samples = 62
Total number of pore-water samples = 62
Total number of surficial water samples = 4

6.1.4.2. Suspended Particulate Matter

Samples from the water column at each site, approximately 5-10m above the sea bed, were taken using trace metal clean externally rigged Niskin bottles. The CTD deployments were shared with colleagues from University of Cambridge, University of Bangor and University of Edinburgh. Multiple deployments were undertaken during the cruise to obtain bottom water, additional bottles were also fired at the depths of the proposed SAPs deployments (coincident with sediment trap depth).

The clean container supplied by RVS is not ideal and should not be used as a clean chemistry container on other cruises. I appreciated the effort that has gone into the preparation of this container but find it difficult to understand why the flow cytometry container was used for upgrading rather than the old clean container which was used as the radiochemical container on this cruise. The flow cytometry container has a number of faults.

1) No antechamber, this made is nearly impossible to keep dirt from outside entering the container.
2) A large number of metal fixings were present in the container
3) The compressed air line was not connected at the start of the cruise and did not work after connection. Both of these points were corrected by the RVS technician on board.
4) Particles (possibly) rust were continually deposited on the bench near the back of the container, adjacent to the laminar flow hood. No source was identified but after cleaning they persisted to be present.
5) Many of the door latches undid in bad weather.
6) The sink was metallic.

Water from these bottles were filtered using acid cleaned pre-weighed Nuclepore filters. It was found that after filtration of approximately 10l the filters became blocked by the fine particles and subsequent filtration was time consuming. After filtration typically ~20l, a coating of fine light green material was observed on the filters. For each site multiple filtrations (x5) of bottom water 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 10µm and 0.4µm poresize 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 Dunstaffnage Marine Laboratory. 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	Water Depth m	Height above bed m	Bottom Water Temp °C	No 0.4µm Filters	No 10µm Filters	Dissolved Sample Volume l	Volume Filtered l
A	3562	7	2.44	6	1	0.5	137
		30		1		0.5	16
		50		1		0.5	19
		1000		1		0.5	15
B	1109	5	5.4	7	1	0.5	123
		50		1		0.5	16
		300		1		0.5	18
C	2084	7	3.15	7	1	0.5	107
		20		1		0.5	15
		50		1		0.5	18
		300		1		0.5	19

Total number of 0.4µm filtered samples = 28

6.1.4.3. SEM Samples

From the CTD deployments, 100ml of water from each depth was filtered through a 25mm 0.4µm 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 9µg 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.

6.1.4.4. 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 (U. Edinburgh) and trace metal (DML) analysis. 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 2m apart and the SAP's containing the Nuclepore filters was placed above the one containing the GFF filter.

Cast 1. Site A. Water Depth – 3562m, Pumping time – 2.5h

This was the first deployment of the cruise. The weather was very poor and the SAP's were deployed in conditions of heavy swell and waves. Prior to deployment the filter housing clamps and the filter housing pump fitting were checked for tightness. During deployment and retrieval the ship propeller was turned off. Each SAP was clamp into position and then a polypropylene strop was fastened around the frame of the SAP and the wire. Below each SAP a clamp was bolted to the wire to prevent slippage. 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. Severe wire angle problems and the subsequent time taken to reposition the ship prior to attaching the final SAPs pair, resulted in the SAP's pumping for 10minute prior to arriving at the required depth.

During retrieval the upper SAP at 50m a.b. was missing and only a torn strop was recovered (this strop was clipped to the wire, even though during deployment it was clipped to the other end of the strop). The wire clamp was also missing. The filter housing of the lower SAP was missing. The plastic coating on the wire between the initial positions of the two SAPs was torn and in place completely removed. Recovery of the last two SAP's revealed that the upper SAPs had its flowmeter

removed and the lower SAP had its piping between the flowmeter and cartridge holders disconnected.

Examining the damaged to the wire and to the lower SAP of the 50m a.b pair suggests that the upper SAP was rotating around the wire during deployment. This rotation caused the plastic coating to be split at the clamp points. The removal of the plastic coating would not allow the clamps to grip the wire, the bare wire having smaller diameter than the plastic coated section. Initial an up and down motion would occur and the SAP would batter again the wire clamp and finally the SAP would fall off the wire. The strop would retain the SAP and the SAP would then batter against the lower SAP. This resulted in the loss of the filter head and the deep scratching of the upper surfaces of the lower SAP. Finally, the strop would part and the SAP fell off the wire. The pumping time of the remaining SAPs was noted and this seemed to indicate the pumping stopped while the SAPs were at depth.

The loss of the flowmeter on the deepest SAP was similar to that observed during a SAPs deployment during CD111. The disconnection of the piping on the other SAP pair (even though it was clamped with a jubilee clip) suggests a degree of lateral force (possibly due to rotation of the SAP about the wire) causes the flowmeter the bend, the flowmeter is rigidly fixed to the pump housing. This may cause the flowmeter to break away from the pump housing or induce stress fractures causing the flowmeter to eventually break off.

Table III. *Data collection information relating to SAPS Cast I*

Intended Sampling Depth above bed **m**	**Filter Type**	**Pumping time remaining** **h**	**Volume Filtered** **l**	**Flow rate** **l/h**	**Comments**
1000	0.4µm	N/A	1261.5	505	Filter ok
1000	GFF	N/A	2051.3	821	Filter torn
50	0.4µm	0.5	1967.3	984	Filter head lost
50	GFF	N/A	N/A		SAP lost
20	0.4µm	0.6	764	402.05	Filter torn/piping disconnected
20	GFF	1.6	N/A		Filter torn/flowmeter lost

Cast 2. Site B. Water depth – 1114m, Pumping time – 3h

Due to the loss of a SAP and damage to the other, only two SAP pairs were deployed at this site. The cast at site B was successful. The weather was calm.

Table IV. *Data collection information relating to SAPS Cast II*

Intended Sampling Depth above bed m	Filter Type	Pumping time remaining h	Volume Filtered l	Flowrate l/h	Comments
50	0.4µm	N/A	941.9	314	Filter ok
50	GFF	N/A	2261	754	Filter ok
20	0.4µm	1.0	590.3	295	Filter ok
20	GFF	1.9	896.3	815	Filter ok

Cast 3. Site C. Water depth – 1950m

NO DEPLOYMENT OCCURRED DUE TO POOR SEA STATE.

6.1.4.5. Lander Deployments

Due to the requirement of a longer incubation deployment at site C for the lander, no deployment occurred to use the lander to obtain very near bottom samples.

6.1.4.6. Summary

This cruise has provide invaluable post bloom samples for comparison with the pre bloom samples obtained during CD111. Most of the work has been replicated. The bad weather throughout this cruise has caused may alterations of the scientific plan and difficulties. This has not been help by the failure of equipment, such as the CTD. A lot of effort has been put in by the technical members of RVS to overcome these problems.

6.1.5. Gary Fones (Lancaster University) *'High resolution concentration gradients and fluxes of trace metals, major ions and nutrients at the benthic boundary layer'*

6.1.5.1. Introduction

The working scheme for this cruise was to deploy the lander at each station for both Oxygen and pH micro-electrodes and for the gel deployment system. Coupled with this would be the collection of mega and multi cores for the insertion of gel probes to measure a suite of trace metals and major cations and anions including nutrients. From these deployments the concentration gradients and fluxes for each constituent will be determined along with spatial heterogeneity and the buffering capacity of the pore waters.

6.1.5.2. Station C (No. 54701)

1. Lander with gel deployed on 30/6/98 at 57 00 55.14N and 12 30 03.64 W. Gels deployed were DGT (0.3 mm DL-22), DGT (0.5 mm DL-21), UH-R DET (23) and Ladder DET (A). The assessment of the sediment water interface was underestimated and the probes were only inserted into the sediment up to the 3/4 screw hole, about 5 cm penetration. However because of the fluff on the surface and that the probes will be analysed for trace metals at ultra high resolution (100 microns) this should prove to be a very successful deployment

2. Lander with oxygen and pH micro-electrodes deployed on 1st July at 57 04 23.27N and 12 29 20.24W. Only two oxygen micro-electrodes were working but this were calibrated to three points. 100 % oxygen, 20 % oxygen and 0 % oxygen. Oxygen concentrations were determined using a Metrohm oxygen titration system. Assessment of the data showed that the electrodes had penetrated the sediment before the profiling had begun thus missing the interface. This was to be rectified at the next site by starting the profiling earlier.

3. Mega-core collection undertaken on 1st July at 57 04 24.22N and 12 29 23.25W. DGT probes were inserted at 12.10 am for 30 hrs. Probes inserted were 0.3 DL(28), 0.3 DL (25)(ceramic), 0.5 DL(29) and 0.8 DL(30) for trace metals and two probes for phosphate, 0.5(26) and 0.8 DL(27). Seven DET probes were also inserted to measure Fe/Mn (2 & 3), major cations and anions (11 & 12) and ammonia and total CO_2 (4 & 13) and an ultra-high resolution DET (24). Analysis of ammonia on board showed that the concentrations were below the detection limit, however, analysis for total CO_2 was possible with the profile showing no appreciable change in concentration over 10 depth.

