UNIVERSITY OF EDINBURGH

DEPARTMENT OF GEOLOGY AND GEOPHYSICS
MARINE GEOSCIENCES UNIT

Cruise Report

RRS CHARLES DARWIN 53
BOFS 1990 LEG C

G.B. Shimmield

UNIVERSITY OF EDINBURGH

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R.R.S. *CHARLES DARWIN*

Cruise 53

18th September - 24th October
Barry - Tenerife

BOFS 1990 Leg C

Leg C - *Benthic studies, water column particulates and sediment trap deployments: components of the Biogeochemical Ocean Flux Study between 47° N and 18° N along the 20° W meridian in the northeast Atlantic Ocean.*

Principal Scientist:

Dr Graham Shimmield

1990

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1. INTRODUCTION

RRS *Charles Darwin* cruise 53 was the sixth cruise of the Biogeochemical Ocean Flux Study programme in 1990. This cruise extended the transect study, commenced in 1989 along the 20°W meridian, further south into the more meso- and eutrophic waters off west Africa (as far south as 18°N). Earlier BOFS cruises in 1990 carried out a Langrangian study in the northeast Atlantic near 50°N. Cruise 53 was multidisciplinary, with scientists carrying out measurements and sample collection throughout the entire water column and deep into the sediment to evaluate carbon fluxes on a wide range of time scales.

(a) *Scientific aims*

(i) To determine fluxes of carbon and associated organic matter components through the water column and across the sediment-water interface.

(ii) To evaluate the role of contemporary benthic processes in the cycling and remineralisation of organic carbon, and to aid the interpretation of the Holocene historical record.

(iii) To compare the palaeoceanographic record at four major sites, and at a variety of water depths, with the present biogeochemical flux of biogenic detritus.

(iv) To evaluate the change in surface water pCO_2 as a function of productivity and water mass temperature and chemistry.

(b) *Specific cruise objectives*

(i) To survey four principal sites along the 20°W transect using echo sounder, 3.5kHz reflection profiler and sea floor photography.

(ii) At the four sites to recover, at a variety of water depths, multicore, box core, kasten core and piston core material. This would enable sediment samples with a variety of ages and sample resolutions to be collected.

(iii) To X-ray and sample the cores in detail, providing samples for water content, organic carbon and $CaCO_3$ content and chemistry, magnetic susceptibility, grain-size, radiochemistry, mineralogy, micropalaeontology, stable isotope analysis and dating.

(iv) To sample cores and archive samples on behalf of other workers.

(v) To extract pore waters and use micro electrodes to evaluate the status of nutrients and metals within the upper sediment column.

(vi) To recover particulate organic matter compounds and dissolved and particulate radionuclides from the water column using large volume filtration (stand-alone pumps, SAPS) and Go-Flo bottles.

(vii) To study the pCO_2 of surface water using underway measurement techniques, together with nutrients and chlorophyll measurements, and ADCP logs.

(viii) To recover one sediment trap array, and deploy three other arrays for later collection.

(ix) To undertake basic BOFS measurements on water bottle samples (T/S, nutrients, POC, PON, pigments).

(x) To take CTD/transmission-fluorescence casts with 12 x 10l Go-Flo bottles at each coring and trap site.

(c) *Cruise narrative*

(For details see Cruise Log - Table 1 and Fig.1)
We left Barry pier at 17.48 on the 18th September 1990, heading for the BIOTRANS Site at 47°N 20°W in order to recover a BOFS sediment trap rig. By late evening on 21/9 the rig had been recovered successfully due to the skill of the RVS staff and the bosun and his men. We decided to use the rest of the night to have a shakedown station to check the corer, pumps and CTD. Unfortunately, this showed up the inadequacy of the box corer which was to plague us for the rest of the cruise (see further details below). Underway to Site A we conducted pCO_2 measurements and online nutrients and T/S measurements with ^{234}Th sample collection.

Arriving at Site A, Azores-Biscay Rise, we began a series of deployments that was to set the pattern for the remainder of the cruise. Generally, we adopted a coring strategy (Kasten, box, multicore) followed by camera and SAPs, finishing with CTD casts. At each station a 3.5kHz profile was run in order to determine seafloor bathymetry, and to try and estimate the degree of sediment induration. Site A was limited to only two stations; on the 26/9 the weather was worsening and we decided to be prudent and head further south to Site B on the Western Madeira Rise. At this site we were rather more successful, although the box core was still proving obstinate. After a set of trials using different filter techniques, the SAPs were behaving well. In fact, by the end of cruise 53, we had collected the best set of SAP samples obtained from a BOFS cruise.

En route to Site C we deployed the first of three trap arrays. The site was well surveyed beforehand, and we found the deployment reasonably glitch-free, apart from a mislabelled drum with an incorrect rope length. A SAP profile was also run at this trap site. Arriving at Site C (Saharan seamounts) on the 7/10 the cruise was now in full swing. The various coring, SAP and CTD teams were working well, with very little time spent with gear on deck. However, the deep water depths resulted in many hours of wire time. Fortunately, problems with the winches were few (see Mechanical Equipment Report below) and thus we were able to maximise our sampling time. Practically, the position of the Kasten/piston core bucket presented some problems for box and CTD deployment, whilst changing warps for the SAPs (ie covered to uncovered wire) became an efficient process. As we worked westwards along the Site C transect into deeper water we had been asked to run a magnetometer survey for Dr R. White (Cambridge University). Unfortunately, despite spending several hours trying to isolate the source of high frequency noise on the chart record, we were forced to give up. By this stage, a combination of improving weather (sea state) and more organic-rich, silty mud enabled us to recover some useful box cores and proceed with our projected pore water analysis program. Site C was terminated with the deployment of our second sediment trap array, which was successfully completed on the 12/10/90.

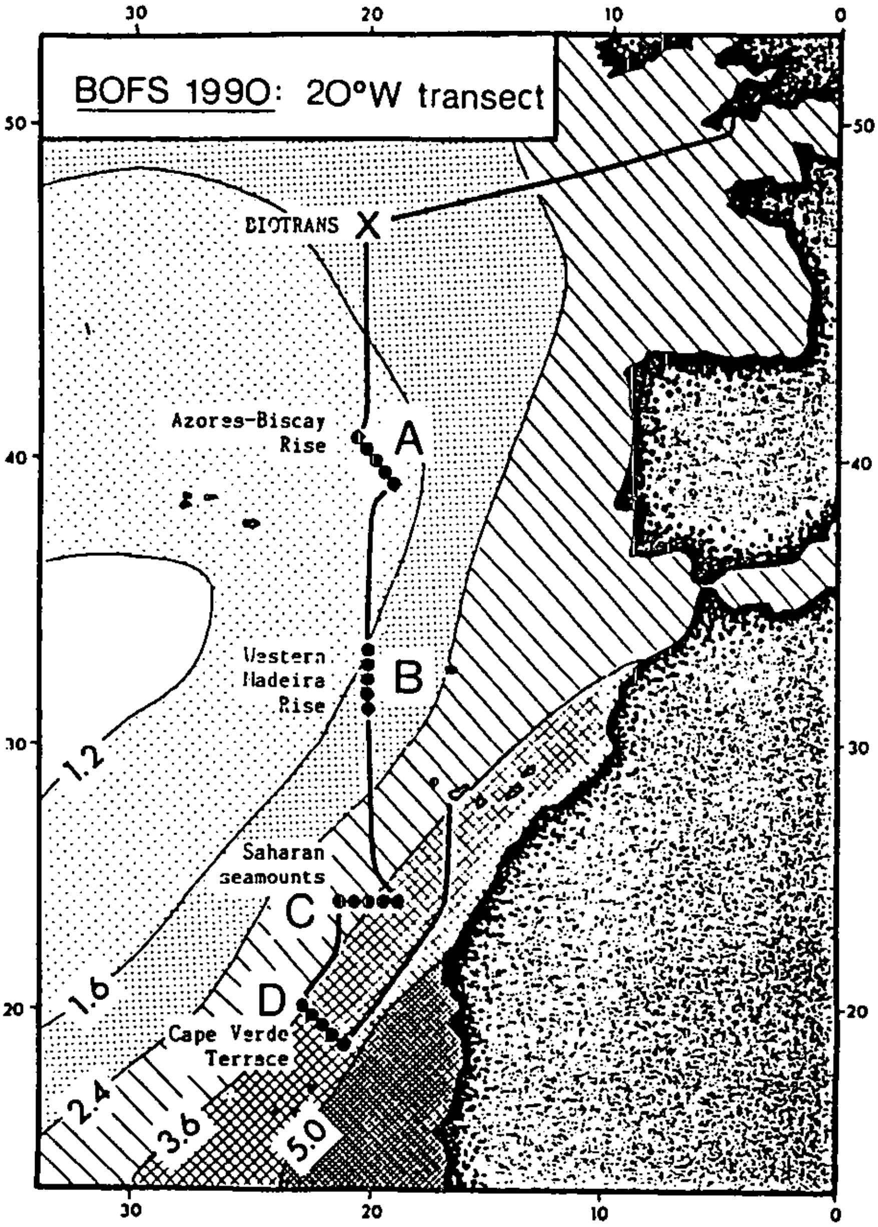

Figure 1. Schematic cruise track for RRS *Charles Darwin* 53.

Moving on to Site D we noticed a strong change in water colour from the deep-blue of the oligotrophic waters to a more steel-grey of the meso/eutrophic waters associated with the northwest African upwelling system. We planned to core and sample along a southeasterly trending transect, running up the Cape Verde terrace, equidistant between Cape Verde and Mauritania national waters. Starting in deep waters we were about half way through the transect when a distress call was received from a vessel to our west-south-west. Twelve hours later we were back on station having made sure the vessel in distress (a French fishing boat) was being attended to by another vessel. On the 19/10/90 our third, and last, sediment trap array was successfully deployed. This trap array is part of a collaborative effort between BOFS and the French EUMELI programme. Once the traps were over the side, we retraced our track along the NW-SE transect to the deepest station (Station 32) were we carried out a full set of coring procedures.

With 40 hours in hand we decided to retrace our course back to the vicinity of the Saharan seamounts (Site C) in order to try to recover some shallow-water pteropod-rich ooze. Despite some repeated attempts in 995 m of water on a seamount that we carefully surveyed with the 3.5kHz profiler we were rather unlucky apart from a shallow box core. The final station of the cruise was a repeat of Station 26 which was en route for Tenerife. In 3640 m of water we again failed to obtain a box core in the well-indurated foram ooze, but a piston core was obtained. The final 36 hours to Tenerife passed quickly, amidst a welter of sample curation and instrument packing. A very successful and enjoyable cruise.

Graham Shimmield

Charles Darwin 53 Station Log

Date	Time (GM	Lat (N)	Long (W)	Station Number	Deployment	Remarks
18.09.90	17.48					Depart Barry pier
19.09.90	04.00	50 56.7	05 24.6			Reduce speed, excessive pounding
21.09.90	14.42	47 45.5	19 27.8			Commence search for sediment traps
	20.15	47 46.2	19 30.5			All traps recovered
	22.04	47 47.2	19 29.6	CD53-SS#1BX	Box core	Shakedown station, 4610 m (failed)
22.09.90	02.58	47 48.4	19 29.0	CD53-SS#2SA	SAPs	
	05.49	47 48.4	19 26.6	CD53-SS#3CT	CTD	12 bottle test
	06.30	47 48.3	19 26.2			Shakedown sation ends
SITE A						
23.09.90	12.19	42 03.3	21 19.9			Commence 3.5KHz survey
	13.23	42 02.4	21 21.4	CD53-18#1K	Kasten core	4101 m depth
	16.38	42 03.8	21 23.1	CD53-18#2BX	Box core	4151 m depth (failed)
	21.52	42 05.4	21 24.8	CD53-18#3C	Camera	
24.09.90	01.30	42 05.9	21 25.6	CD53-18#4M	Multi core	4112 m depth
	05.38	42 06.9	21 26.8	CD53-18#5SA	SAPs	
	15.56	42 10.0	21 27.4	CD53-18#6CT	CTD	
	20.45	42 10.1	21 28.4	CD53-18#7CT	CTD	
	22.05	42 10.7	21 28.4	CD53-18#8CT	CTD	
25.09.90	04.45	41 09.5	20 49.8			Commence 3.5KHz survey, station 19
	05.41	41 04.5	20 46.6	CD53-19#1K	Kasten core	3805 m depth
	09.03	41 05.4	20 46.4	CD53-19#2BX	Box core	3815 m depth
	13.33	41 06.6	20 45.2	CD53-19#3M	Multi core	3680 m depth
	17.04	41 06.7	20 42.3	CD53-19#4SA	SAPs	
26.06.90	00.15	41 08.9	20 42.8			Deteriorating weather, station abandoned
	14.15	39 54.8	19 50.2	CD53-20#1CT	CTD	Only deployment, weather worsening