6.1.5.3. Station B (No. 54702)

1. Lander with gel deployed on 3/7/98 at 57 24 13.10N and 15 44 54.25 W. Gels deployed were DGT (0.3 mm DL-37), DGT (0.5 mm DL-38), UH-R DET (39) and Ladder DET (B). The assessment of the sediment water interface was underestimated as the lander did not penetrate into the sediment as far

as at station C. There also seemed to a problem with the lander computer as it was programmed for 180 mm penetration and only registered 150 mm. The gels still came back to the start point so we are still not sure how this occurred. When the calculations were undertaken it appears that the gels only penetrated the sediment by a few mm, this was confirmed as sediment was only visible on the first screw hole.

2. Lander with oxygen and pH micro-electrodes deployed on 2nd July at 57 24 30.53N and 15.44 35.01W. Only two oxygen micro-electrodes were working but this were calibrated to three points. 100 % oxygen, 20 % oxygen and 0 % oxygen. Oxygen concentrations were determined using a Metrohm oxygen titration system. Assessment of the data showed that the profiling had started above the interface and the profile showed a very sharp sub-surface gradient with the oxygen concentration diminishing to zero within a few cm.

3. Mega-core collection undertaken on 2nd July at 57 23 57N and 14 44 64.24W. DGT probes were inserted at 23.15 for 36 hrs. Probes inserted were 0.3 DL(33), 0.3 DL (37)(ceramic), 0.5 DL(34 &35) and 0.8 DL(31 &32) for trace metals and one probe for sulfide, 0.5(38). Seven DET probes were also inserted to measure Fe/Mn (5 & 6), major cations and anions (14 & 7) and ammonia and total CO_2 (1 & 15) and an ultra-high resolution DET (36). Analysis of ammonia on board showed that the concentrations were below the detection limit, however, analysis for total CO_2 was possible with the profile showing no appreciable change in concentration over 10 depth.

6.1.5.4. Station A (No.54703)

1. Lander with gel deployed on 7/7/98 at 52 54 48.97N and 16 54 48.37W. Gels deployed were DGT (0.3 mm DL-48), DGT (0.8 mm DL-47), Phosphate (0.5 mm DL-45) and Ladder DET (C). The sediment water interface was re-calculated and the height of the lander legs adjusted to ensure there was enough penetration into the sediment.

2. Lander with oxygen and pH micro-electrodes deployed on 6th July at 52 54 18.97N and 16 54 20.17W. Only one oxygen micro-electrode was working but this was calibrated to three points. 100 % oxygen, 20 % oxygen and 0 % oxygen. Oxygen concentrations were determined using a Metrohm oxygen titration system. Assessment of the data showed that the profiling had started above the interface and the profile showed a sub-surface gradient, however this gradient started about 2 cm below the sediment water interface unlike station C.

3. Mega-core collection undertaken on 6th July at 52 54 40.86N and 16 55 04.84W. DGT probes were inserted at 10.30 am. Probes inserted were 0.3 DL(49), 0.3 DL (46)(ceramic), 0.5 DL(50) and 0.8 DL(51) for trace metals, one probe for sulfide, 0.5(42)

4. Multi cores were collected due to the poor success rate of the mega-corer. The multi-cores were collected on 7th July at 52 55 07.35N and 16 53 52.10W. The collection was very successful with 10 out of 12 cores collected. perhaps the multi-corer should have been more extensively used. Seven DET

probes were inserted to measure Fe/Mn (8 & 9), major cations and anions (16 & 17) and ammonia and total CO_2 (10 & 18) and an ultra-high resolution DET (40). Two phosphate DGT probes were also inserted 0.5 (43) and 0.8 (44).

6.1.6 David Hughes and Peter Lamont, CD113 A&B (Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban) *'Benthic community activity and biomass in biogeochemical processes at the deep ocean bed'*

6.1.6.1 Objectives

The SAMS project within BENBO has two main objectives, firstly to assess the extent and likely influence of bioturbation on biogeochemical processes at the three contrasting study sites, and secondly yo determine the biomass size structure of the metazoan benthos in order to estimate rates of carbon flow through each size class. The biological sampling on cruise CD113 was intended to supplement that undertaken on BENBO cruise CD111, to increase sample sizes and to observe any changes associated with flux of phytodetritus to the sea bed which may have occurred between the two cruises.

6.1.6.2 Methods

The main priority was given to examination of boxcores, since these provided both faunal samples and the means to assess bioturbation by excavation of preserved burrow structures. All boxcores recovered were drawn and photographed, then carefully excavated by trowel. Vertical sections of sediment were collected for X-ray analysis. The superficial 1 cm of sediment and the underlying layer down to 10 cm were collected separately for sieving of macrofauna on 250 and 300 μm. The deeper sediments (below 10 cm) were sieved on a coarser mesh (1 mm) when time allowed, but were always examined carefully for larger burrowing animals. Burrows uncovered by trowelling were traced and mapped as far as possible, and any distinctive contents sampled for chemical analysis. Larger burrowing fauna were frozen for later analysis of gut contents.

Some additional macrofauna were extracted from mega-cores used for incubation experiments by other workers on the cruise.

Sediment samples for extraction of meiofauna were collected using the multi-corer (three cores per site). The upper sediments were sliced in 1 cm layers down to 5 cm and fixed in formalin. On cruise CD111 surface-living megafauna were collected using the SOC epibenthic sled, but this was not available on the current cruise. An Agassiz trawl was obtained at short notice from DFR Aberdeen, but lack of time prevented the extensive use of this (one unsuccessful deployment was made). As a replacement for the camera system carried on the SOC sled, the CCMS bedhop camera was deployed at all three sites, using both black-and-white and colour films. This appeared to work successfully and should provide useful quantitative information on the densities of conspicuous megafauna, and also on the abundance of biogenic traces (burrow openings, etc.) indicative of bioturbation. Films will be processed on return to Oban.

6.1.6.3 Observations from box cores

Site A (3500 m): Three boxcores were examined from this site. An upper layer of fairly soft, pale fawn-coloured sediment down to approximately 17 cm was underlain by a dense, sticky, chocolate-brown clay, with a narrow band of coarse sand and grit separating them. Cores showed a low level of visible biological activity, with no conspicuous surface burrow openings, and virtually no discernible biogenic structures below the surface. The deeper clay in particular seemed to be devoid of burrows. No large organisms were encountered in any of the cores. A few small worms were found in the upper few cm of sediment.

Site B (1100 m): Five boxcores were collected here. The sediment profile consisted of an upper 8 - 9cm of soft, pale fawn sediment underlain by a stiff, highly compact grey clay. Siliceous sponge spicules were abundant in some of the cores. A much higher level of biological activity was apparent here. Four out of five cores contained one or more large surface burrow openings (up to 3.5 cm diameter). Smaller polychaete tubes and forams protruding above the surface were also numerous. Excavation showed that the upper 10 cm of sediment was penetrated by numerous polychaete tubes and burrows. Larger burrowers were also encountered. One core contained three sipunculan worms in vertical shaft-like burrows up to 15 cm deep. A probable burrowing anemone was encountered in a membranous tube extending down to 14 cm. A particularly interesting megafaunal burrow was traced from a large

surface opening down to 19 cm, where the vertical shaft led into a horizontal tunnel which extended to the edge of the boxcore (approximately 35 cm linear extent). The horizontal tunnel was filled with a greenish slurry. Samples of this were frozen and will be analyzed in the laboratory to determine whether this represents fresh phytodetritus, possible subducted into the burrow by its occupant. Unfortunately this burrow continued beyond the limits of the boxcore and the occupant was not collected, but this is likely to have been a large worm, possibly an echiuran.

Another exciting find made at Site B was the recovery of a beautifully preserved xenophyophore in a mega-core tube. Normally these fragile giant protozoans are broken into fragments by the collecting gear, but in this case the fortuitous passage of the mega-core tube directly through the organism had preserved it intact during recovery to the surface. The specimen was fixed by addition of formalin to the water in the tube, and extreme care taken to protect it from vibration for the remainder of the cruise and during the return journey to Dunstaffnage.

Site C (1900 m): Two boxcores were examined from this site. Small burrow openings and polychaete tubes were apparent at the surface. The upper 14 cm of sediment was soft and pale fawn in colour, with a dense, sticky grey clay below this. Polychaete burrows were common in the top 10 cm, and some larger burrows were encountered down to 20 cm. The most distinctive sub-surface biogenic features were meandering horizontal tunnels (down to 15 cm depth) filled with masses of ovoid faecal pellets approximately 1 mm long. The pellets did not differ in colour from the surrounding grey sediment. Samples were collected for analysis. No animals were found in obvious association with these pellet masses, but a medium-sized echiuran was collected in a mega-core at this site. This animal's gut contents will be examined in the laboratory to determine whether it may be the species responsible.

6.1.7. Mid-water and Near-Bottom Zooplankton (Corinne Woodstock & Andy Harris SOC, J.Dunn Marine Laboratory Aberdeen [MLA], J.Hunter MLA)

Midwater and near-bottom zooplankton

Two MLA ARIES were used, the first frame was used at sites C & B and lost at site B. The second frame was used at site A. A WASP and altimeter were used on the

first frame to give real time data, along with a Seabird CTD which gave very accurate records when down loaded on recovery. An Optical Plankton Counter provided particle counts in 128 bin sizes, also stored and downloaded on recovery. On the second frame an RMT pressure sensor and altimeter provided real time data, but the remaining seabird system, OPC and ARIES net motor were not depth rated to 3600m so could not be used.

At sites B & C, conductivity, temperature, optical plankton count were logged with depth, time and positional data. A series of discrete plankton samples were taken on 95 μm and two integrated samples, one on mesh size 95 μm, one on 200 μm.

At site C, an initial CTD dip was used to calibrate the wasp pressure sensor and altimeter. The pressure sensor performed reasonably well but the altimeter failed to lock in at all. The swell was too great for the night time deployment and time constraints prevented a second attempt. The noon tow was successfully deployed with mixed results. The altimeter failed to work again. The pressure sensor was used to bring ARIES within 20m of the seabed without contacting it. CTD, OPC, discrete and integrated samples were all successful.

At site B the first noon tow was also successful, again the altimeter didn't lock in and the pressure sensor was used to pilot within 10mab. CTD, OPC, discrete and integrated samples were all successful. The second tow at night was also successful although again the altimeter didn't lock in, but the pressure sensor was used to pilot within 10mab. CTD, OPC, discrete and integrated samples were all successful. During the third tow at site B the ARIES parted from the towing cable, probably because a shackle pin parted from the shackle, but the cause of that is unknown. A total of five attempts over 20 hours were made to recover the vehicle. The fourth of these appeared to make contact with ARIES, but failed to maintain contact and recover. Probably because the grappling hook (the only one available) was too small.

At site A the second ARIES frame was stripped to remove the non depth rated equipment and deployed with the RMT system and four plankton nets with varying

mesh sizes for integrated samples. The altimeter did fail to lock on in both tows although ARIES did remain 100 mab.

Table I *Summary deployment information of the ARIES instrument*

		Start					Finish				
Station	**OPC Data**	**Date**	**Time**	**North**	**West**	**Sounding**	**Date**	**Time**	**North**	**West**	**Sounding**
54701#11	CO5PO11	1.7.98	10.311	57.05.55	12.31.00	1924	1.7.98	14.23	57.12.22	12.27.22	1842
54702#5	CO5PO12	2.7.98	22.29	57.23.12	15.45.67	1047	3.7.98	11.40	57.26.69	15.45.32	779
54702#10	CO5PO13	3.7.98	11.39	57.21.93	15.45.39	1104	3.7.98	14.25	57.26.13	15.45.78	1111
54702#15		4.7.98	11.44	57.27.80	15.44.07	1109	4.7.98	13.11	57.25.87	15.44.92	1111
54703#9		7.7.98	14.39	52.46.98	16.49.85	3545	7.7.98	19.54	52.56.10	16.50.611	3548
54703#14		8.7.98	13:02	52.54.35	16.52.50	3557	8.7.98	18.06	52.49.408	16.59.018	3340(?)

7. SAMPLING PROTOCOL CD 113B

7.1 Leg 113B

7.1.1. 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 59 mm).

From each site three cores were taken for the quantitative analysis of benthic Foraminifera; these were taken from two deployments of the multi-corer at Sites A and C, and from three deployments at Site B. All 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% formaldehyde buffered with sodium borate.

0-0.5 cm and 3-4 cm sections were taken from one core at each site for electron microscopy studies. These samples were fixed in 4% gluteraldehyde buffered with sodium cacodylate.

Site A (7/7/98)

Sample	**Position**	**Depth**	**Details**

54703#10	52° 55' 07.35 N 16° 53' 52.10 W	3557 m	0-0.5 & 3-4 cm sections fixed in gluteraldehyde.

Note: This sample was taken on the first leg of the cruise then stored in the constant-temperature room. It was sectioned and fixed on 15/17/98.

Site A (13/7/98 and 14/7/98)

Sample	Position	Depth	Details
54704#8	52° 54' 07.43 N 16° 54' 54.97 W	3567 m	One core sectioned to 15 cm.
54704#13	52° 55.17514' N 16° 52.93767' W	3559 m	Two cores sectioned to 5 cm.

Site C (16/7/98)

Sample	Position	Depth	Details
54705#7	57° 05' 58.60 N 12° 24' 23.14 W	1963 m	One core sectioned to 15 cm. 0-1 cm section retained from additional core.
54705#8	57° 05' 17.95 N 12° 24' 53.82 W	1980 m	Two cores sectioned to 5 cm. 0-1 cm section retained from additional core. 0-0.5 & 3-4 cm sections from a third core were fixed in gluteraldehyde.

Site B (18/7/98)

Sample	Position	Depth	Details
54706#6	57° 24' 24.79 N 15° 41' 21.09 W	1085 m	One core sectioned to 10 cm. 0-1 cm section retained from additional core.
54706#7	57° 24' 24.72 N 15° 41' 26.62 W	1095 m	One core sectioned to 5 cm. 0-1 cm section retained from additional core. 0-0.5 & 3-4 cm sections from a third core were fixed in gluteraldehyde.
54706#8	57° 24' 26.14 N 15° 41' 32.25 W	1095 m	One core sectioned to 5 cm.
54706#13			Sub-core taken from box core for John Thompson, SOC.

7.1.2. G. Cowie and S. Mowbray (University of Edinburgh)

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

Please refer to the Cruise Report from CD111 for full descriptions of objectives, experimental design and planned analyses.

7.1.2.1 Sample Collection:

BENBO Site A:

a) *Mega-cores*: Two mega-cores were sampled for subsequent analyses. 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-prerinsed disposable Whatman or Gelman 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 precombusted glass vials. Other solids were stored frozen in plastic zip-lock bags. A further mega-core was collected for a shipboard whole-core incubation study (see below). Surface sediments from two final cores was used, with similar material from multi-cores, to provide a mixed substrate for high-pressure incubation studies (see below)

b) *Multi-cores*. Five undisturbed multi-cores were obtained. These were also extruded in the controlled temperature room. Only the surficial 0-0.5 cm interval was collected. Materials from the 5 multi-cores cores and 2 mega-cores were combined, to be used as a substrate in high-pressure incubation studies (see below).

c) *Suspended particles:* Due to bad weather, no time was available for a CTD cast to collect bottom waters for suspended particles. A SAPS deployment was attempted at ca. 20, 50 and 1000 m off bottom, but, also due to bad weather, the GFF filters were ruptured and some SAPS were lost or damaged (see report by M. Williams).

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 C

a). *Mega-cores*: Five 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 and then split and then either frozen or refrigerated, for use as substrate and inocculum in high-pressure incubation

studies on return to Edinburgh (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 a shipboard incubation study.

b) *Suspended particles*: No SAPS or CTD deployment due to lack of time on station.

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

BENBO Site B:

a) *Mega-cores:* Five Mega-cores were collected from 2 drops. One was sectioned for pore-waters and solids as per site A. A second was used in a whole-core incubation study (as per site A) and the remaining three were sampled only for the surficial 0.5 cm and the combined materials used as substrates in high-pressure incubation studies (see below).

b) *Suspended particles*:

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

7.1.2.2. Incubation studies:

Two types of incubation studies were carried out:

a. Whole-core incubations

b. High-pressure slurry incubations in rotating pressure vessels.

Whole-core incubations. These studies were carried out at all three sites. Approximately 1 liter of overlying water was retained in a mega-core barrel. The core top and overlying water were then sealed with a plexiglass plug fitted with an o-ring, through which penetrated a stirring paddle fitted to a low rpm motor, an oxygen electrode and a temperature probe, as well as two teflon tubes (for sampling/injection). The objective was to obtain rates of oxygen consumption and nutrient flux in order to assess organic decay rates (to complement or replace lander incubation data).

At site A, a potassium bromide solution was added as a conservative tracer as the first water sample was extracted, to determine total incubation volume and dilution of sample with replacement liquid (UV-treated seawater). The core was then left for a period of ca. 2 days with periodic sampling for O_2 (microtitration), nutrients, DOC, DON and amino acids. The incubation was slowly stirred for 5 minutes prior to each sampling. At site C, a similar experiment was run but, rather than sealing the chamber and replacing all sample volumes with UV-treated seawater, a headspace was left above the overlying water in the core, and

this was continuously flushed with nitrogen. This system worked well with the exception that erroneous oxygen values are suspected because the N_2 flow in the overlying headspace appeared to cause degassing of the incubation volume. At site B, the incubation was further modified. We returned to a sealed chamber without headspace. As each sample volume was removed, the sediment core was pushed up to immediately expel air, thus maintining a closed system, removed from atmospheric oxygen supply. In this instance, a steady, gradual decline in oxygen concentration was observed in the incubation over the course of 2 days.

Pressure-vessel incubations: Surficial sediments collected from sites A and B were placed in heat-sealed polyethylene bags and place in stainless steel pressure vessles which were subsequently pressurised to local pressures (3600 and 1110 bars, respectivley). These vessels were then placed on carrousels and rotated, in order to maintain solids in suspension. These vessels will be sampled at roughtly weekly intervals over a 7-8 week period in order to assess organic matter alteration. These rates will be compared to those observed with the benthic lander deployments and whole-core incubations.

Sampling was also completed for the short-term incubations (with sediment slurries and desorbed organic material) that were begun during CD-111A.