	15.20	39 54.5	19 49.8			Site abandoned, set course 12
SITE B						
28.9.90	19.48	33 00.3	18 15.0			Commence 3.5KHz survey
	21.24	33 01.1	18 13.6	CD53-21#1K	Kasten core	2975 m depth
	23.50	33 02.3	18 15.2	CD53-21#2BX	Box core	3010 m depth (failed)
29.09.90	02.55	33 01.3	18 13.8	CD53-21#3BX	Box core	(failed)
	06.16	33 01.0	18 12.7	CD53-21#4M	Multi core	2964 m depth
	10.22	33 00.2	18 14.7	CD53-21#5C	Camera	
	13.08	33 00.8	18 15.8	CD53-21#6BX	Box core	2980 m depth (failed)
	16.14	32 59.4	18 16.6	CD53-21#7M	Multi core	3032 m depth (failed)
	19.59	32 59.9	18 16.0	CD53-21#8M	Multi core	2990 m depth
	23.14	33 01.3	18 18.3	CD53-21#9CT	CTD	
30.09.90	02.30	33 00.3	18 16.0		Regaining station position	
	03.45	33 00.3	18 16.0	CD53-21#10B	Box core	3010 m depth
	06.30	32 59.7	18 15.3		Station 21 ends	
	12.26	32 54.0	19 09.9		On Station 22	
	12.33	32 54.1	19 09.9	CD53-22#1K	Kasten core	3740 m depth (<1m)
	15.35	32 53.1	19 11.6	CD53-22#2M	Multi core	3777 m depth
	19.01	32 52.4	19 13.5	CD52-22#3K	Kasten core	3808 m depth
	21.45	32 52.8	19 15.5	CD53-22#4BX	Box core	3825 m depth (failed)
01.10.90	01.56	32 54.0	19 17.2	CD53-22#5CT	CTD	
	05.28	32 53.9	19 16.7	CD53-22#6M	Multi core	3860 m depth
	09.13	32 53.1	19 16.5	CD53-22#7BX	Box core	3850 m depth
	13.50	32 51.9	19 18.6		Station 22 complete	
	20.29	32 32.4	20 23.5	CD53-23#1P	Piston core	4650 m depth
02.10.90	02.58	32 32.1	20 23.7	CD53-23#2M	Multi core	4724 m depth
	07.15	32 31.8	20 25.1	CD53-23#3K	Kasten core	4650 m depth
	11.03	32 31.8	20 25.9	CD53-23#4BX	Box core	4655 m depth (failed)
	15.40	32 32.2	20 25.4	CD53-23#5CT	CTD	
	16.57	32 32.0	20 25.3	CD53-23#6SA	SAPs	
	23.39	32 30.0	20 25.1	CD53-23#7M	Multi core	4680 m depth
03.10.90	03.33	32 29.5	20 26.2	CD53-23#8CT	CTD	

	07.50	32 28.5	20 27.8	CD53-23#9K	Kasten core	4680 m depth (for Cardiff)
	12.42	32 29.2	20 24.8	CD53-23#10C	CTD	
	14.42	32 32.2	20 23.9	CD53-23#11S	SAPs	
04.10.90	01.15	32 33.3	20 21.0	CD53-23#12M	Multi core	4735 m depth
	04.36	32 33.1	20 20.9		Station 23 ends	
	→22.18	29 30.3	22 00.0	CD53-24#1CT	CTD in prep for trap deployment	
TRAP SITE						
05.10.90	10.32	27 59.1	22 00.2		Commence trap site survey	
	12.10	27 59.5	22 00.0	CD53-25#1T	Commence trap deployment	
	16.47	28 00.4	21 59.2		Trap mooring on bottom	
	18.08	28 00.9	22 05.1	CD53-25#2SA	SAPs	
06.10.90	02.58	28 03.7	22 03.6	CD53-25#3M	Multi core	4920 m depth
	08.37	28 05.3	22 03.6	CD53-25#4SA	SAPs	
	18.24	28 07.3	22 02.8		SAPs complete, underway to Site C	
SITE C						
07.10.90	15.12	24 30.0	20 00.0		Commence 3.5KHz survey	
	16.00	24 29.6	19 53.2	CD53-26#1K	Kasten core	3715 m depth
	18.51	24 28.7	19 53.2	CD53-26#2M	Multi core	3660 m depth
	22.08	24 28.2	19 52.1	CD53-26#3BX	Box core	3650 m depth (failed)
08.10.90	02.14	24 28.1	19 51.4	CD53-26#4C	Camera	
	05.02	24 27.6	19 50.9	CD53-26#5BX	Box core	3645 m depth (failed)
	08.55	24 27.0	19 50.0	CD53-26#6K	Kasten core	3635 m depth (for Cardiff)
	11.40	24 26.4	19 49.6		Depart Station 26	
	15.06	24 26.8	20 24.6		Hove to on Station 27	
	15.10	24 26.8	20 24.5	CD53-27#1CT	CTD	
	16.41	24 27.5	20 23.9	CD53-27#2CT	CTD	
	17.39	24 27.6	20 23.4	CD53-27#3SA	SAPs	
09.10.90	01.00	24 27.1	20 24.3	CD53-27#4K	Kasten core	4000 m depth
	05.12	24 28.9	20 23.2	CD53-27#5M	Multi core	4007 m depth
	09.03	24 30.2	20 25.0	CD53-27#6BX	Box core	4000 m depth
	12.56	24 31.5	20 24.7	CD53-27#7P	Piston core	4015 m depth

	17.56	24 34.2	20 24.2	CD53-27#8SA	SAPs	
	23.47	24 34.4	20 21.6		SAPs inboard, deploy magnetometers	
10.10.90	02.22				Increase to full speed.	Magnetometers U/S
	12.08	24 34.1	22 48.7		Commence 3.5KHz survey, Stn 28	
	14.24	24 38.8	22 49.4	CD53-28#1M	Multi core	4929 m depth
	18.20	24 34.3	22 48.6	CD53-28#2SA	SAPs	
11.10.90	04.50	24 36.9	22 45.7	CD53-28#3K	Kasten core	4840 m depth
	09.13	24 36.9	22 45.5	CD53-28#4BX	Box core	4840 m depth (failed)
	13.39	24 36.6	22 47.1	CD53-28#5CT	CTD	
	18.04	24 37.2	22 47.0	CD53-28#6SA	SAPs	
12.10.90	04.17	24 38.3	22 48.7	CD53-28#7BX	Box core	4840 m depth
	→ 09.16	24 37.8	22 47.8	CD53-28#8CT	CTD	
	10.36	24 33.8	22 48.9		Commence trap deployment	
	13.23	24 33.2	22 50.2		Mooring on way down	
	15.39	24 32.9	22 50.0		Trap mooring secure, depart Sta.29	
Site D						
13.10.90	13.02	20 34.2	21 08.2		Commence 3.5KHz survey, Station29	
	13.42	20 31.0	21 07.0	CD53-29#1K	Kasten core	4000 m depth
	16.54	20 31.8	21 07.1	CD53-29#2M	Multi core	4000 m depth
	20.32	20 33.0	21 06.6	CD53-29#3SA	SAPs	
14.10.90	06.36	20 31.6	21 06.6	CD53-29#4BX	Box core	3995 m depth
	12.49	20 33.6	21 07.1	CD53-29#5P	Piston core	4005 m depth
	16.30	20 32.4	21 07.4	CD53-29#6C	Camera (fault on winch during deployment)	
	19.27	20 34.5	21 07.6	CD53-29#7CT	CTD	
	21.12	20 34.8	21 08.0		Depart for Sation 30	
15.10.90	04.00	19 40.0	20 40.0		Hove to on Station 30	
	04.14	19 40.2	20 40.5	CD53-30#1M	Multi core	3565 m depth
	08.01	19 41.5	20 40.7	CD53-30#2P	Piston core	3565 m depth
	14.22	19 44.8	20 43.5	CD53-30#3K	Kasten core	3580 m depth
	17.41	19 40.4	20 40.4	CD53-30#4BX	Box core	3545 m depth (aborted)
	18.41	19 40.8	20 40.5		Distress call on VHF	
	18.59	19 40.9	20 40.5		Box core abandoned, answering distress call	
16.10.90	00.12	19 03.6	21 31.8		Distress call completed, return to #30	

	07.42	19 40.0	20 40.1		Hove to again on Station 30	
	07.58	19 39.7	20 40.6	CD53-30#5BX	Box core	3540 m depth
	12.34	19 41.2	20 43.1	CD53-30#6SA	SAPs	
	19.04	19 42.5	20 43.2	CD53-30#7CT	CTD	
	20.00	19 42.8	20 43.5	CD53-30#8C	Camera	
	22.43	19 43.8	20 43.6		Depart for Station 31	
17.10.90	04.02	19 00.2	20 10.3		Commence 3.5 KHz survey, Station 31	
	06.22	18 59.9	20 09.7	CD53-31#1K	Kasten core	3300 m depth (failed)
	09.38	19 00.4	20 10.3	CD53-31#2K	Kasten core repeat	3300 m depth
	12.38	18 59.9	20 09.8	CD53-31#3M	Multi core	3295 m depth
	15.58	18 59.7	20 10.0	CD53-31#4CT	CTD	
	19.36	19 00.2	20 10.0	CD53-31#5S	SAPs	
18.10.90	05.30	19 00.1	20 10.4	CD53-31#6BX	Box core	3300 m depth (failed)
	09.14	19 00.1	20 10.0	CD53-31#7BX	Box core - repeat	3300 m depth
	12.32	19 01.3	20 09.9		Replacing bridge window	
	14.30	19 00.0	20 10.0		Back on station	
	14.38	19 00.0	20 10.0	CD53-31#8C	Camera	
	17.01	19 00.0	20 10.0	CD53-31#9P	Piston core	3300 m depth
	20.47	19 00.2	20 10.2	CD53-31#10S	SAPs	
19.10.90	04.12	18 59.2	20 09.8	CD53-31#10C	CTD	
	07.47	18 59.8	20 10.8		Commence trap deployment	
	10.41	19 00.3	20 10.8		Trap rig deployed	
	11.37	19 00.2	20 10.8		Trap position fixed after survey	
	12.25	19 04.0	20 15.1	CD53-31#11C	CTD	
	13.38	19 04.0	20 15.1		Underway for Station 32	
20.10.90	11.49	22 30.1	21 59.9		Hove to on Station 32	
	12.06	22 30.2	22 00.0	CD53-32#1BX	Box core	4550 m depth
	16.45	22 30.9	22 00.2	CD53-32#2P	Piston core	4550 m depth
	21.37	22 31.3	22 00.8	CD53-32#3M	Multi core	4555m depth
21.10.90	02.40	22 32.9	22 00.0	CD53-32#4K	Kasten core	4555 m depth
	05.54	22 32.8	22 00.7		Underway to Station 33	
	16.20	23 46.9	20 43.8		Commence Commence 3.5KHz survey	
	19.29	23 53.3	20 42.4	CD53-33#1C	Camera	

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	20.41	23 53.1	20 42.1	CD53-33#2BX	Box core	995 m depth (failed)
	21.58	23 53.1	20 41.8	CD53-33#3BX	Box core	995 m depth
	23.06	23 53.0	20 41.7	CD53-33#4K	Kasten core	955 m depth (failed)
22.10.90	00.18	23 52.9	20 41.7		Resume 3.5 KHz survey	
	01.24	23 51.6	20 44.4	CD53-33#5K	Kasten core	1010 m depth (failed)
	02.24	23 51.5	20 44.4		Underway to return Station 26	
	04.18	24 00.0	20 30.0		Hove to to sort out CTD wire	
	12.01	24 27.1	19 50.0		Hove to on Station 26	
	12.37	24 27.1	19 50.0	CD53-26#7BX	Box core	3640 m depth (failed)
	16.12	24 28.1	19 50.2	CD53-26#8P	Piston core	3640 m depth
22.10.90	20.00	24 28.1	19 50.2		Underway - return to Tenerife	
24.10.90	08.30				Arrival at Tenerife	

2. TOPOGRAPHY, 3.5kHZ PROFILES AND PHOTOGRAPHY

In general, the bathymetry of the northeast Atlantic is well known. Planning for the cruise used maps supplied by IOS and the GEBCO chart series. The four main sites were chosen to allow sediment samples from a variety of water depths to be recovered (see Fig.1). In addition territorial water belonging to Mauritania and the Cape Verde islands at the southernmost site had to be avoided. The Portuguese government are thanked for their permission to core the Western Madeira Rise.

For Sites B, C and D large scale bathymetric charts obtained from IOS enabled us to define a coring transect with some confidence. In addition, published papers by Kidd *et al.* (1989) on the Saharan Slide (well illustrated with GLORIA images) helped us avoid the worst sediment disturbance caused by submarine slides. At Site D two stations (53-31 and 53-32) were chosen to approximately correspond to Sites 657 and 659 of Leg 108 of the Ocean Drilling Program. The large scale charts were accurate and we defined our sample sites to lie on continuous gradients away from potential submarine channels or eroded ridges.

The 3.5kHz profiler was employed at the sample sites selected from the charts, and at the trap sites. Generally good results were obtained, in particular the characteristic hyperbolic echoes associated with sediment slides and mud waves warned us of possible disturbance. The two northern sites, A and B, where characterised by well-indurated carbonate ooze which defeated nearly all our attempts with the box-corer (see below). The 3.5kHz record indicated little signal penetration through an otherwise smooth sea floor. Further south, where bottom sediments became rather more silty and organic-rich, penetration increased and mud drape over ?basaltic basement escarpments could be seen clearly.