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

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

7.1.3.1. Microbial production and decomposition of surficial deep-sea sediment organic carbon and pore water DOC

The experiment was carried out at the deepest station A (3570m;54704#5 and #8; 52°54'09.02" N; 16°55' 27.76" W; 13 July 1998) after any potential "fluff" fall. No layers of "fluff" or old "fluff" were visible although the odd aggregate could be seen.

The top 2 cm of 10 multi-cores were removed, pooled and 3ml samples taken for dry weight and CHN analysis. A further 260ml volume of the sediment pool was removed and made into a 1:1 slurry (C) with 0.2μm filtered seawater overlying the cores (FMC) for incubation over a 45 day period.

Pore-water, extracted from the 0-2 cm sediment horizon from 28 multi-cores by centrifugation and filtered through 0.2 um filter and mixed (1:1) with overlying

water (P) (unfiltered), was also incubated to follow any DOC enrichment from pore waters. The same volumes and sub-samples of filtered pore water (PC) without the multi-core water addition and multi-core water (MC) on its own were also incubation for the full duration of the experiment to act as controls.

Incubation conditions were at *in situ* pressure (360 atmospheres) and temperature (2-3^{o}C) and sampling times were around 0, 2, 5, 10, 15, 20, 45 days. At each sampling time subsamples were removed from the above experiments for bacterial numbers, bacterial DNA synthesis, bacterial protein synthesis, α and β glucosidase, amino peptidase and esterase exoenzyme activities, POC, PON, DOC (H Kennedy et al.), DIC (H Kennedy et al.), carbohydrates (G Cowie et al.) and amino acids (G Cowie et al.). FMC was used as a control for exoenzymatic activities. DOC, DIC, bacterial numbers and DNA synthesis was measured at each sampling time in the Pore water enrichment experiments. 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 = sediment slurry(50% sediment + 50% filtered MC water, P = pore water enriched with mega-core water, PC = 100% pore water, MC = 100% multi-core water, FMC = Filtered mega-core water,*

Incubation duration		C (1 x 60ml bag)	P (1 x 60ml bag)	PC (1 x 60ml bag)	FMC water (1 x 5ml bag)	MC (1 x 60ml 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 45	*	*	*	*	*

7.1.3.2. Microbial production and decomposition of surficial deep-sea sediment and "fluff" organic carbon

The experiment was carried out at station C (1937m; 54705#3 and #4; 57^{o}05' 05.59" N; 12^{o}13' 21.31" W; 16 July 1998) on "fluff" and sediment collected at this site. The fluff was c 0.5-1cm thick when sampled for this experiment (16 July 1998) in contrast to the first leg of CD 113 when 1-3cm was the norm.

Fluff from 11 mega-cores was removed and pooled. This was allowed to settle and overlying water removed so that the "fluff" slurry was concentrated. Seven 60ml volumes of 100% "fluff" (F) were placed in polyethylene bags and incubated under *in situ* pressure and temperature.

The top 2 cm of seven mega-cores were removed, pooled and 3ml samples taken for dry weight and CHN analysis. Further 260ml volumes of sediment were removed and made into a 1:1 slurry (C) period with 0.2μm filtered seawater overlying the cores (FMC), dispensed into 60ml volumes and incubated in bags for times over a 45 day period.

Sediment was enriched with "fluff" (1:1)(E) and similar volumes dispensed and incubated in the same conditions and over the same period as above. This was to see if there was any enrichment effect on the sediment by this addition.

Multi-core water (MC) on its own was also incubation for the full duration of the experiment to act as controls.

Incubation conditions were at *in situ* pressure (194 atm) and temperature ($3^{o}C$) and sampling times were around 0, 2, 5, 10, 15, 20, 45 days. At each sampling time subsamples were removed from the above experiments for bacterial numbers, bacterial DNA synthesis, bacterial protein synthesis, α and β glucosidase, amino peptidase and esterase exoenzyme activities, POC, PON, DOC (H Kennedy et al.), DIC (H Kennedy et al.), carbohydrates (G Cowie et al.) and amino acids (G Cowie et al.). 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. 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 I1: *Summary of experimental plan and sample volumes. C = sediment slurry(50% sediment + 50% filtered MC water, F = 100% "fluff", E = 50% sediment + 50% "fluff", MC = 100% multi-core water, FMC = Filtered mega-core water,*

Incubation duration	C (1 x 60ml bag)	F (1 x 60ml bag)	E (1 x 60ml bag)	FMC water (1 x 5ml bag)	MC (1 x 60ml 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 45	*	*	*	*	*

7.1.3.3. Effect of temperature on microbial rate measurements

This experiment was carried out at station B (54706#2; 1095m; 57°25' 28.27" N; 15°40' 35.92" W; 18 July 1998). The aim was to investigate the effect of temperature on microbial and enzymatic activity in the surficial sediments. The top 2 cm of 5 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), α and β glucosidase, amino peptidase and esterase exoenzyme activities, POC and PON. These measurements were taken before and after 3 hour incubation at temperatures of 2, 5, 8, 12, 19 ° C. A further set of incubations were carried out at *in situ* temperature (5 ° C) and pressure (101 atm) for comparison with rates at other stations and those at 1 atm on station B.

Table III: *Summary of experimental plan, analyses, sample volumes and replicates. Tdr = thymidine incorporation, Leu = leucine incorporation, AODC = bacterial numbers, α-gluc = α-glucosidase activity, β-gluc = β-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 temperatures.*

Sediment Slurry: Bacterial Nos/Production						**Bacterial Exoenzyme Activities**			
			Tdr	Leu	AODC	α-gluc	β-gluc	Peptidase	Esterase
(°C)	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)
2	1	t_0	✓	✓	✓	✓	✓	✓	✓
2	1	t_1	✓	✓	✓	✓	✓	✓	✓
5	1	t_1	✓	✓	✓	✓	✓	✓	✓
8	1	t_1	✓	✓	✓	✓	✓	✓	✓
12	1	t_1	✓	✓	✓	✓	✓	✓	✓
19	1	t_1	✓	✓	✓	✓	✓	✓	✓
5	101	t_1	✓	✓	✓	✓	✓	✓	✓

7.1.3.4. Determination of free enzymatic activity in pore waters of deep-sea sediments and their variation with depth

This aim of this is too see if enzymatic activity is mainly associated with particles or are free in the pore waters. Pore water from three horizons (0-2 cm; 2-4 cm; 4-6 cm) was extruded and 0.2 μm filtered. The hydrolysis rates of α and β glucosidase, amino peptidase and esterase exoenzymes were determined in 3 replicates of each over a period of 24 hours at *in situ* temperature. This experiment was carried out at the following stations on extruded, 0.2 μm-filtered pore water:

Stat	Stat#/cast	Date	Sampler	n cores	Lat	Long	Depth
A	54704#13	14.7.98	multi-core	7	52 º 55'53.34"	16 º 53'14.12"	3560 m
B	54706#15	19.7.98	mega-core	5	57 º 22'02.94"	15 º 44'36.12"	1106 m

7.1.3.5. Microbial and enzymatic activity in faecal pellet layer

On a later deployment of the multi-corer at station C (54705#1; 1963 m; 57 º 05' 58.60"N; 12 º 24' 23.14"W) the "fluff" layer had been replaced mainly by a layer of faecal pellets (possibly holothurian?) about 1.5 x 5 mm. This layer was removed from 4 multi-core tubes and pooled and subsampled for replicate measurements of bacterial numbers (AODC), bacterial DNA synthesis (^{3}H-thymidine incorporation), bacterial protein synthesis (^{3}H-leucine incorporation), α and β glucosidase, amino peptidase and esterase exoenzyme activities, POC and PON. The rate measurements for DNA and protein synthesis were carried out under *in situ* pressure (194 atm) and temperature (5 º C). This experiment will enables us to compare activities in the faecal pellets with the "fluff" and surficial sediment.

Three of the above multi-cores (MC/1; MC/2 and MC/3) were sectioned to 6cm in 1cm horizons and stored in sterile petri dishes and frozen for future reference and/or analysis. One core was extruded whole into a plastic bag and stored frozen (MC/4).

7.1.3.6. Estimation of enzyme turnover times

In an attempt to estimate *in situ* turnover times of α and β glucosidase, amino peptidase and esterase exoenzymes in deep sea sediments we compared activities in killed (with glutaraldehyde) samples with living samples. We will also test the effect of glutaraldehyde on activities of pure enzyme in the laboratory to ensure any effect is not due to a deleterious effect of the glutaraldehyde on the enzyme.

7.1.6.7. ^{3}H-Thymidine and leucine methodology

a. Determination of isotope dilution

Different concentrations of hot and cold thymidine and leucine were added to 0-2cm sections of sediment (Station B; 54706#15; 19.7.98; mega-core; 57° 22'02.94"; 15° 44'36.12"; 1106 m) which had been slurried and subsamples incubated at *in situ* temperature for 3 hrs and then terminated. This will enable us to determine the isotope dilution in deep-sea sediment for both thymidine and leucine.

b. Conversion factor for bacterial production

This experiment is to determine the conversion factor from mols of thymidine (DNA synthesis) or leucine incorporation (protein synthesis) to rates of bacterial production. We believe that this is the first attempt to do this in deep-sea sediments. Subsamples from the top 0-2 cm horizon from 11 mega-cores at station C (1937m; 54 705#3 and #4; 57°05' 05.59" N; 12°13' 21.31" W; 16 July 1998) were slurried (1:1) and incubated over a 5 day period at *in situ* temperature. Subsamples were removed every 12 hrs for the determination of bacterial biomass, bacterial DNA synthesis (^{3}H-thymidine incorporation) and bacterial protein synthesis (^{3}H-leucine incorporation).

c. DNA and protein extraction methodology

Two 100ml sediment slurries from station B (54706#15; 19.7.98; mega-core; 57° 22'02.94"; 15° 44'36.12"; 1106 m) were incubated with ^{3}H-thymidine and ^{3}H-leucine for 3 hrs and 10 x 10ml replicates of each removed for detailed method testing and development back in the laboratory.