At most stations the twin camera rig was deployed. Initially, this was loaded with black and white film to obtain a stereo-pair, but we reverted to colour slide film in one camera and black and white in the other (to obtain a record consistent with *Discovery* 184). In all cases, a compass-current vane was used in an effort to orientate any sea floor features with the prevailing bottom current direction. There appeared to be a general increase in bioturbation and benthic activity southwards along the transect, although the abundance of fluff and organic phytodetritus seen on D184 north of 47°N was absent.

Graham Shimmield

3. CORING OPERATIONS

(a) *Core numbering system*

Following the recommendation made by I.N. McCave (D184) we commenced core numbering at Station 18. In addition, all stations are prefaced by the ship and cruise number ("CD53"). Ship station numbers are not used on the *Charles Darwin*. Therefore the following convention is used:

"CD53-nn#nX"

CD53	Ship and cruise number
-nn	Station number, commencing at Station 18
#n	Deployment number, numbered consecutively whether successful or not
X	A letter designating the deployment activity: M - multicore BX - box core K - kasten core P - piston core C - camera SAP CTD

Table 2 presents a summary of all the coring operations during this cruise.

(b) Multicore sampling

Shallow sediment cores were collected using the Multicore Sampler (Duncan and Associates) for solid phase geochemical analysis and pore water oxygen measurements. The Multicore Sampler obtains cores no deeper than 35 cm and normally ensures total preservation of the sediment water interface. This is necessary to allow millimeter-scale sectioning of the upper part of the cores. Prior to sectioning an oxygen-selective electrode was inserted into the top of the core stepwise using a micromanipulator with a resolution of 0.1mm. The micro current generated by the electrode was amplified to a millivoltage and read from a normal multimeter. The electrode was calibrated prior to each profile by collecting the water above the sediment in the core tube and vigorously aerating one fraction of it to give a reading for 100% saturation and adding sodium dithionite to another fraction to give a reading for 0% saturation. All measurements were carried out at 3°C.

When possible three cores were collected from each Multicore deployment for solid phase geochemical analysis and porewater oxygen measurement. In total 14 stations yielded 34 cores from which approximately 1300 sediment slices were obtained. The details of each Multicore deployment are given in the coring log (Table 2). The principal aims for the solid phase geochemistry is to examine the kinetics of organic carbon remineralisation and $CaCO_3$ dissolution, to determine bioturbation depth and rates from ^{210}Pb data, and to determine particle fluxes from reactive trace metal and U-series radioisotope data.

Tim Brand

(c) Box core sampling

A prerequisite of this programme was a good suite of box core samples since the multicore sampler provides insufficient material for the depth resolution desired, whilst the kasten core characteristically severely disturbs the sediment-water interface. Unfortunately, the box core provided had apparently been scrapped only a few weeks prior to the cruise and consequently was not in A1 condition at the outset. It failed to obtain any useful material whatsoever at the northern sites, either, we believe, as a result of it bouncing on (rather than entering) the carbonate ooze, or as a result of poor seals between the box and the spades. Only following major maintenance and redesign of the spades by RVS staff were usable cores finally obtained. Although box coring is part an art and part science, it is considered negligent on the part of RVS that a deep-sea benthic cruise should be serviced with a corer more appropriate for nearshore, shallow water studies. Maybe confusion in corer nomenclature was to blame, in which case it should be made abundantly clear to future benthic cruises which particular box corer design will be supplied/is being requested, since some (SMBA-type) are more "heavy duty" than others. Also the IOSDL core used on last year's BOFS benthic cruise is acoustically released and can therefore be deployed more rapidly through the water column without fear of pre-triggering, thus saving on wire time (see RRS *Discovery* Cruise 184 (1989) Report, p.14). We believe that this corer would have been available had a request been made to IOSDL for its loan.

Simon Wakefield
Sarah Colley

(d) Kasten core sampling

Objectives
The Kasten-coring program of Darwin cruise 53 consisted of an extension of last years BOFS leg 3 (Discovery 184) from 45°N to 18°N along the 20°W meridian. The principle objectives of the Kasten coring were identical with last years: provision of a historical record of the changing oceanic conditions from the Late-Pleistocene to present day to allow the analysis of the glacial to modern history of the fluctuating burial rates of carbon and associated elements in order to elucidate the contribution of oceanic processes to the rapid increase in CO_2 and temperature at the end of the ice age and their role in shorter term climatic variations. With the completion of Darwin cruise 53, we are now in possession of a complete transect of Kasten cores from high northern oceanic productivity to high southern oceanic productivity in the North Atlantic.

Technique
The Kasten coring technique[1] which was first introduced during last year's cruise was only slightly modified and improved. In 1989 Cambridge had furnished 2 and 3 metre long U-shaped barrels with double bottom lifting mechanisms. This year, we provided 3 and 4 metre barrels, while RVS had meanwhile produced 1 and 2 metre barrels, so that a range of 1-4 metre corers was available during the cruise. The 4-metre barrel was built after oxygen isotope determinations of Discovery 184 cores had revealed maximum ages of 80,000 years only. The extra metre is hoped to extend the record back at least to oxygen isotope stage 5e (125,000 bp). The core catchers had been slightly strengthened and modified and Cambridge now provided a second stainless steel core catcher for back up purposes. Because of sufficiently satisfying results, however, we ended up using only one core catcher and only the 3 and 4 metre barrels. From Station 27K southward, only the 4-metre barrel was used. To reduce the resistance of the 4-metre barrel during sediment penetration, the sliding weight and its stopper plates were removed and the trigger-wings of the core catcher shortened. This resulted in complete

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[1] Zangger, E. and McCave, I.N. (1990). A redesigned Kasten-core barrel and sampling technique. *Marine Geology*, 64, 165-171.

penetration up to the weightstand in all but one of the subsequent core attempts. Due to the compression of the sediment in the core barrel, the maximum yield of the 4-metre barrel turned out to be 3.63 metres.

U-shaped square tubes of one metre length were again used to provide different research groups with undisturbed and nearly identical sub-cores. However, the square drain pipes used last year (dimensions 1000x60x60 mm), however, were not sufficiently rigid to be filled completely and did not seal well enough to prevent a drying up of the core material. Thus, this time, we used square cases for electrical cables with purpose-made lids (dimensions 1000x50x50 mm). These tubes performed exceedingly well, but are significantly more expensive (c. £5) than drain pipes (c. £1). In order to completely prevent a drying of the core, the square subcores were additionally sealed in plastic hoses.

A pair of such square core liners was pressed into the exposed surface of the Kasten core and individual samples of ≈10 cm^3 were taken in 4 cm spacing between the tubes and stored in air-tight containers to allow water content analysis. The core was then lifted by 5 cm using the double bottom lift-mechanism and the tubes were separated from the core with a cheese wire. They were then closed, sealed and stored in wooden trays. A layer of plastic trays (330 x 150 x 20 mm) was pressed into the core surface and removed. These trays were X-rayed onboard and, still at sea, used to measure magnetic susceptibility. After this step, the X-ray slabs were stored in the cold storage room. Finally, two more square pipes were taken from each metre. Because of the slightly smaller dimensions of the new coreliners, it is possible to take two sets of X-ray slabs, which was done in the case of cores 28K and 30K in order to provide IOS with reference sections.

Two Kasten cores (23#9K and 26#6K) were completely dedicated to the use of IOS and Cardiff University, after cores (23#3K and 26#1K) from the same sites had been processed for analysis in Cambridge.

Results

The table indicates the number of kasten-coring attempts (18), their location and depth, core length and the number of subsamples taken from each core. The barrel returned empty or nearly empty four times (22#3, 31#1, 33#4, 33#5), the latter two can be attributed to the depositional environment of the Sahara seamounts which appears unfit for the use of Kasten corers. In the other two instances a repeated coring attempt was more successful. Altogether, 32.13 m of core were retrieved at 14 sites were kasten-coring was possible, providing an improvement of c. 10% over last year's total yield. The average core length was 2.30 m compared to 2 metre in 1989. These cores provided 126 square sub-cores 1 m long, 117 X-ray slabs and 701 subsamples for water content and CHNOS-analysis. All cores were described at sea noting the kind of deposit, texture, structure, colour, and the nature of the boundaries.

The stratigraphy turned out to be much less pronounced than in the cores further north. Essentially all cores consisted of more or less homogeneous foram-nanno ooze. Sediment gravity flow deposits occurred only in 28K and 32K. The grain size was almost consistently described as gritty mud, while colours typically fell in the range of 10YR5/3 to 7.5YR6/4. Reduced iron colours (such as 5B4/1 and 5GY5/1) occurred in 30K and 31K. Magnetic susceptibility was low throughout all cores except for 32K. Glacial dropstones were only found in 18K. In general, the glacial/interglacial shifts of the polar front do not appear to have left an impact south of 42°N. The X-radiographs confirmed the monotonous impression of the macroscopic descriptions. Bioturbation and the occasional gravity flow deposits formed the only distinguishable structures.

Figure 2 (BOFS-Core 26K at Lat. 24°N) shows the typical low magnetic susceptibility of the cores retrieved during this cruise. For comparison, Figure 2 (BOFS-Core 5K) displays the pronounced fluctuations found last year further north at Lat.50°

Eberhard Zangger
Barbara Afergan
Heidi Turnbull

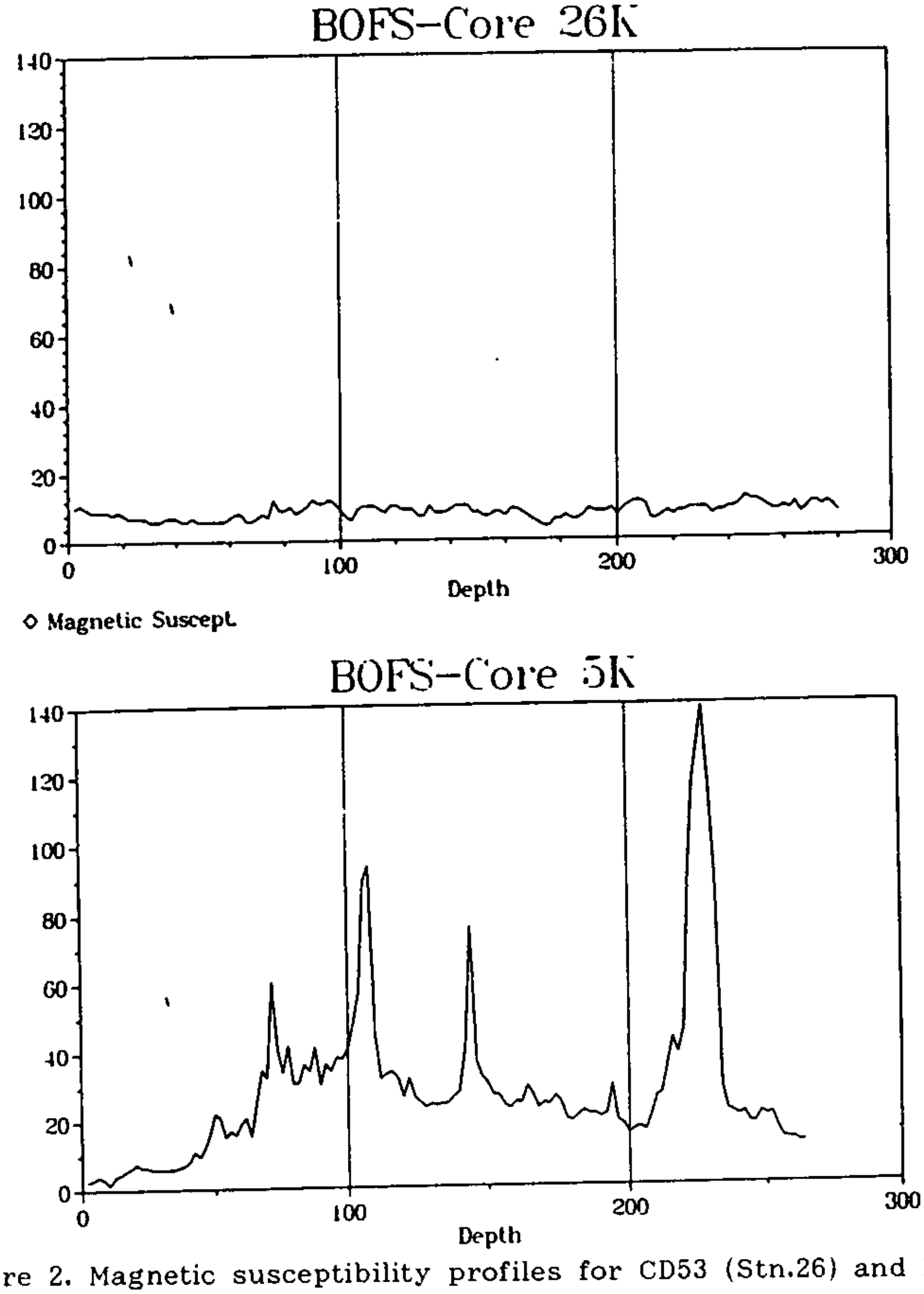


Figure 2. Magnetic susceptibility profiles for CD53 (Stn.26) and D184 (Stn.5)

(d) Piston core sampling

At selected sites to the south of the transect (Table 2) piston cores were collected. The RVS corer with 4 barrels (3 at the first deployment) was used. Thick-wall polycarbonate liner contained the sediment core. As noted above for the Kasten core, there was evidence of compaction as the corer seemed to penetrate the mud by up to 10-12 m but the core length within the liner never exceeded 9 m. The following core lengths have been returned to Edinburgh University and curated at 4°C. No cores were opened onboard ship.

CD53-23#1	**CD53-26#**	**CD53-27#7**	**CD53-29**
1 / 3 90cm	1 / 8 83cm	1 / 9 121cm	1 / 8 88cm
2 / 3 90cm	2 / 8 72cm	2 / 9 102cm	2 / 8 81cm
3 / 3 98cm	3 / 8 129cm	3 / 9 101cm	3 / 8 99cm
Pilot 8cm	4 / 8 95cm	4 / 9 105cm	4 / 8 90cm
	5 / 8 81cm	5 / 9 20cm	5 / 8 106cm
	6 / 8 98cm	6 / 9 98cm	6 / 8 74cm
	7 / 8 87cm	7 / 9 100cm	7 / 8 101cm
	8 / 8 115cm	8 / 9 89cm	8 / 8 124cm
	Pilot 121cm	9 / 9 9cm	Pilot 109cm
		Pilot 106cm	

CD53-30#2	**CD53-31#9**	**CD53-32**
1 / 9 83cm	1 / 9 87cm	1 / 8 73cm
2 / 9 92cm	2 / 9 87cm	2 / 8 77cm
3 / 9 98cm	3 / 9 91cm	3 / 8 98cm
4 / 9 102cm	4 / 9 102cm	4 / 8 103cm
5 / 9 101cm	5 / 9 102cm	5 / 8 100cm
6 / 9 6cm	6 / 9 100cm	6 / 8 98cm
7 / 9 101cm	7 / 9 88cm	7 / 8 101cm
8 / 9 100cm	8 / 9 114cm	8 / 8 100cm
9 / 9 99cm	9 / 9 98cm	Pilot 70cm
Pilot 93cm	Pilot 82cm	between 5&6 13cm

Graham Shimmield

Charles Darwin 53 *Core Log*

KASTEN CORES

Date	Time (GMT)	Lat (N)	Long (W)	ID	Depth (m)	Remarks
23.09.90	14.44	42 02.57	21 21.93	CD53-18#1K	4128	Good core
25.09.90	07.35	41 04.86	20 46.81	CD53-19#1K	3742	
28.09.90	22.25	33 01.17	18 14.19	CD53-21#1K	2975	
30.09.90	13.50	32 53.48	19 10.54	CD53-22#1K	3740	<1m, repeat
30.09.90	20.20	32 52.40	19 14.71	CD53-22#3K	3808	
02.10.90	09.05	32 31.68	20 25.98	CD53-23#3K	4650	
03.10.90	09.37	32 28.09	20 28.53	CD53-23#9K	4680	To Cardiff/IOS
07.10.90	17.10	24 29.20	19 53.20	CD53-26#1K	3680	
08.10.90	10.25	24 26.63	19 50.08	CD53-26#6K	3635	To Cardiff/IOS
09.10.90	02.35	24 27.64	20 24.32	CD53-27#4K	4000	
11.10.90	06.40	24 38.10	22 44.63	CD53-28#3K	4840	
13.10.90	15.10	20 31.38	21 06.94	CD53-29#1K	4000	
15.10.90	15.44	19 45.30	20 43.71	CD53-30#3K	3580	
17.10.90	07.35	19 00.10	20 09.50	CD53-31#1K	3300	failed
17.10.90	10.40	19 00.80	20 10.29	CD53-31#2K	3300	
21.10.90	04.10	22 32.93	22 00.15	CD53-32#4K	4555	
21.10.90	23.35	23 52.87	20 42.09	CD53-33#4K	955	failed
22.10.90	01.46	23 51.71	20 44.11	CD53-33#5K	1010	failed

MULTI CORES

Date	Time (GMT)	Lat (N)	Long (W)	ID	Depth (m)	Remarks
24.09.90	03.24	42 06.41	21 26.46	CD53-18#4M	4090	1/6, 1 to Edinburgh
25.09.90	13.30	41 05.98	20 44.21	CD53-19#3M	3775	2/6, 2 to Bristol
29.09.90	07.29	33 00.59	18 12.79	CD53-21#4M	2940	Failed
29.09.90	17.30	32 59.12	18 17.12	CD53-21#7M	2985	2/6, 1 to Edinburgh, 1 to Bristol
29.09.90	21.33	33 00.23	18 17.24	CD53-21#8M	2990	2/6, 1 to Edinburgh, 1 to Bristol
30.09.90	17.20	32 52.84	19 12.98	CD53-22#2M	3780	2/6, 1 to Edinburgh, 1 to Bristol
01.10.90	07.15	32 53.54	19 16.40	CD53-22#6M	3830	3/6, 2 to IOS, 1 to Bristol
02.10.90	02.30	32 31.73	20 23.43	CD53-23#2M	4650	4/6, 4 to Edinburgh
03.10.90	23.40	32 29.80	20 25.15	CD53-23#7M	4665	1/6, 1 to Bristol
04.10.90	03.12	32 33.28	20 20.89	CD53-23#12M	4660	4/6, 3 to IOS, 1 to Bristol
06.10.90	03.00	28 04.23	22 03.58	CD53-25#3M	4830	5/6, 3 to IOS, 2 to Edinburgh
07.10.90	18.45	24 28.68	19 53.46	CD53-26#2M	3660	5/6, 2 to Edinburgh, 2 Bristol, 1 IOS
09.10.90	06.58	24 29.44	20 22.77	CD53-27#5M	4010	5/6, 3 to Edinburgh, 2 to Bristol
10.10.90	14.15	24 34.23	22 49.28	CD53-28#1M	4855	5/6, 3 to Edinburgh, 2 to Bristol
13.10.90	18.40	20 32.31	21 06.88	CD53-29#2M	4000	6/6, 3 to Edin., 2 to Bristol, 1 archive
15.10.90	06.05	19 40.90	20 40.69	CD53-30#1M	3565	5/6, 3 to Edinburgh, 2 to Bristol
17.10.90	14.08	18 59.65	20 09.24	CD53-31#3M	3295	5/6, 3 to Edinburgh, 2 to Bristol
20.10.90	21.30	22 31.42	22 01.36	CD53-32#3M	4555	5/6, 3 to Edinburgh, 2 to Bristol

BOX CORES

Date	Time (GMT)	Lat (N)	Long (W)	ID	Depth (m)	Remarks
22.09.90	00.48	47 47.91	19 28.85	CD53-SS#1B	4610	Failed
23.09.90	19.30	42 04.81	21 23.95	CD53-18#2B	4095	Failed
25.09.90	11.10	41 06.06	20 46.44	CD53-19#2B	3790	Failed
29.09.90	01.13	33 01.23	18 15.57	CD53-21#2B	2960	Failed
29.09.90	04.35	33 01.51	18 13.58	CD53-21#3B	2940	Failed
29.09.90	14.55	32 59.90	18 16.68	CD53-21#6B	2980	Failed
30.09.90	05.25	33 00.48	18 15.48	CD53-21#10B	2965	Failed
01.10.90	00.20	32 53.33	19 16.95	CD53-22#4B	3825	Failed
01.10.90	11.40	32 51.82	19 17.16	CD53-22#7B	3825	
02.10.90	13.18	32 32.08	20 26.00	CD53-23#4B	4655	Failed
07.10.90	23.52	24 26.96	19 52.75	CD53-26#3B	3650	Failed
08.10.90	07.20	24 27.19	19 50.24	CD53-26#5B	3645	Failed
09.10.90	11.20	24 31.12	20 24.74	CD53-27#6B	4000	
11.10.90	11.33	24 37.09	22 46.17	CD53-28#4B	4840	Failed
12.10.90	07.16	24 38.16	22 47.94	CD53-28#7B	4840	
14.10.90	09.03	20 32.20	21 06.70	CD53-29#4B	3995	
15.10.90	18.36	19 40.47	20 40.64	CD53-30#4B	3545	Abort due to distress call
16.10.90	10.24	19 40.01	20 41.49	CD53-30#5B	3540	
18.10.90	07.38	19 00.14	20 11.14	CD53-31#6B	3300	Failed
18.10.90	11.18	19 00.99	20 10.63	CD53-31#7B	3300	
20.10.90	14.55	22 30.99	22 00.18	CD53-32#1B	4550	
21.10.90	21.10	23 52.89	20 42.55	CD53-33#2B	995	Bulk sample pteropod ooze
21.10.90	22.31	23 53.06	20 42.06	CD53-33#3B	995	
22.10.90	14.50	24 27.46	19 50.27	CD53-26#7B	3640	failed

PISTON CORES

Date	Time (GMT)	Lat (N)	Long (W)	ID	Depth (m)	Remarks
01.10.90	23.16	32 32.45	20 22.69	CD53-23#1P	4650	2.78 m length
09.10.90	15.00	24 32.26	20 24.74	CD53-27#7P	4015	7.45 m length
14.10.90	12.15	20 33.65	21 07.19	CD53-29#5P	4005	7.63 m length
15.10.90	10.50	19 42.78	20 42.81	CD53-30#2P	3565	7.82 m length
18.10.90	18.47	18 59.69	20 10.02	CD53-31#9P	3300	8.69 m length
20.10.90	18.55	22 30.79	22 00.15	CD53-32#2P	4560	7.63 m length
22.10.90	16.11	24 27.46	19 50.27	CD53-26#8P	3640	7.60 m length

4. PORE WATER STUDIES

(a) *Extraction for nutrients and trace metals*

Aim

To obtain further samples of pore waters from box cores sampling the top 50cm of the sediment pile to complement the 306 samples taken in 1989. These are to be used to characterise organic matter breakdown products and the redox state of the upper sediments.

Pore water extraction

Samples, when obtained, were processed using standard Cardiff/IOSDL techniques. This involves slicing 10 cm i.d. subcores in nitrogen-filled glove bags located in the CT laboratory held at 4°C. Unfortunately, at the high humidity experienced in the tropics the *Darwin*'s CT room is inadequate and cannot maintain a temperature of 4°C without freezing up. This sometimes caused unacceptable delays in processing and could possibly be solved by providing a back-up unit to maintain low temperatures whilst the main unit was defrosted. The time taken to process a core limits the number of pore water sections to a maximum of 24 per core. These are usually taken contiguously over the first 10cm or so and then as dictated by stratigraphy. Pore waters were extracted by refrigerated centrifugation (≈3000 rpm, 30 min) and then filtered through in line Minisart^{R} membrane filters (5µm and 0.2µm) and stored cool in two separate bottles. One, acidified to 1% v/v 6M Aristar HCl will be analysed initially for Si, P, Fe, and Mn while the other, pickled with 3 µg/L HgCL, 2 drops/ml, will be analysed for nitrogen species. The residual solids from the centrifugation were stored in plastic bags and, along with any "intermediate" sections, stored cool. Apart from Station 31, all cores had been processed within 12 hours of arriving on deck.

Owing to difficulties experienced with the box corer (see above) pore water samples were also taken from two kasten cores using 60ml syringes to extract plugs of sediment from the core side. These were then placed in the glove bag and processed in exactly the same way as box core samples.

Summary of Activities

Station#	Depth (m)	Length (cm)	Pore water Sections	Sediment Sections
Box cores				
CD53-22#7B	3825	16	13	0
CD53-27#6B	4000	14	15	0
CD53-28#7B	4840	43	24	19
CD53-29#4B	4000	38	24	15
CD53-30#5B	3540	39	24	15
CD53-31#7B	3300	49	24	25
CD53-32#1B	4550	41	24	17
Kasten cores				
CD53-23#9K	4680	115	24	0
CD53-26#6K	3635	257	24	0

Hence, a total of 196 pore water and 91 non-pore water samples were obtained from 2.40 m of box core and 3.72 m of kasten core.

In addition, sub-cores were taken and retained intact from box core Stations 27 to 33 inclusive. (Sample from 33 was of poor quality and hence no pore water extractions were performed on it.)

Simon Wakefield

(b) *Bioturbation and sedimentation studies*

Box cores were sub-sampled for the following purposes:

(1) Studies of active solid phase bioturbation (to 10cm), and
(2) radiocarbon dating (to 0.5m)

The sub-cores obtained from each box core for bioturbation studies were sampled on board to 10cm, and the remaining core sections were sealed for later sampling at the laboratory. Sub-samples were taken from:

CD53-22#7B
CD53-27#6B
CD53-28#7B
CD53-29#4B
CD53-30#5B
CD53-31#7B

At two stations where box cores were not retrieved successfully, kasten cores were sub-sampled. In these cases high resolution surface bioturbation detail was supplied using multicore sampling. These stations and cores were:
CD53-23#9K plus three cores from CD53-23#12M
CD53-26#6K plus one core from CD53-26#2M

Multicore sub-sampling was also carried out at CD53-22#6M (2 cores) and CD53-25#3M (2 cores)

Sarah Colley

(c) Oxygen microelectrodes

This work was carried out on samples from the Multicorer by Mr T. Brand. See above (Section 3b) for techniques employed.

5. *IN SITU* LARGE VOLUME FILTRATION

(a) *Stand alone pumps*

Water column particulates were collected by *in situ* large volume filtration using Stand Alone Pumps (SAPS). Nine such instruments of three different designs (see Summary) were used, each capable of filtering up to ca. 2000l seawater through the chosen filters (see below). SAPS were deployed from the aft-deck winches through the A-frame, clamped to a 2000m plastic-coated wire.