8. LANDER OPERATIONS Oli Peppe (Dunstaffnage Marine Laboratory)

8.1 Introduction

After late delivery of the BENBO lander at DML, successful technical trials of the lander were carried out during CD111. However most of the lander deployments during CD111 were of limited scientific value, and so CD113 provided the first real chance for Benbo to use the lander for gathering data.

Eight deployments were made, all but one of which were successful in obtaining valid data. In total the lander was on the sea-bed for over 15 days out of a total cruise science time of about 17 days.

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 and nutrient fluxes over long deployments, using both mini-electrodes and a syringe sampling unit. The system is also capable of retrieving a small box core.

8.2. Pre-cruise preparation

In preparation for this cruise, much work was done by the Marine Technology group at DML to build on the operational experience gained during BENBO cruise CD111. However given the time constraints it was not possible to implement many of the desired modifications, and the emphasis was placed on issues critical to the science plan. Any changes which would significantly affect the technical operation of the lander were avoided, so as to minimise chances of new technical problems arising during CD113.

A summary of the work and changes carried out is given below:

- Purchase and fitting of new gel system motor with lower gearing ratio, to ensure gels pushed into sediment
- Modification of the electronics to provide a higher current cut-out for the gel system motor
- Overhaul of the stirrer motor in the chamber system
- Purchase of new oxygen micro-electrodes, and replacement of all ascorbate type oxygen mini / micro-electrodes
- Testing of electrodes and development of electrode calibration procedures
- Investigation into possible interference on oxygen electrode signals in chamber system from stirrer motor; any interference was found to be insignificant.
- Modification of Argos antenna design to avoid damage on lander recovery, and optimise link with satellites
- Investigation into fitting a deep-sea camera onto the lander. Unfortunately this was deemed impracticable given time and financial constraints.
- Fitting of mini core tubes to each leg to indicate depth of penetration of lander, and angle on the sea bed
- Fitting of sacrificial anodes to lander frame to reduce corrosion
- Fitting of new water bottle sampler for electrode pressure calibrations

8.3. Deployment plan

The first leg of CD113 was devoted to Oxygen profile and gel work. The aim was to deploy the lander twice at each site on the leg, once in the oxygen profiler configuration, and once in the gel system configuration.

The second leg was to be used for chamber incubation experiments, with the aim of getting the longest deployments possible at each site in order to maximise the chance of seeing a change in nutrient levels over the course of the incubation. In the event, it was decided (based on results from CD111 incubations) that the two days originally allowed for incubations at sites B and C were not really sufficient. For this reason the incubation at site B was abandoned in order to allow a much longer (5 day) incubation at site C. Due to the site locations and the cruise schedule it was unfortunately impossible to do a 5 day incubation at site B which would have provided a direct comparison with the incubation at site B during CD111.

8.4. Operational notes

After the experience gained during CD111 the technical running of the lander proved to be smooth and relatively trouble free. Once again we were lucky with the weather during lander operations. However twice the lander had to be recovered in a sea-state of around force 5. Whilst it is always preferable to avoid such conditions when recovering the lander, the recoveries on these two occasions were achieved safely and without mishap or any damage to the lander. It should be emphasised that the lander operations were made significantly easier, especially at the start of this cruise, by the fact that the deck crew had all had experience in handling the lander during CD111.

8.5. Details of deployments

A summary of the lander configuration and the deployment and recovery times and positions for each deployment is given in Table 1.

Deployment #008_GEL – Leg A; Site C; 30/06/98 – 01/07/98

The gels were set to be in the sediment for 29 hours, with the height set such that if the sediment was level with the lander leg plates then the gels would have 50mm below and 110mm above sediment interface. The logged data showed that the gels had been driven down to the correct height relative to the lander. The core tubes on the legs gave mixed results, with one completely empty, one indicating the sediment level with leg plates, and the third indicating sediment ~ 3 – 4 cm below leg plates. It was not evident at this stage whether this was a real “tilt” on the lander, or whether the core tubes were not sealing correctly

Deployment #009_PRF – Leg A; Site C; 01/07/98 – 02/07/98

Due to a very poor success rate with the new electrodes, we unfortunately only had two working oxygen micro-electrodes at the start of this deployment. 4 of 6 new electrodes weren't working on receipt, presumably due to damage during shipment from Denmark. A further new electrode ceased to work after a short time, due to leaking electrolyte. Only one of the original electrodes was still working when tested before deployment. A problem with all the pH electrodes meant that although 2 pH electrodes were attached for the deployment, the data was meaningless.

The electrodes were set to start profiling roughly 20mm above sediment (assuming sediment level with leg plates), and profile down and up 70mm in 0.25mm steps. Initial inspection of the electrode data indicates that the oxygen level was already very low when the profiling was started, which would imply that the tips were already in the sediment, and therefore that the sediment was higher than the leg plates. This does not agree with data from the core tubes, which suggest the sediment was ~ 10 – 30 mm *below* the leg plates. This discrepancy could possibly be explained by a layer of "fluff" on top of the sediment of roughly 50mm depth which was seen on cores taken from this site.

It was also realised at this point that the imbalance of buoyancy caused by having only 8 spheres on the lander was almost certainly causing it to sit at an angle on the sea-bed, as indicated by the core tubes after both deployments at site C. This problem could be overcome by putting a corresponding imbalance in the weight of ballast attached to each leg.

Deployment #010_PRF – Leg A; Site B; 02/07/98 – 03/07/98

In order to try and correct the tilt of the lander on the sea-bed the ballast weights on each leg were altered so that the leg closest to the gap in buoyancy was lightest, and that furthest from the gap was heaviest with the differential weight between legs being max 10kg. On recovery the depth of cores in the tubes still indicated a significant tilt.

Both working oxygen micro-electrodes from #009_PRF were still working for this deployment. The calibration procedures were the same, although the post deployment calibration from #009_PRF was used as the pre-deployment calibration for #010_PRF. Again two pH electrodes were attached, but were not giving valid data.

The electrodes were set to start profiling roughly 50 mm above sediment, and profile down and up 90mm in 0.25mm steps. Starting higher above the nominal sediment interface (than in #009_PRF) ensured the full range in oxygen variation was recorded. In contrast to #009_PRF the electrode data obtained indicated a sediment height corresponding well with the sediment height calculated from the depths of the cores in the core tubes. The oxygen profiles showed a very sharp decrease in oxygen levels in the first 10 – 20 mm below the sediment interface.

Deployment #011_GEL – Leg A; Site B; 03/07/98 – 05/07/98

The ballast weights were made more uneven for this deployment, with a max differential between legs of 20kg. On recovery the depth of cores in the tubes indicated the tilt had been significantly reduced, with a max difference in penetration of the legs of ~ 20mm.

The gels were set to be in the sediment for 32 hours, with the nominal sediment interface roughly 60mm above the bottom of the gel (10mm further into sediment than for #008_GEL). However on recovery data logged indicated that the gel rack had stopped 30mm above the set level, presumably because the motor current cut-out triggered. The sediment was also reckoned (from the core tubes) to be ~30mm below the leg plates. The combination of these two effects unfortunately meant that the gels would have not penetrated into the sediment at all, although the bottom of the gel holders would have been ~30mm below the sediment interface.

Deployment #012_PRF – Leg A; Site A; 06/07/98 – 07/07/98

The same ballast imbalance was used as that used for #011_GEL. In this case the depth of cores in the tubes on recovery indicated less than 10mm difference in height of the leg plates above the sediment interface.

Unfortunately one of the working oxygen micro-electrodes was broken between #010_PRF and #012_PRF, and so the system was deployed with only one working oxygen electrode. The pH electrodes were still giving invalid results.

The profiling routine used was the same as for #010_PRF, starting ~ 50mm above nominal sediment interface, and profiling down and up 90mm. The electrode data recorded showed a less significant decrease in oxygen levels with depth than for Site B, and there was less correlation between the height of sediment interface indicated by the oxygen profile, and that calculated from the depth of cores in the core tubes.

Deployment #013_GEL – Leg A; Site A; 07/07/98 – 08/07/98
In order to try and avoid the problems experienced in #011_GEL when the gels were not implanted correctly into the sediment, the legs on the lander were raised by 50mm for this deployment. This lowered the height of the gels relative to the leg plates, and therefore the sediment interface. The system was set so that the sediment interface would be ~ 120mm above the bottom of the gel if the gels were driven in to the correct depth. However data from the computer showed that the gel rack stopped ~50mm above desired depth. This information combined with data from the core tubes indicates that the actual sediment interface was ~ 50 – 60 mm above the bottom of the gel. The gels were in the sediment for 30 hours.