For casts deeper than 2000m, this wire was shackled to the main coring warp. The plastic-coated wire is intended to reduce metal and grease contamination of samples, although samples destined for radionuclide analysis can be clamped to the main coring warp. SAPS were programmed to pump for up to 3h, using preset delays to allow positioning of pumps in the water column. Descent and ascent wire-out rates were kept below $0.8 ms^{-1}$ to minimise potential rupturing of filters (see below).

Individual deployments and SAP configuration details are given in Table 3. In total 112 SAPS deployments were made and 116 tonnes water filtered, probably amounting to a total of a few grammes of water column particulates. Further information relating to the SAPS methodologies specific to each BOFS group are briefly outlined below.

(b) *Trials*

The first cast (SS#2SA) was principally dedicated to trials aimed at establishing the cause of filter-tearing during deployments. This problem has seriously plagued recent BOFS studies; details available via M. Gough, co-ordinator of the SAPS users group, PML. The trials isolated the back flow of both air and water through the SAP as likely causes of filter rupture. Two main methods of circumnavigating the problem were established; physically strengthening the filter by use of a filter sandwich (GFF with Nucleopore), and careful filling of the pump with seawater before deployment so as to exclude air. Improvised one-way valve trials were also undertaken. Such methods increased success rates to > 90%. Deployments in heavy swells appear to be less successful, presumably due to increased back flow of water, and hence stress to filters, during deployment. A detailed report will be prepared separately for use by the SAPS users group.

(c) *Radionuclides*

Seawater was filtered first through a Nucleopore 1.0μm filter (293mm diameter) and then in series through two 1μm pore-size polypropylene cartridge filters impregnated with MnO_2. This arrangement is designed to quantitatively collect >1μm and <1μm radionuclide phases respectively. The principal nuclides of interest are ^{230}Th and ^{228}Th, together with ^{210}Po, ^{210}Pb and ^{226}Ra. A trial (27#3SA) was also carried out to compare MnO_2-impregnated cartridges with resin-impregnated versions, the advantage of the latter being easier laboratory processing. Samples were collected from throughout the water column at the three sediment trap mooring stations, and at one additional station (29#3SA).

(d) *Organic biomarkers and phytogenetic studies*

Seawater was filtered through precombusted (to remove organic contaminants) GFF filters (293mm diameter). Samples are intended for analysis of POC, PON, stable isotopes, organic biomarkers (lipids, pigments...) and phytogenetic studies. Such a broad diversity of analyses necessitates splitting of samples, effected shipboard by random punching of circular sub-samples. Certain SAPS filter assembly configurations caused an annular concentration of material at the centre of filters, imposing a constraint on the randomness of this method. Sub-samples were then stored; lipids in 2:1 $CHCl_3$:CH_3OH, phytogenetics flash frozen in $N_2(l)$, and these and all others then frozen normally. In order to reduce potential organic contamination, all filter manipulations were conducted under a laminar flow air hood. Filter tearing was avoided by both methods established by the trials cast (see above), and Nitex prefilters were also tested. Samples were collected at the 4 main study sites, mostly in the top 800m with a few deep samples and blanks (see Table 3).

(e) *Major and trace elements*

Seawater was filtered through 0.4μm Nucleopore filters (293mm diameter). Samples are intended for analysis of a variety of major and trace elements. Collected samples were stored frozen. All filter manipulations were carried out under a laminar flow air hood, the SAPS filter assembly thoroughly rinsed in MQ water between deployments, and general trace element contamination precautions observed. Filter tearing was avoided by both methods established in the trials cast; the filter sandwich option was found to be most reliable, although contamination with some elements from GFF filters may prove to be a problem. Samples and blanks were collected at the three sediment trap mooring stations, at a minimum of the three trap depths, and also at Site B (see Table 3).

(f) *How quantitative are SAPS?*

An uncertainty surrounding SAPS regards the validity of the assertion that the particles collected on a filter are quantitatively representative of the volume of water pumped. Particles may be lost from the filter after pumping and during SAP recovery by physical agitation, flushing or back flow, either to the walls of the filtration assembly interior or back to the water column. Previous BOFS studies suggest that undersampling of particulate radionuclides might be a problem with SAPS. Although the inside of the filtration assembly is visually clean, wiping with tissues after filter removal reveals that a potentially significant fraction of material may have been lost from the filter. Cast 27#3SA was dedicated to a quantitative investigation of this observation. Filters and tissue wipes were taken from all pumps, as well as cartridges for two samples, and stored for analysis of ^{210}Po (tissue blanks should be low). As an attempted "calibration" of the SAPS, this cast immediately followed a shallow CTD for 210Po (particulate and dissolved; Ritchie, Edinburgh) at the same depths as the SAPS. These samples are 0.4μm Asypore filtered. Given certain assumptions about the relative natures of particulate loads sampled by CTD and SAPS, and given that 0.4μm Asypore and Nucleopore filters were used in the SAPS at each depth, an estimated "calibration" of the SAPS relative to CTD should be possible, as well as a comparison of the two filter types.

Sarah Colley
Luiz Madureira
Philip Newton

SAPS DEPLOYMENT SUMMARY

STATION (DATE)	CAST (WAT DEP)	PUMPS								
		1	2	3	4	5	6	7	8	9
47°48'N 19°27'W (22/9)	SS#2SA TRIAL	G/N/ 0.5lB 20m	G/ 0.2lB 30m	Gx 200.0l 40m	None -35.0lB 50m	G/ -0.8lB 60m	Gx -0.2lB 70m	G/ 0.0lB 80m	N2Cx -0.6lB 90m	-
42°09'N 21°28'W (24/9)	18#5SA 4100m	G/ 307.2l 3300m	G/N/ -67.6lB 3200m	N/ 879.6l 3100m	N/ 1140.6l 3050m	G/ 1445.1l 3000m	G/ 1952.8l 3900m	N2C/ 1480.2l 1900m	N2C/ 1302.8l 1910m	-
41°07'N 20°43'W (25/9)	19#4SA 3775m	G/N/ 1602.1l 800m	G/ 2070.0l 400m	G/ 1185.9l 200m	G/ 742.0l 100m	G/ 856.6l 80m	Gx 639.5l 60m	Gx 605.0l 40m	G/ 564.4l 20m	-
32°29'N 20°25'W (2/10)	23#6SA 4700m	G/N/ 1487.3l 800m	G/ 1545.5l 400m	G/ 1171.1l 200m	G/ 1055.6l 100m	Gx 1294.2l 80m	G/ 961.6l 60m	Gx 909.2l 40m	G/ 429.1l 20m	-
32°33'N 20°24'W (3/10)	23#11SA 4700m	Nx 2179.3l 2900m	G/ 1329.4l 3000m	G/ 15.8lB 3500m	N/ 1184.2l 4450m	G/ 2352.5l 4500m	G/ 263.8l 4000m	N/ 1008.2l 3700m	G/ 9.3lB 3600m	-
28°02'N 22°05'W (5/10)	25#2SA 4830m	N/G/ 772.4l 3000m	Nx 913.2l 2020m	N/ 657.1l 1010m	N2C/ 1371.2l 2500m	N2C/ 1922.6l 2000m	N2C/ 1121.0l 1500m	N2C/ 1191.1l 1000m	N2C/ 1106.8l 500m	N2C/ 1637.2 250m
28°06'N 22°04'W (6/10)	25#4SA 4830m	N/G/ 731.2l 4710m	N/ -47.0lB 3200m	N/ 929.5l 3800m	N2C/ 1306.5l 4750m	N2C/ 1847.3l 4400m	N2C/ 957.1l 4000m	N2C/ 1204.2 3500m	N2C/ 956.7l 250m	N2C/ 1963.9l 3000m
24°28'N 20°22'W (8/10)	27#3SA 4000m	A/ 691.6l 1000m	N/ 620.0l 1000m	A/ 478.5l 115m	N/ 505.3l 115m	-	A/ 172.8l 35m	N/ 196.1l 35m	N2C*/ 565.8l 500m	N2C/ 1099.6l 500m
24°35'N 20°23'W (9/10)	27#8SA 4010m	G/N/ 1035.3l 800m	G/ 1063.8l 400m	G/ 1331.6l 200m	G/ 1373.4l 100m	G/ 1451.0l 80m	G/ 910.9l 60m	G/ 1288.6l 40m	G/N/ 412.6l 20m	-
24°35'N 22°48'W (10/10)	28#2SA 4850m	N/G/ 868.3l 2800m	N/G/ 322.6l 1850m	N/G/ 604.2l 3750m	N2C/ 1366.4l 3000m	N2C/ 1997.0l 2500m	N2C/ 750.6l 2000m	N2C/ 1142.5l 1000m	N2C/ 913.2l 500m	N2C/ 1892.5 1500m
24°38'N 22°48'W (11/10)	28#6SAP 4845m	N/G/ 1052.4l 4750m	G/ 1521.6l 3600m	G/ 1376.4l 4650m	N2C/ 1162.0l 4790m	N2C/ 1755.3l 4500m	N2C/ 700.0l 4250m	N2C/ 1439.9l 3500m	N2C/ 951.0l 2500m	N2C/ 1942.0l 4000m
20°34'N 21°06'W (13/10)	29#3SA 4005m	-	G/N/ 8.3lB 2800m	G/N/ 1.2lB 3800m	N2C/ 1051.9l 3940m	N2C/ 1115.3l 3500m	N2C/ 669.4l 3000m	N2C/ 986.9l 1000m	N2C/ 1213.8l 500m	N2C/ 1764.2l 2000m
19°42'N 20°43'W (16/10)	30#6SA 3540m	G/ 1541.5l 800m	G/ 1063.4l 200m	G/Nx 399.7l 80m	G/N/ 250.4l 60m	G+P/ 896.5l 100m	G+Px 750.1l 400m	G/Nx 211.4l 40m	Gx 437.8l 20m	-
19°00'N 20°08'W (17/10)	31#5SA 3310m	N/G/ 389.8l 1500m	N/G/ 34.2lB 2300m	N/G/ 830.1l 3200m	N2C/ 1101.6l 3000m	N2C/ 1678.1l 3100m	N2C/ 537.0l 3240m	N2C/ 980.7l 2750m	N2C/ 643.6l 2500m	N2C/ 1663.3l 2000m
19°00'N 20°10'W (18/10)	31#10SA 3300m	N/G/ 446.4l 1000m	N/G/ 26.3lB 1980m	N/G/ 19.7lB 1990m	N2C/ 1042.4l 980m	N2C/ 1520.3l 1500m	N2C/ 571.1l 2010m	N2C/ 795.7l 500m	N2C/ 565.5l 250m	N2C/ 1690.1l 750m

KEY:

Filter codes;
N = Nuclepore 0.4μm
G = GFF
A = Asypore 0.4μm
N2C = Nuclepore 1.0μm, 2 Mn-coated cartridges (or * resin-coated)
N/G = Filter sandwich, N above G
G/N = " " , G above N

/ indicates recovery of undamaged filter
x indicates filter torn

Volumes pumped are given in litres (l), B indicates non-pumped blank
Pump depths are given in metres (m)

Pumps;
1-3 Challenger Oceanics, Haslemere.
4-8 IOSDL, modified by Challenger, 2 filtration assembly designs.
9 IOSDL early prototype, loaned by T.J.P. Gwilliam.

SAMPLES:

	Analysis	Contacts
N2C samples	Radionuclides	Colley, Thomson, IOSDL
G & G/N samples	POC, PON, stable isotopes Organic biomarkers & phytogenetic studies	Kennedy, UCNW Conte, Univ. Bristol.
N, A & N/G samples	Major and trace elements ^{210}Po (27#3SA only)	Newton, Jickells, UEA Ritchie, Edinburgh; Newton UEA

6. PARTICLE FLUX STUDIES (SEDIMENT TRAPS)

One sediment trap mooring was recovered and three moorings deployed, as detailed below. Specifications of the mooring designs and performance during recovery and deployment are described elsewhere in this report (Sediment trap design; Washington). The selected mooring sites are supported by water column and sediment coring activities of the BOFS programmes, as well as collaborations with LRP4 (IOSDL, A. Rice) and the French EUMELI community programme (a JGOFS collaboration). Mooring deployments were preceded by figure-of-eight 10kHz surveys in order to confirm the expected bottom bathymetry. Immediately following deployments, box surveys were conducted, fixing on the acoustic releases, in order to pinpoint the actual GPS location of the moorings.

(a) ***BOFS sediment trap mooring V*** recovered, 21/9/90, CD53-SS#1T.
47°45.7'N 19°29.4'W (GPS)

The entire mooring was recovered intact, all four traps and the current meter having functioned successfully. Final trap depths from wire-in lengths were 310m, 1060m, 3055m and 4500m, current meter at 330m. Initial inspection of pressure data shows no evidence of mooring knockdown. Time lapse camera at 415m also recovered, status to be ascertained on land. Sediment trap samples were immediately removed from traps, ≈20ml supernatant decanted and frozen, and 1.0ml formaldehyde solution (40% formaldehyde, buffered with sodium tetraborate, trace metal cleaned) added to each sample as excess preservative. Samples were stored in the dark at 2-4°C. These samples represent 11 consecutive flux samples at each trap depth, each of a two week sampling period, commencing 22/4/90. Previous trap moorings at this station have collected similar time series' during the 12 months prior to this period.