Deployment #014_ELI – Leg A/B; Site A; 09/07/98 – 14/07/98
A five day incubation experiment, with water samples taken every 24 hours using the syringe sampler. As for the incubation experiments on CD111, plastic syringes were used and thus the water in the Teflon tubing between the chamber and syringes was also collected for measurements requiring non-plastic sampling containers.

Two oxygen mini-electrodes were fitted (one inside and one outside the chamber). Unfortunately the data indicates that the chamber electrode failed at the start of the deployment. A pH electrode was also fitted in the chamber, with a reference outside. The data from this electrode looks valid, unlike all the data obtained from the pH micro-electrodes on the Profilur deployments.

No sediment was collected in the chamber, although the shovel and lid were both closed correctly. It is suspected that the sediment washed out of the chamber during the ascent and recovery. The height of the cores in the mini-core tubes indicated that the depth of sediment in the chamber would have been roughly 70mm at the shallowest end and 155mm at the deepest end.

Deployment #015_ELI – Leg B; Site A; 16/07/98 -
Another five day incubation experiment, which was preferred to a two day incubation at each of sites B and C. The syringe set-up was the same as for #014_ELI, except that the samples were taken at 23 hour intervals to allow for the slightly shorter deployment time.

After the failure of one oxygen mini-electrode during #014_ELI, and the failure of another electrode between deployments, only one oxygen electrode was available, and so there was no external reference electrode for this deployment. The pH electrode set-up was unchanged. Both the oxygen and pH electrode data obtained appears to be valid.

A good core was obtained in the chamber, which proved that the lander was sinking in further than originally thought, and possibly even as high as 20mm above the leg plates. The oxygen electrode tip was just 5 – 10mm from the sediment surface.

8.5. Electrode calibration procedures

A automatic titration system using the micro-winkler technique had been acquired in order to get oxygen concentration values for the micro-electrode calibrations. This was the first time it had been used, and initially there were a few problems getting consistent results, probably due to the sampling method being used. The electrodes were calibrated both before and after the deployment, and were

also calibrated against bottom water from the water bottle sampler, which closes as the lander is released from the bottom. The procedures used for calibrating the electrodes in the lab are outlined below:

1. Lower electrodes into sea water cooled to *in-situ* temperature, and bubble air through the water for ~10 min. using a diffuser stone. The calibration water should be surrounded by ice to maintain temperature.
2. Take two samples from the calibration water, and titrate for oxygen concentration. At the same time note the values of the electrode signals.
3. Stop bubbling air through the water, and start bubbling nitrogen through the water for ~ 5 min.
4. After 5 min., slow (or stop) the rate of nitrogen to a trickle and let the electrode signals level out. Then take two samples and titrate as before, noting value of electrode signals.
5. Speed up rate of nitrogen for a further 5 min. and then add 2 small spatulas of Sodium dithionite.
6. After ~ 1 min, note the value of the electrode signals. These are the zero values. NB the oxygen level at this point is too low for a valid titration to be performed.

***Table I**: Lander deployment summary*

Deployment #	**008_GEL**	**009_PRF**	**010_PRF**	**011_GEL**	**012_PRF**	**013_GEL**	**014_ELI**	**015_ELI**
Site	C	C	B	B	A	A	A	C
Station #	54701 #02	54701 #13	54702 #02	54702 #13	54703 #02	54703 #07	54703 #18	54705 #01
Configuration	Gel	Profilur	Profilur	Gel	Profilur	Gel	Elinor incubation	Elinor incubation
Deployment date	30/06/98	01/07/98	02/07/98	03/07/98	06/07/98	07/07/98	09/07/98	16/07/98
Deployment time	0056	1909	1807	1804	1653	0922	0640	0331
Deployment position	57.0155N 12.5008W	57.0732N 12.4892W	57.4083N 15.7428W	57.4035N 15.7490W	52.9048N 16.9055W	52.9137N 16.9137W	52.9113N 16.9083W	57.0810N 12.4995W
Deployment Water depth (m)	1960	1961	1101	1105	3563	3563	3560	~1950
Recovery date	01/07/98	02/07/98	03/07/98	05/07/98	07/07/98	08/07/98	14/07/98	21/07/98
Recovery time	0903	0425	0525	0442	0436	2030	1740	0753
Recovery position	57.0072N 12.4953W	57.0675N 12.4792W	57.4040N 15.7372W	57.3999N 15.7452W	52.9035N 16.9032W	52.9138N 16.9050W	52.9113N 16.8932W	57.0783N 12.4997W
Time on bottom (hrs)	30.5	7.8	10.2	33.8	9.5	33.8	129	123
Weight on descent (kg)	53	41	47	52	46	52	53	53
Weight on ascent (kg)	-75	-81	-81	-75	-81	-75	-98	-98
Descent speed (m/min)	~ 50 (estimate)	52	58	61	57	59	61	~64
Ascent speed (m/min)	57	61	61	55	67	60	71	~67
Estimated max. penetration of electrodes, gels or chamber into sediment (mm)	80	40	45	30	30	80	155	205

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

9. CTD OPERATIONS (including a section on associated instrumentation)

9.1. CTD System: Neil Brown MkIIIc, GO 1015 Tone Fire 12 bottle Rosette

The first cast was at site C to a depth of 1950m. Although the CTD was operating normally, the rosette exhibited a number of misfires one after another. The following cast, to a similar depth, was attempted, but this time a fault arose with the ctd computer such that no logging or display could be shown. The cast was continued as the ship's ABC system was still able to log the data. However, the rosette again indicated a majority of misfires.
The next cast was at site B and to a depth of 1100m. Another PC was substituted for the CTD computer and the system successfully entered acquisition mode. The rosette was also replaced with the spare unit. The cast was completed with no misfires; all the bottles closing normally.
The next cast exhibited the same computer problem as had been experienced earlier. However, the dip was continued, logging again being carried out by the ABC system. The problem was finally thought to be a bug in the data acquisition "Oceansoft" software. This could not be rectified on-board as no master copy was available and both working copies of the software exhibited the same problem. From this time on, logging of the ctd casts were solely carried out by the ABC system.

At site A, cast CTD05 to a depth of 3560m was aborted at maximum depth due to a termination problem. This was found to be a break in the termination "tail" itself and was subsequently replaced. After the boat transfer at Galway, the opportunity was taken to substitute the ctd for the spare unit; since the data being logged up to that time was becoming increasingly noisy. After exchanging the CTD's the noise was no longer apparent.
The subsequent casts at site A to more than 3500m showed the rosette to exhibit some misfiring yet again. The remaining casts at the other two sites were to less than 2000m depth and no misfires were indicated.

CTD data

Example data for each site is given in Figure 3. The water column structure clearly differs between sites, as noted in CD111. Site A (deep site) has

essentially a two layer structure, with a steep reduction in temperature commencing around 1000 m. The other two site display a very shallow (100-200 m thick) surface mixed layer. At site B, underneath this upper layer, the temperature is approximately constant with depth to within 100 m above the seabed. Site C has a thermally uniform water layer beneath the surface mixed layer to a depth of c. 800 m, below which the temperature decreases monotionically with depth. These bottom water temperatures are:

Fluorescence profiles show a clear surface maximum at each of the sites. The magnitude of this is far greater at site A in comparison to the other two sites. There is no evidence for a deep water, nearbed enhancement of chlorophyll. Output from the light backscatter sensors may be used to infer regions of greater particulate concentration. From this data set, enhanced nearbed concentrations are evident at each of the sites, although again Site A appears to be much more turbid. However, this trend is reversed during CD113B, where the fluorescence signal is very large and the backscatter signal relatively small. One must not abstract global conclusions from these sample data. For a more accurate, overall picture of the nature of the water column throughout the cruise period, one should examine the entire data set.

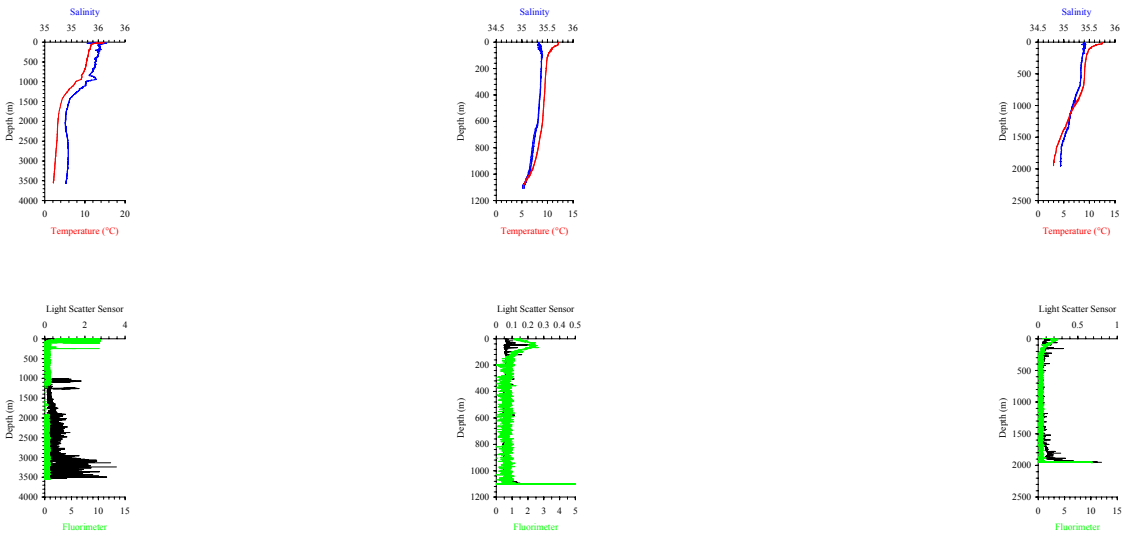

Figure 3. Profiles of temperature, salinity, light scatter and fluorescence from CTD dips at each of the sites made during CD113A (courtesy of Mark Williams)

9.2. Associated instrumentation

9.2.1. Thermosalinograph (TSG)

The TSG operated reliably during the first leg of the cruise. However, an anomalous rise in the fluorometer reading was detected during this time, thought to be due to organic matter accumulating in the system. After the boat transfer at Galway, the system was shutdown and backflushed. This cleaned out the system and the fluorometer reading returned to a reasonable value.

However, noise was then detected on the Housing Temperature, and Salinity and Conductivity channels. When time allowed, the Housing temperature and Remote temperature probes were exchanged to observe if any difference occurred. The noise initially vanished only to return at infrequent intervals. At the time of writing, this is thought to be possibly due to some electrical equipment switched on after the boat transfer of personnel at Galway. On finally leaving site for the last time the values for the Housing and Remote temperatures have returned to normal and the noise has not returned.

The only other minor problems were a few leaks in the piping of the TSG system which were repaired.

9.2.2. Vessel-Mounted ADCP (VM-ADCP)

The VM-ADCP was activated when time allowed using the RDI "Transect" software. No problems were apparent, and the system operated reliably throughout the cruise.

9.2.3. Mooring at Site C

This mooring comprised two Aanderaa RCM8s, two Seatech transmissometers, two USB7 Marine Monitors, an Oceano RT661 release, and associated buoyancy. The mooring was recovered on the 30/6/98 without incident. Both the current meters and the Marine Monitors had successfully logged data for the duration of their deployment. A cursory examination of the data at this time indicates a good data return. The mooring was re-deployed on the 1/7/98, again without incident. All the instruments except the

transmissometers were replaced with previously prepared units similar to those recovered.

9.2.4. Self-Contained ADCP (SC-ADCP)

The SC-ADCP was moored at site B on the sea floor at a depth of 1100m. It was recovered on the 18/7/98 without experiencing any problems. The data was down-loaded to a pc indicating that 1.9Mb of data was recorded. No examination of the data was possible at this time.

9.2.5. Stand-Alone Pumps (SAPs)

Three SAP deployments were planned; one at each of the three sites. The six SAPs were to be used in pairs approximately 2m apart and at three discrete heights above the sea floor. One from each of the pairs of SAPs would contain a filter for trace-metal work, while the other carried one for biological work. The SAPs were to be deployed over the stern as opposed to amidships due to the tortuous route a wire would have taken to avoid various obstacles on the deck.

The first site, station A, was also the deepest at over 3,500m. The deployment began on the 13/7/98 at 2200 in marginal conditions with a heavy swell. A weight was attached to the end of the “clean” plastic-coated wire and the first pair of SAPs clamped into position 10m above it. The next pair were clamped at 40m followed by a pinger at 90m. The last pair of SAPs were at a height of 1000m. All the SAPs were secured with safety strops and clamps.

There was some delay in the SAPs arriving at the required depths due to wire angle problems. The pinger was kept at a height of 100m above bottom resulting in the SAP pairs being towed at 20m, 50m and 1000m above bottom respectively. After a pumping time of 2.5 hours the SAPs were recovered.

The pair at 1000m were recovered with intact filters. Of the pair at 50m a.b., the upper SAP was missing along with it’s safety clamp; and it’s strop was torn but still clipped to the wire. The plastic coating of the wire in the vicinity of this SAP was badly damaged. The lower SAP was missing it’s filter housing.

Recovery of the last two SAPs revealed that the upper one had it's volume-meter removed and the lower of the pair had the hose between the meter and the cartridge holders disconnected.

From the damage to the wire coating at the 50m position, and the scoring on the upper surface of the lower SAP, a possible series of events may be deduced as follows. The excessive heave at the stern of the ship led to the wire becoming slack and then taught again in a whip-like motion. This action over the 10 hour deployment and at the end of a large wire-out (over 3,500m in total) would be significant. A spin was induced in the upper SAP causing it's clamps to cut away and in one place totally remove the plastic jacketing of the wire and become loosened. The instrument then slipped a short distance to the safety clamp which it proceeded to "hammer" down the wire stripping more of the jacketing. Once a sufficient length of wire had been stripped, the safety clamp too would become loose and eventually be lost. The SAP, then only being held to the wire by it's safety strop, slipped until it struck the instrument beneath leading to the loss of its filter housing. Eventually, after causing some scoring to the upper surface of the lower SAP, the safety strop of the upper SAP parted leading to the loss of the instrument. Of the lowest pair of instruments, lateral forces (again possibly due to the rotation of the SAP around the wire) acting on the rigid pipes caused these pipes to part resulting in one case of the loss of the volume meter.

The weather at the next station, site C, was again marginal and after the experience at site A the SAP deployment was aborted. At the final station, site B, due to the loss of one instrument and damage to another, it was decided to only deploy two pairs of SAPs at 20 and 50m a.b. respectively. Deployment began at 2230 on the 18/7/98 in about 1100m depth. A pinger was clamped at 100m a.b. for monitoring the position above bottom. The SAPs were inboard by 0800 on the 19th with all instruments and filters intact.

From the events at site A, several recommendations may be made. Where possible, deployment of SAPs should be carried out from the mid-ships gantry where heave is much reduced. If SAP operations must be carried out

over the stern, they must only be deployed in calm weather both for safety reasons and to reduce the risk of losing equipment. When time and finances allow, perhaps an altogether different clamp and wire system for attaching the SAPs could be considered, the description of which is beyond the scope of this report (see J. Wynar/R. Phipps).

9.2.6. EA500 Echosounder

Upon sailing, the EA500 was activated and it was immediately apparent that there was a fault with the system as a strong bottom echo could not be received reliably. On investigation, the problem was found to be two high-power resistors on the A.C. power supply board which had become open-circuit. A spare board was connected in the place of the faulty one and the system re-activated.

The system operated for a few hours and then once again the bottom echo began to break up and finally stopped altogether. The problem this time was found to be in the 10kHz transceiver board. After some cleaning of the transceiver, the board was re-inserted into the system and the echosounder tested. The EA500 began to operate and detected the bottom reliably. The fault was probably some small solder fragments from the breakdown of the a.c. power supply board.

The echosounder continued to operate for the rest of the cruise without further problems arising.

10. MOORING OPERATIONS

Mooring operations on this cruise were limited to turn-around of the mooring at site C.

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 CD113. 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. Cloud cover during much of the cruise reduced the utility of the satellite images. Images were received for the following days:

29th June, 1998
7th July, 1998
12th July, 1998
14th July, 1998
17th July, 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.

12. CONCLUSION

CD 113 was, on the whole, a reasonably successful cruise. However, several periods of bad weather completely stopped the scientific programme at times, and much needed science time was lost. Re-routing of the ship during Leg B to site C then across to site B before sailing home was a direct example of bad weather contingency. In addition, a number of technical, hardware-related problems beset us (e.g. the wire load cell, the echo-sounder, the CTD logging system), and I should like to thank the RVS support for their efforts in these matters. The loss of the MLA ARIES system at site B was rather unfortunate, but every effort was made to retrieve the system without seriously compromising other scientific activities.

It is regrettable that the seabed was not smothered in as much fluff as one might have hoped. The participants of CD112 (in the Faero-Shetland channel farther north) indicated that an intense phytoplankton bloom had occurred during much of their cruise, and only the remnants of this fluff was found in BENBO samples. Site A appeared to have the most fluff in cores (1-2 cm), trace amounts were found at site B, and photographic evidence shows some fluff was deposited at site C (113B). Nonetheless, it is likely that the

biogeochemical signal of fluff deposition at each of our sites will be in the surficial sediments. This highlights the difficulties associated with planning cruises around temporally variable, natural phenomena.

The Lander has been a central part of the BENBO cruises. Much experience was gained from the activities on CD111, and CD113 provided an opportunity to gain some valid scientific data. Useful data was obtained, although clearly the use of the Lander was not optimised. The short run-up to BENBO as a whole is reflected in the amount of data gathered by the Lander, but at least now the system is thoroughly field-tested and will probably be of much greater use to future programmes.

CD113 is the last of the BENBO process cruises. In conclusion, both cruises have gone as well as could be expected. CD111 was perhaps more fruitful than one might have imagined (because the weather was uncharacteristically good!). We achieved true pre- and post-bloom conditions, although as noted we arrived rather late in terms of the peak time of deposition of fluff on the seafloor. On both cruises, the majority of scientists were happy with the quantity of work they managed to undertake, and the personnel exchange at Galway enabled far more scientists to actually participate in the cruises. The lander generated some useful data on oxygen content, oxygen consumption and solute fluxes.