(b) ***BOFS/LRP4 sediment trap mooring VI*** deployed, 5/10/90, CD53-25#1T.
28°00.4'N 21°59.2'W (GPS)

This mooring was deployed on behalf of BOFS and LRP4 (A. Rice, IOSDL) in a water depth of 4820m, comprising three traps at 1100m, 3650m and 4710m depth, and a current meter at 1200m depth (see Washington below). The mooring had to be located about 90nm from the originally chosen site owing to territorial water limitations. Each trap was programmed to collect 12 consecutive particle flux samples each of 3 or 4 week sampling periods, commencing 7/10/90 and finishing 28/7/91. The 13th cup on each trap serves as a blank. Prior to deployment, sample cups were filled with seawater collected from the trap depths (CTD, 24#1CTD) dosed with pre-prepared formaldehyde to 2%, NaCl to a 5‰ salinity enhancement, and a $CsNO_3$ tracer. These additives had been stripped of trace metals on Chelex resin columns. All trap solution preparations were conducted under a laminar flow air hood to further minimise contamination. Nutrient levels were measured shipboard for the seawater used for these solutions. This mooring will be recovered August 1990 by LRP4, IOSDL. Analyses will be conducted by the BOFS community, and the data made available to LRP4.

(c) ***BOFS sediment trap mooring VII*** deployed, 12/10/90, CD53-28#9T.
24°33.0'N 22°50.1'W (GPS)

This mooring was deployed in a water depth of 4860m, comprising three traps at 1700m, 3900m and 4750m depth, and a current meter at 1750m depth (see Washington, this report). The mooring was originally designed to have the top trap at a depth of 1000m, but sufficient jacketed wire to protect the mooring from fishbite damage in shallow waters was not delivered to RVS on time. The top trap was therefore dropped to 1700m depth, below the anticipated influence of fishbites. Traps were programmed as for mooring VI, but commencing 14/10/90. Trap solutions were also prepared and manipulated as for mooring VI, using seawater from CTD cast 28#5CTD. Nutrient levels were determined shipboard. LRP4, IOSDL have kindly offered to recover this mooring in August 1990.

(d) ***BOFS sediment trap mooring VIII*** deployed, 19/10/90, CD53-31#12T.
19°00.3'N 20°11.1'W (GPS)

This mooring was deployed in a water depth of 3295m, comprising three traps at 1150m, 2200m and 3190m depth, and two current meters at 1250m and 1900m depth (see Washington below). Traps were programmed as for mooring VI, but commencing 21/10/90. Trap solutions were similarly prepared as for mooring VI, using seawater from CTD cast 31#3CTD. Nutrient levels were determined shipboard. The mooring has been deployed in an area to be studied in the forthcoming French EUMELI community programme, about 100km from their planned sediment trap mooring site (commencing January 1991). BOFS and EUMELI are thus engaging in a collaborative study through their sediment trapping programmes, and EUMELI will recover the BOFS mooring in July 1990. It is hoped to redeploy the mooring directly following recovery, and to thus develop a longer term trap site.

Philip Newton

(e) ***Sediment trap design***

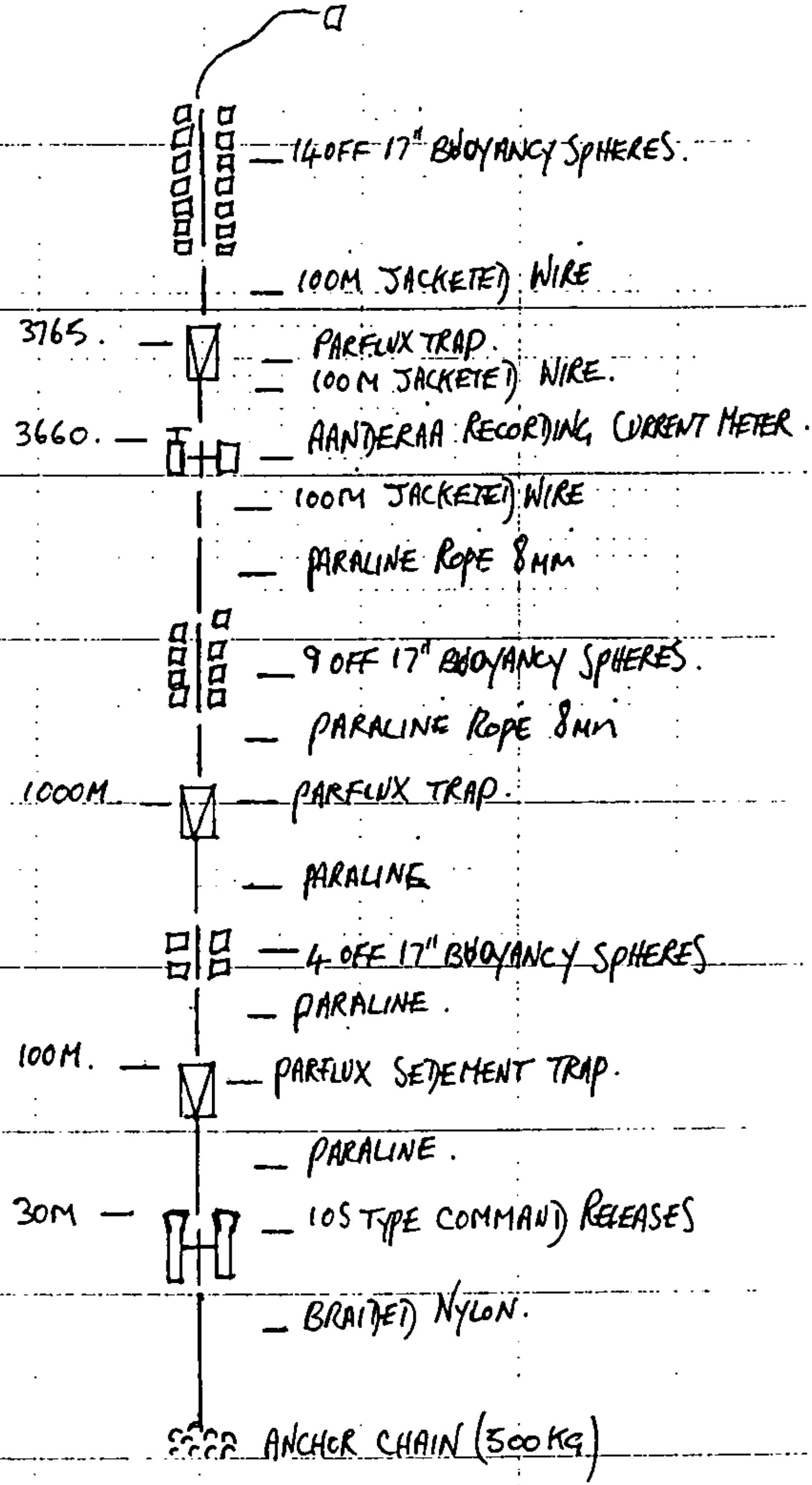
Mooring deployment was undertaken using an anchor-first method from the RVS double barrel capstan; the cable passing through a wide-throated sheave block fixed to the port Effer Hiab crane. When the mooring was fully deployed it's descent was monitored using the PES which was receiving the FM signal from the command releases. When the mooring was on the sea bed a box search was undertaken to establish it's position.

The three moorings were deployed with sediment traps and Anderaa current meters (see Figs. 3-5). The IOS command releases were tested at their working depth by attaching them to the CTD. Two of the releases supplied by IOS failed to perform effectively so were not used on the moorings. The mooring line consisted of paraline polyester rope (8mm diam.) and 6mm jacketed wire at the top to prevent fish bite. The buoyancy consisted of deep-sea glass spheres.

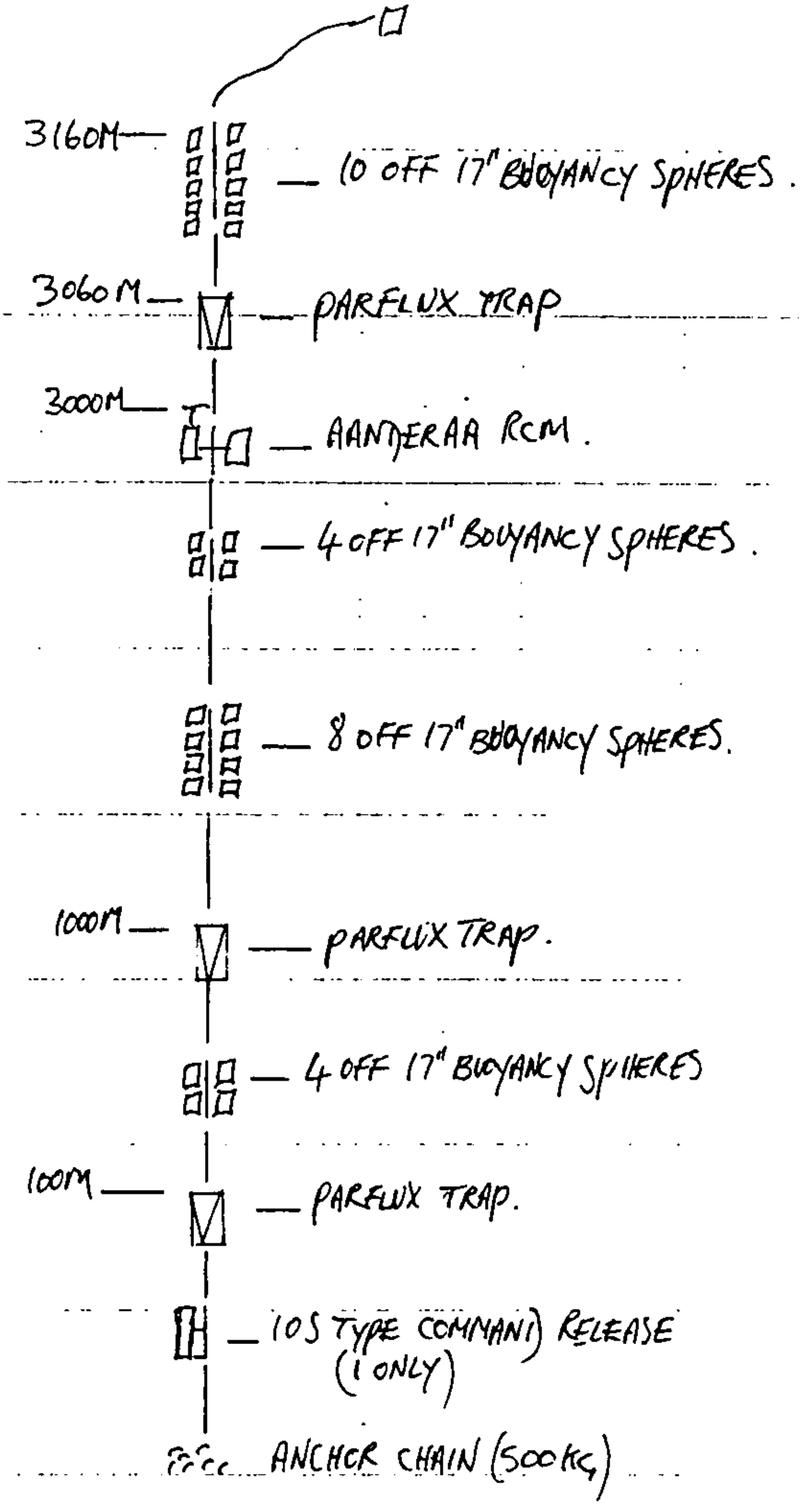
Clive Washington

MOORING 1. WATER DEPTH
4820M

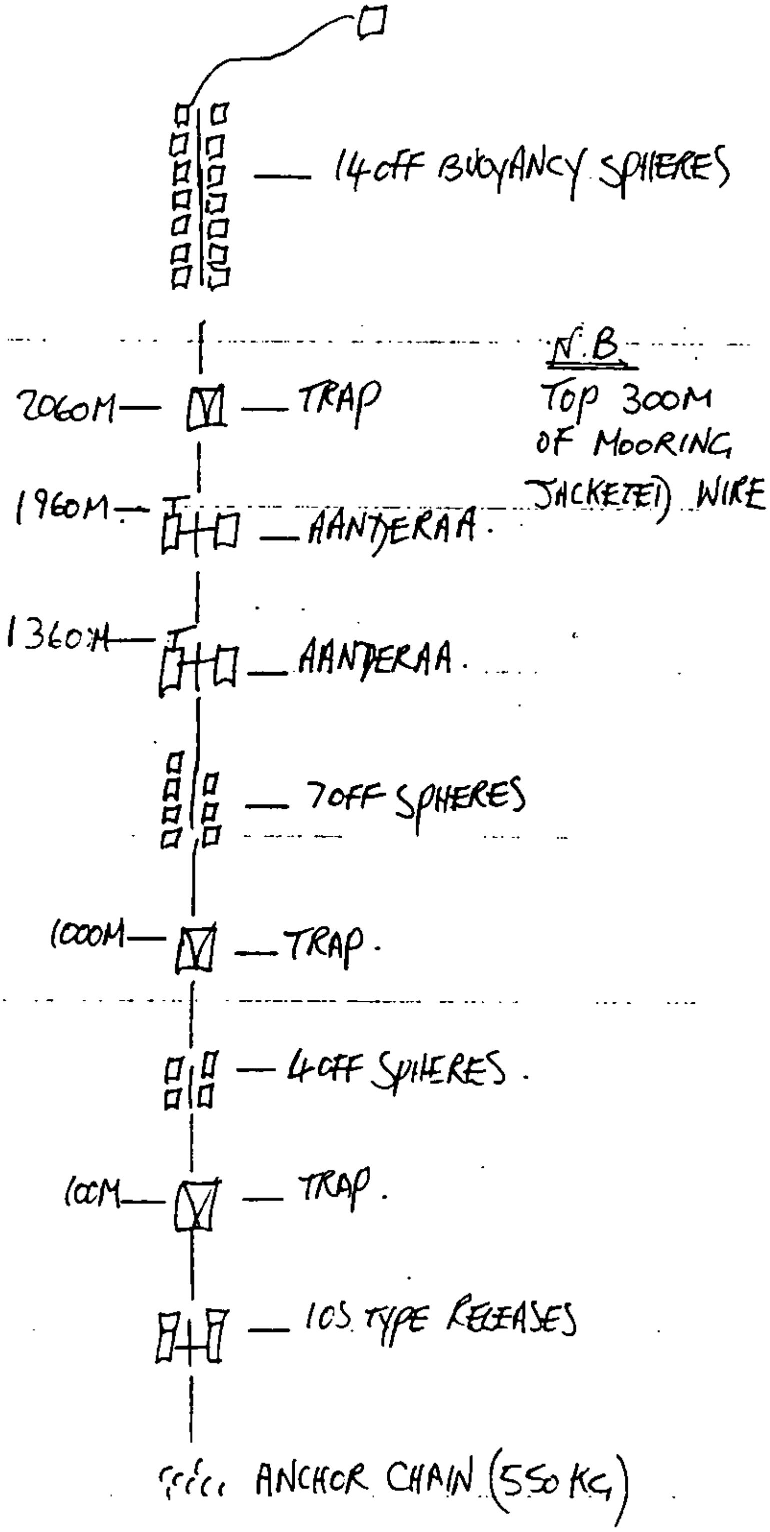
pos. 28°0.4'N.
21°59.2'W.



MOORING 2
WATER DEPTH
4860M.
POS 24° 33.0'N
22° 50.0'N.



MOORING 3
WATER DEPTH 3295M
pos 19° 0.3'N
20° 11.01'W



N.B.
TOP 300M
OF MOORING
JACKETED WIRE

7. WATER BOTTLE SAMPLING

(a) *Radionuclides*

Water samples were taken from the CTD to determine the levels of ^{210}Po and ^{210}Pb in the dissolved (<0.45μm) and particulate (>0.45μm) phases in the upper water column (down to 1000m depth). The disequilibrium between these naturally -occurring radionuclides in both phases provides information on the flux and remineralisation rate of organic carbon in the upper waters.

Seven, twenty litre, samples (6*2 CTD bottles + on line surface sample) were taken. Each was gravity filtered through 0.45μm ASYPOR™ filters, the filters being stored for processing ashore. The samples were then acidified with HCl (conc:40ml) and spiked with ^{206}Pb (10mg) and ^{208}Po (10dpm) as tracers. After two days equilibration cobalt (0.5mg) and APDC (1g) were added, coprecipitating out the metals. The precipitate was then filtered off onto a GF/D filter which was stored for processing ashore.

Samples were taken at the following stations:
20#1, 23#5, 27#1, 29#7, 31#13.

George Ritchie

(b) *$\delta^{15}N$ stable isotope analysis*

Analysis of the stable isotopes of nitrogen in seawater from the mixed layer can provide information about the utilisation and regeneration of nitrogen-bearing nutrients necessary for primary productivity. CTD deployments for the analysis were made at each of the sites, except Site A where weather conditions towards the latter stages of work at that site did not permit a CTD deployment. Water samples were collected from various depths within and just below the mixed layer (detailed below) and filtered through precombusted (500°C) 47mm glass fibre filter pads. The filter pads were put into the freezer immediately after collection. Nutrient analysis of nitrate, nitrite, phosphate and silicate were also made from each of the samples collected. $\delta^{15}N$ analysis will be carried out at UCNW by Dr Hilary Kennedy.

STATION	Depths of sampling (m)
21#9CTD	85, 65, 50, 40, 30, 10.
28#8CTD	170, 145, 130, 120, 110, 100, 80, 50, 10.
31#11CTD	120, 80, 70, 60, 50, 40, 30, 15, 5.

Tim Brand

(c) *Miscellaneous measurements*

Seawater samples were collected by CTD at the same stations as shallow SAPs casts (19, 23, 27 and 30), depths 10, 30, 50 and 75m, and at the surface at all stations and every 12 hours whilst underway. These samples were filtered in order to isolate sufficient particulates for analysis of lipids (≈10l filtered), organic carbon and nitrogen (2l + 2l replicates), pigments (2l), phytogenetic studies (1l), phytoplankton cultures (volume inoculated dependant on biological state of seawater, samples from 50 and 75m only) and species composition (2 x

100ml). All samples were filtered through GFF filters (47mm), bar those used for phytogenetic studies for which 3.0μm Nucleopore^R filters (47mm) were used.

Analysis	Contact
Lipids, C, N, pigments	M. Conte, Bristol University
Phytoplankton detritus	J. Green, PML
Phytogenetic studies	M. Conte, Bristol University
Species composition	D. Harbour, PML

Luiz Madureira

8. UNDERWAY MEASUREMENTS

(a) *Surface pCO2 measurements*

Continuous surface pCO_2 values were recorded whilst the ship was underway throughout most of the cruise. Measurements were made from 48°N down to 20°N. Initially, a "sink" was observed at 48°N with surface values of approximately 310 μatm. Chlorophyll values were low with a high percentage of degradation products. Nutrient levels were also low. Examination of the sediment trap lifted at 48°N showed evidence of extensive bloom over the preceding 3/4 weeks. This is substantiated by the obvious air-sea disequilibrium in CO_2. As the ship moved south we passed through equilibrium conditions around 40°N and an increasing pCO_2 content as high as 396 μatm at 20°N. The rising pCO_2 was closely linked to increasing sea surface temperature.

Along with continuous pCO_2 measurements, a 4 hr sampling regime was carried out for TCO_2, $\delta^{13}C_{TCO2}$ and $\delta^{13}C_{POC}$. Samples will be analysed later at UCNW Bangor by myself and Dr Hilary Kennedy. In addition, water samples were filtered and analysed on a regular basis in order to calibrate the flow through fluorimeter, both on deck and on the CTD. Replicate samples were frozen to be analysed later at PML if necessary. Salinity samples were also taken and analysed onboard in order to provide an accurate calibration for the thermosalinograph.

Jane Robertson

(b) Radionuclide measurements

Analysis of the activity and partitioning of ^{234}Th in dissolved and particulate states from surfaces waters can lead to an understanding of particulate residence time and degradation rate. Three polypropylene filter cartridges were fitted in series to the on-line non-toxic supply. The first cartridge is a plain filter (nominal 1μm pore size) and removes particulate material from the water on which the particle-reactive ^{234}Th is attached. The second and third filter cartridges were coated in manganese hydroxide which is a highly efficient dissolved metal ion scavenger. These were used to remove the dissolved ^{234}Th. The filtration rig was used when the ship was underway and the filters were changed every 24 hours. Samples were returned to Edinburgh University for gamma spectroscopy. Details of the start and finish locations and volumes filtered for each filter batch are given below:

Batch	Start	Finish	Volume Filtered (l)
CD53#1	46°02.64'N 20°04.37'W 22-9-90	42°03.17'N 21°18.99'W 23-9-90	1435
CD53#2	41°08.56'N 20°42.77'W 26-9-90	39°52.52'N 19°48.65'W 26-9-90	1290
CD53#3	39°50.31'N 19°48.53'W 26-9-90	34°04.00'N 18°33.03'W 28-9-90	4204
CD53#4	32°53.31'N 19°16.88'W	32°54.1'N 19°17.1'W	7656
CD53#5	30°33.85'N 27°59.71'W 04-10-90	27°59.71'N 22°00.05'W 05-10-90	2292
CD53#6	27°55.12'N 21°58.75'W 06-10-90	24°27.65'N 19°52.69'W 07-10-90	2632
CD53#7	24°32.29'N 22°49.77'W 12-10-90	20°31.14'N 21°07.72'W 13-10-90	2812
CD53#8	20°30.51'N 21°03.2'W 19-10-90	22°29.92'N 22°00.01'W 20-10-90	1100

Tim Brand
Graham Shimmield

8. BASIC BOFS MEASUREMENTS

Nutrients

The determination of seawater nutrients (nitrate, nitrite, phosphate, and silicate) was undertaken using the BOFS auto analyser supplied by PML following methods recommended by Dr Malcolm Woodward

Discrete samples were taken by CTD, covering the whole water column, at the following stations (Figs. 6,7):

18#6, 18#7, 22#5, 28#5, 28#8, 31#3, 31#11.

Surface nutrients were also determined continuously between the following stations:

SS#3 to 18#1, 20#1 to 21#1, 23#12 to 24#1, 24#1 to 25#1, 28#9 to 29#1, 31#13 to 32#1.

Station: CD53-SS#3CTD

Date	Time	Lat	Long
22.9.90	05.49	47 48.4	19 26.3

Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	500	496.291	9.888	35.307	0.425	4.309	3.772
2	500	498.192	9.890	35.304	0.408	4.309	3.773
3	500	498.192	9.890	35.287	0.483	4.307	3.781
4	500	495.690	9.888	35.306	0.366	4.309	3.772
5	500	494.990	9.896	35.298	0.500	4.309	3.771
6	500	495.390	9.898	35.298	0.403	4.309	3.771
7	50	53.080	15.758	35.708	1.602	4.202	3.498
8	50	53.080	15.758	35.708	1.602	4.202	3.498
9	30	30.665	18.002	35.757	1.060	4.182	3.527
10	30	30.665	18.002	35.757	1.060	4.182	3.527
11	10	13.853	18.042	35.748	1.011	4.180	3.574
12	10	13.853	18.042	35.748	1.011	4.180	3.574

Station: CD53-18#6CTD

Date	Time	Lat	Long	Remarks
24.9.90	15.56	42 10.0	21 27.4	Level 1 nutrients & POC/PON

Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	4000	3998.340	2.612	34.907	0.110	4.307	4.216
2	3500	3499.391	2.670	34.902	0.095	4.309	4.107
3	3000	2997.940	2.810	34.917	0.261	4.314	4.082
4	3000	2997.940	2.810	34.917	0.261	4.314	4.082
5	2500	2500.693	3.128	34.926	-0.134	4.314	4.092
6	2500	2500.693	3.128	34.926	-0.134	4.314	4.092
7	2000	1998.441	3.600	34.946	0.227	4.314	4.015
8	2000	1998.441	3.600	34.946	0.227	4.314	4.015
9	1500	1505.997	4.604	35.047	0.359	4.314	3.707
10	1500	1505.997	4.604	35.047	0.359	4.314	3.707
11	1000	1001.044	8.116	35.485	0.420	4.314	2.812
12	1000	1001.044	8.116	35.485	0.420	4.314	2.812

Station: CD53-18#7CTD

Date	Time	Lat	Long	Remarks:
24.9.90	20.45	42 10.1	21 28.4	Level 1 nutrients & POC/PON

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	500	501.294	10.586	35.407	0.435	4.316
2	500	501.294	10.586	35.407	0.435	4.316
3	300	300.454	11.850	35.615	0.430	4.316
4	200	197.181	12.170	35.670	0.540	4.314
5	100	97.912	13.282	35.814	0.613	4.302
6	75	72.294	14.210	35.815	1.179	4.253
7	60	62.687	15.378	35.883	1.797	4.207
8	50	50.679	16.700	35.876	1.809	4.199
9	30	32.266	20.682	35.983	0.762	4.236
10	20	20.758	20.774	35.999	0.698	4.226
11	10	10.751	20.814	35.998	0.698	4.224
12	2	5.047	20.802	36.001	0.740	4.221

Station: CD53-18#7CTD

Depth	NO2	NO3	PO4	SiO4
4500				
4000	0.034	21.5	1.57	31.67
3500	0.034	21.0	1.54	28.89
3000	0.034	18.0	1.44	23.33
2500	0.034	17.5	1.34	16.11
2000	0.034	17.0	1.31	11.11
1500	0.034	17.0	1.31	9.44
1000	0.034	17.0	1.28	8.33
500	0.034	13.5	0.95	6.67
300	0.034	10.0	0.72	5.00
200	0.034	9.5	0.69	4.44
100	0.034	7.0	0.56	3.33
75	0.034	11.5	0.82	5.56
60	0.169	1.0	0.20	2.78
50	0.056	0.0	0.10	2.22
30	0.034	0.0	0.03	2.22
20	0.034	0.0	0.03	2.22
10	0.034	0.0	0.03	2.22
2	0.034	0.0	0.03	2.22

Station: CD53-18#8CTD

Date	Time	Lat	Long	Remarks:
24.9.90	22.05	42 10.7	21 28.4	Samples for OGU, Bristol