Appendix I

Cruise Log

Date	SOC#	Activity	Time Start	Time Stop	Water depth/m	Lat-Long
CD 113A						

29/06/98	54701#1	underway water sample	08:50	09:00		56 03 03.06 08 45 09.00

Station C

30/06/98	54701#2	Lander deploy. (gel)	00:58	07:16		57 00 54.14 12 30 03.64
	54701#3	mooring recovery	10:29			
	54701#4	CTD	15:29	17:10	1951 m	57 04 05.82 12 29 05.34
	54701#5	mega-core	18:10	20:05	1965 m	57 04 02.52 12 29 02.04
	54701#6	mega-core	20:42	22:35	1968 m	57 04 20.05 12 29 23.58
	54701#7	mega-core	22:52	**01/07/98** 00:35	1967 m	57 04 24.22 12 29 36.60
01/07/98	54701#8	box core	01:30	03:13		57 04 18.50 12 29 36.60
	54701#9	mega-core	03:38	05:06		57 04 23.79 12 28 43.40
	54701#10	Lander recovery		09:13		
	54701#11	ARIES deploy.	10:33	14:40		57 05 02.10 12 31 00.18
	54701#12	CTD (acoustic rel. test)		21:18		57 04 22.96 12 29 20.29
	54701#13	Lander deploy.	19:10			57 04 23.27 12 29 20.34
	54701#14	mooring deploy.	20:05	21.52		57 02 24.00 12 28 54.00
	54701#15	bed-hop camera	22:43	**02/07/98** 01:25	1954 m	57 03 33.38 12 32 45.63
02/07/98	54701#16	lander recovery	04:43			57 04 04.30 12 29 01.01

Station B

	54702#1	bed-hop camera	15:40	17:15	1103 m	57 24 56.50 15 43 45.75
	54702#2	Lander deploy. (oxygen)	18:07		1101 m	54 24 30.53 15 44 35.10
	54702#3	mega-core	18:52	20:00	1104 m	57 23 57.37 15 44 30.03
	54702#4	mega-core	20:16	21:15	1104 m	57 24 04.24 15 44 34.65
	54702#5	ARIES deploy.	22:00	03/07/98 00:35	1110 m	57 22 54.60 15 48 57.00
03/07/98	54702#6	Lander recovery	05:39			
	54702#7	box core	06:14	07:00	1104 m	57 24 25.98 15 44 31.61
	54702#8	mega-core	07:42	08:50	1100 m	57 24 19.10 15 44 04.96
	54702#9	mega-core	09:15	10:26	1102 m	57 24 08.19 15 44 14.91
	54702#10	ARIES deploy.	11.39			
	54702#11	CTD	15:03		1102 m	57 26 00.90 15 44 24.60
	54702#12	mega-core	16:30	17:20	1101 m	57 24 16.20 15 44 05.62
	54702#13	Lander deploy.	18:08		1105 m	57 24 13.10 15 44 54.25
04/07/98	54702#14	CTD	09:10		1106 m	57 25 05.34 15 44 29.41
	54702#15	ARIES deploy. ARIES lost - search	11:00 13:00			
05/07/98	54702#16	Lander recovery	05:02			

Station A

06/07/98	54703#1	mega-core	13:40	16:30	3560 m	52 54 21.60 16 54 30.15
	54703#2	Lander deploy. (oxygen)	16:55		3357 m	52 54 18.97 16 54 20.77
	54703#3	CTD	18:50	21:13	3560 m	52 54 43.81 16 54 30.00
	54703#4	Bed hop camera	21:28	**07/07/98** 00:56	3559 m	52 55 02.40 16 54 03.84
07/07/98	54703#5	Lander recovery	04:45			
	54703#6	mega-core	05:20	08:30	3565 m	52 54 40.86 16 55 04.87
	54703#7	Lander deploy. (gel)	09:20		3651 m	52 54 48.97 16 54 48.37
	54703#8	box core	10:00	13:14	3562 m	52 54 47.67 16 55 08.37
	54703#9	ARIES deploy.	14:38		3548 m	52 46 57.00 16 49 52.20
	54703#10	multi-core	20:31	23:26	3557 m	52 55 07.35 16 53 52.10
08/07/98	54703#11	CTD	00:59	04:00	3563 m	52 54 19.20 16 54 00.60
	54703#12	mega-core	04:50	09:00	3564 m	52 54 19.20 16 54 26.45
	54703#13	CTD	09:24	12:45	3562 m	52 54 23.90 16 54 31.00
	54703#14	ARIES deploy.	14:12	19:00	3677 m	52 53 27.60 16 53 44.41
	54703#15	Lander recovery	20:45		3559 m	52 54 57.03 16 54 10.12
	54703#16	mega-core	21:09	**09/07/98** 00:37	3560 m	52 55 00.97 16 54 32.82
09/07/98	54703#17	mega-core	00:41	03:47		52 55 47.27 16 53 01.02

	54703#18	Lander deploy. (chamber)	06:40			52 54 40.80 16 54 30.00

CD 113B

Station A

12/07/98	54704#1	CTD	11:05	14:13	3562 m	52 55 01.24 16 54 31.69
	54704#2	CTD	17:00	19:36	3558 m	52 54 02.40 16 55 02.40
	54704#3	box core	20:24	23:23	3569 m	52 54 12.60 16 55 25.47
13/07/98	54704#	box core	00:00	03:18	3570 m	52 54 00.73 16 56 49.10
	54704#5	multi-core	04:17	07:15	3567 m	52 54 09.02 16 55 27.76
	54704#6	multi-core	07:50	10:34	3570 m	52 54 03.00 16 55 20.15
	54704#7	multi-core	11:07	13:58	3568 m	52 54 17.25 16 55 23.80
	54704#8	multi-core	15:30	17:07	3567 m	52 54 18.45 16 55 17.76
	54704#9	mega-core	18:18	21:23	3567 m	52 54 47.82 16 54 55.06
				14/07/98		
	54704#10	SAPS deploy.	22:30	06:00		52 52 52.76 16 56 13.77
14/07/98	54704#11	box core	06:51	09:56		52 54 12.85 16 55 23.80
	54704#12	multi-core	10:55	13:45	3568 m	52 54 12.85 16 54 57.94
	54704#13	multi-core	14:20		3560 m	52 55 53.34 16 53 14.12
	54704#14	Lander recovery	17:44			
	54704#15	bed hop camera	18:17	22:31		52 54 46.16

						16 55 06.96

Station C

16/07/98	54705#1	Lander deploy.	03:31			57 04 52.37 12 30 04.84
	54705#2	mega-core	04:38	06:15	1935 m	57 05 12.18 12 13 21.31
	54705#3	mega-core	08:00	10:00	1937 m	57 05 05.59 12 13 21.31
	54705#4	mega-core	10:20	10:59	1938 m	57 05 20.55 12 30 30.58
	54705#5	box core	11:13	12:47	1941 m	57 05 12.66 12 30 21.00
	54705#6	CTD	13:27	15:09	1948 m	57 06 09.18 12 26 25.33
	54705#7	multi-core	15:42	17:00	1963 m	57 05 58.60 12 24 23.14
	54705#8	multi-core	17:49	19:23	1980 m	57 05 30.98 12 24 25.55
	54705#9	box core	20:38	21:38		57 04 40.80 12 27 13.20
				17/07/98		
	54705#10	bed-hop camera	23:07	01:47	1988 m	57 05 05.39 12 24 59.62
17/07/98	54705#11	Agassiz trawl		02:39	2027 m	57 04 46.21 12 20 45.75

Station B

18/07/98	54706#1	SC-ADCP recovery	07:43		1098 m	57 25 30.60 15 41 24.56
	54706#2	mega-core	10:03	11:11	1092 m	57 25 28.27 15 40 35.92
	54706#3	mega-core	11:35	12:25		57 25 10.60 15 40 53.93
	54706#4	mega-core	13:00	13:51		57 25 24.70 15 40 51.38

	54706#5	box core	14:11	15:00	1091 m	57 24 50.18 15 40 35.69
	54706#6	multi-core	15:37	16:39	1094 m	57 24 24.29 15 41 31.27
	54706#7	multi-core	16:57	17:55	1095 m	57 44 25.87 15 41 30.92
	54706#8	multi-core	18:13	19:10	1095 m	57 24 25.31 15 41 28.33
	54706#9	bed-hop camera	19:40	23:32	1095 m	57 24 10.15 15 41 37.01
	54706#10	CTD	21:48	22:45	1093 m	57 23 39.66 15 41 09.59
				19/07/98		
	54706#11	SAPS deploy.	22:50	05:05	1090 m	57 23 08.33 15 40 39.53
19/07/98	54706#12	Kasten core	06:15	07:07	10936 m	57 22 12.03 15 41 57.40
	54706#13	box core	07:43	08:43		57 22 10.20 15 42 40.85
	54706#14	bed-hop camera	09:00	10:45	1098 m	57 22 01.49 15 43 19.65
	54706#15	mega-core	11:00	12:00	1106 m	57 22 02.94 15 44 36.12
	54706#16	CTD	12:26	13:25	1108 m	57 22 00.48 15 45 00.54
	54706#17	box core	14:42	15:40		57 22 53.26 15 45 20.71
	54706#18	box core	17:01	18:00		57 23 00.84 15 45 35.40