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	75	75.496	14.178	3.840	1.189	4.238
2	75	75.496	14.178	3.840	1.189	4.238
3	75	75.496	14.178	3.840	1.189	4.238
4	50	50.679	16.434	35.874	1.824	4.197
5	50	50.679	16.434	35.874	1.824	4.197
6	50	50.679	16.434	35.874	1.824	4.197
7	30	30.665	20.676	35.992	0.754	4.231
8	30	30.665	20.676	35.992	0.754	4.231
9	30	30.665	20.676	35.992	0.754	4.231
10	10	11.451	20.718	35.998	0.615	4.224
11	10	11.451	20.718	35.998	0.615	4.224
12	10	11.451	20.718	35.998	0.615	4.224

Station: CD53-20#1CTD

Date	Time	Lat	Long	Remarks:
26.9.90	14.15	39 54.8	19 50.2	Radionuclides, Edinburgh

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	1000	1002.645	10.141	35.893	0.364	4.321
2	1000	1002.645	10.141	35.893	0.364	4.321
3	500	498.992	10.957	35.505	0.403	4.314
4	500	498.992	10.957	35.505	0.403	4.314
5	300	304.156	11.885	35.609	0.454	4.312
6	300	304.156	11.885	35.609	0.454	4.312
7	100	99.713	13.804	35.883	0.769	4.285
8	100	99.713	13.804	35.883	0.769	4.285
9	50	50.078	16.588	35.995	1.160	4.229
10	50	50.078	16.588	35.995	1.160	4.229
11	25	25.861	21.083	36.177	0.601	4.263
12	25	25.861	21.083	36.177	0.601	4.263

Station: CD53-21#9CTD

Date	Time	Lat	Long	Remarks:
29.9.90	23.17	33 01.3	18 18.3	

Lost signal at bottom, no bottles fired

Station: CD53-22#5CTD

Date	Time	Lat	Long	Remarks:
01.10.90	01.56	32 54.4	19 17.6	Level 1 nutrients & POC/PON

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	3800					
2	2000					
3	1000					
4	500					
5	300					
6	200					
7	100					
8	75					
9	60					
10	50					
11	30					
12	10					

Lost signal at bottom, bottles fired, no values for sample depths

Station: CD53-22#5CTD

Depth (m)	NO2 (uM)	NO3 (uM)	PO4 (uM)	SiO4 (uM)
4500				
4000				
3500	0.03	23.3	1.53	35.80
3000				
2500				
2000	0.03	20.0	1.29	16.78
1500				
1000	0.03	21.0	1.32	13.43
500	0.03	14.0	0.87	6.43
300	0.04	10.0	0.61	4.76
200	0.05	6.3	0.37	3.36
100	0.08	1.3	0.10	2.24
75	0.03	0.0	0.03	2.24
60	0.03	0.0	0.03	0.00
50	0.03	0.0	0.03	0.00
30	0.03	0.0	0.03	0.00
20				
10	0.03	0.0	0.03	0.00
2	0.03	0.0	0.03	0.00

Station: CD53-23#5CTD

Date	Time	Lat	Long	Remarks:
02.10.90	15.44	32 32.2	20 25.4	Radionuclides, Edinburgh

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	1000	998.442	9.304	35.611	0.518	6.863
2	1000	998.442	9.304	35.611	0.518	6.863
3	500	501.394	12.396	35.664	0.415	6.851
4	500	501.394	12.396	35.664	0.415	6.851
5	300	300.253	14.858	36.021	0.479	6.848
6	300	300.253	14.858	36.021	0.479	6.848
7	125	126.732	17.378	36.538	0.510	6.848
8	125	126.732	17.378	36.538	0.510	6.848
9	50	49.878	20.443	36.627	0.522	6.853
10	50	49.878	20.443	36.627	0.522	6.853
11	25	25.861	23.454	36.869	0.464	6.853
12	25	25.861	23.454	36.869	0.464	6.853

Station: CD53-23#8CTD

Date	Time	Lat	Long	Remarks:
03.10.90	03.33	32 29.5	20 26.2	

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	4000	3999.041	2.429	34.890	0.281	6.802
2	4000	3999.041	2.429	34.890	0.281	6.802
3	3000	3002.644	2.778	34.925	0.376	6.794
4	3000	3002.644	2.778	34.925	0.376	6.794
5	2500	2500.092	3.323	34.965	0.181	6.792
6	2500	2500.092	3.323	34.965	0.181	6.792
7	2000	1996.440	4.310	35.084	0.317	6.794
8	2000	1996.440	4.310	35.084	0.317	6.794
9	1500	1498.091	6.656	35.424	0.542	6.802
10	1500	1498.091	6.656	35.424	0.542	6.802
11	1000	999.242	9.316	35.587	0.388	6.812
12	1000	999.242	9.316	35.587	0.388	6.812

Transmissometer not working, except on bottle firing

Station: CD53-23#10CTD

Date	Time	Lat	Long	Remarks:
03.10.90	12.37	32 28.4	20 29.6	

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	75	75.496	18.544	36.635	0.684	4.421
2	75	75.496	18.544	36.635	0.684	4.421
3	75	75.496	18.544	36.635	0.684	4.421
4	50	50.679	20.281	36.662	0.688	4.402
5	50	50.679	20.281	36.662	0.688	4.402
6	50	50.679	20.281	36.662	0.688	4.402
7	30	31.165	23.466	36.894	0.588	4.414
8	30	31.165	23.466	36.894	0.588	4.414
9	30	31.165	23.466	36.894	0.588	4.414
10	10	11.652	23.534	36.893	0.544	4.416
11	10	11.652	23.534	36.893	0.544	4.416
12	10	11.652	23.534	36.893	0.544	4.416

Station: CD53-24#1CTD

Date	Time	Lat	Long	Remarks:
04.10.90	22.17	29 30.0	21 59.6	CTD for trap reconnaisance

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	3800	3800.402	2.458	34.890	0.342	4.470
2	3800	3800.402	2.458	34.890	0.342	4.470
3	3800	3800.402	2.458	34.890	0.342	4.470
4	3800	3800.402	2.458	34.890	0.342	4.470
5	3800	3800.402	2.458	34.890	0.342	4.470
6	3800	3800.402	2.458	34.890	0.342	4.470
7	3800	3800.402	2.458	34.890	0.342	4.470
8	3800	3800.402	2.458	34.890	0.342	4.470
9	1000	1001.544	8.621	35.496	0.449	4.465
10	1000	1001.544	8.621	35.496	0.449	4.465
11	1000	1001.544	8.621	35.496	0.449	4.465
12	1000	1001.544	8.621	35.496	0.449	4.465

Station: CD53-27#2CTD

Date	Time	Lat	Long	Remarks:
08.10.90	16.43	24 27.3	20 24.4	

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	75	73.995	21.792	36.641	0.955	4.392
2	75	73.995	21.792	36.641	0.955	4.392
3	75	73.995	21.792	36.641	0.955	4.392
4	50	49.778	24.879	36.920	0.605	4.407
5	50	49.778	24.879	36.920	0.605	4.407
6	50	49.778	24.879	36.920	0.605	4.407
7	30	30.765	24.902	36.928	0.676	4.404
8	30	30.765	24.902	36.928	0.676	4.404
9	30	30.765	24.902	36.928	0.676	4.404
10	10	10.751	24.914	36.925	0.645	4.404
11	10	10.751	24.914	36.925	0.645	4.404
12	10	10.751	24.914	36.925	0.645	4.404

Station: CD53-28#5

Depth (m)	NO2 (uM)	NO3 (uM)	PO4 (uM)	SiO4 (uM)
4500	0.05	21.8	1.53	38.61
4000	0.05	22.0	1.53	37.57
3500				
3000				
2500	0.05	21.0	1.42	26.78
2000	0.05	21.5	1.46	24.00
1500				
1000	0.05	27.0	1.73	18.43
500	0.05	17.5	1.05	8.35
300	0.05	9.5	0.58	5.22
200				
100	0.05	0.3	0.05	3.13
75	0.05	0.3	0.05	3.13
60				
50	0.05	0.3	0.05	3.13
30	0.05	0.3	0.05	3.13
20				
10	0.05	0.3	0.05	3.13
2	0.05	0.3	0.05	3.13

Station: CD53-27#1CTD

Date	Time	Lat	Long	Remarks:
08.10.90	15.06	24 26.2	20 24.3	Radionuclides, Edinburgh

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	1000	1004.456	7.110	35.087	0.493	4.468
2	1000	1004.456	7.110	35.087	0.493	4.468
3	500	500.594	12.019	35.588	0.513	4.468
4	500	500.594	12.019	35.588	0.513	4.468
5	300	302.255	15.101	36.033	0.579	4.465
6	300	302.255	15.101	36.033	0.579	4.465
7	125	128.233	19.588	36.723	0.688	4.456
8	125	128.233	19.588	36.723	0.688	4.456
9	53	53.781	24.897	36.918	0.562	4.407
10	53	53.781	24.897	36.918	0.562	4.407
11	32	32.766	24.905	36.919	0.576	0.576
12	32	32.766	24.905	36.919	0.576	0.576

Station: CD53-28#5CTD

Date	Time	Lat	Long	Remarks:
11.10.90	13.33	24 37.1	22 46.5	Level 1 nutrients & POC/PON

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	4500	4500.391	2.378	34.872	0.293	4.451
2	4000	4002.743	2.386	34.878	0.308	4.448
3	2500	2502.794	3.233	34.963	0.149	4.448
4	2000	2000.543	3.962	35.036	0.334	4.446
5	1000	1001.744	7.278	35.185	0.366	4.443
6	500	499.493	11.871	35.602	0.264	4.441
7	300	299.753	14.866	36.014	0.474	4.438
8	100	98.812	19.972	36.980	0.603	4.412
9	75	74.596	21.066	37.027	0.366	4.402
10	50	48.377	25.218	37.392	0.564	4.387
11	30	28.864	25.355	37.357	0.449	4.380
12	10	11.351	25.404	37.363	0.374	4.385

Station: CD53-28#8CTD

Date	Time	Lat	Long	Remarks:
12.10.90	09.16	24 38.0	22 47.8	Stable isotopes (UCNW)

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	170	171.463	17.860	36.599	0.571	2.446
2	170	171.463	17.860	36.599	0.571	2.446
3	145	144.444	18.622	36.759	0.635	2.195
4	145	144.444	18.622	36.759	0.635	2.195
5	130	130.335	18.858	36.796	0.715	2.349
6	120	121.528	19.280	36.877	0.776	2.395
7	110	111.421	19.561	36.923	0.857	2.490
8	100	101.014	20.046	36.926	0.671	2.629
9	80	80.500	21.381	37.007	0.571	2.825
10	50	50.579	25.300	37.354	0.525	3.203
11	10	11.351	25.303	37.355	0.544	3.333
12	5	4.346	25.296	37.354	0.444	3.242

Station: CD53-29#7CTD

Date	Time	Lat	Long	Remarks:
14.10.90	19.30	20 34.3	21 07.6	Radionuclides, Edinburgh

Bottle	Depth	Press	Temp	Saln	Fluor	Trans
1	1000	1002.645	6.383	34.971	0.542	1.663
2	1000	1002.645	6.383	34.971	0.542	1.663
3	500	497.391	11.28	35.457	0.481	1.914
4	500	497.391	11.28	35.457	0.481	1.914
5	300	301.254	14.206	35.864	0.583	2.083
6	300	301.254	14.206	35.864	0.583	2.083
7	125	125.331	19.028	36.678	0.532	2.253
8	125	125.331	19.028	36.678	0.532	2.253
9	65	65.99	24.981	36.504	1.257	2.407
10	65	65.99	24.981	36.504	1.257	2.407
11	39	40.372	25.336	36.331	0.769	2.314
12	39	40.372	25.336	36.331	0.769	2.314

Station: CD53-31#4CTD

Date	Time	Lat	Long	Remarks:
17.10.90	15.58	19 00.1	20 09.5	

Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	3000	3005.646	2.726	34.927	0.413	1.665	4.042
2	2000	1999.242	3.642	34.958	0.281	1.909	3.583
3	1500	1503.795	4.626	34.997	0.430	2.280	3.023
4	1000	999.442	6.234	34.883	0.427	2.791	1.818
5	500	499.793	9.864	35.197	0.625	3.145	0.921
6	300	296.551	13.042	35.649	0.532	3.140	1.031
7	150	149.148	14.814	35.788	0.579	3.140	0.815
8	75	75.396	16.723	36.035	0.632	2.668	0.772
9	60	61.887	17.130	36.025	0.747	2.629	0.743
10	50	48.277	19.741	36.189	1.489	2.527	0.876
11	30	29.564	25.482	36.273	1.189	2.571	1.843
12	10	10.150	25.524	36.264	1.038	2.532	1.946

Station: CD53-31#13CTD

53-31 #11

Date	Time	Lat	Long	Remarks:
19.10.90	12.22	19 04.2	20 14.8	Radionuclides, Edinburgh

Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	1000	1001.044	6.29	34.968	0.708	1.252	1.822
2	1000	1001.044	6.29	34.968	0.708	1.252	1.822
3	500	498.292	9.722	35.173	0.681	1.345	0.966
4	500	498.292	9.722	35.173	0.681	1.345	0.966
5	300	301.254	12.986	35.647	0.674	1.321	1.111
6	300	301.254	12.986	35.647	0.674	1.321	1.111
7	125	131.635	14.954	35.798	0.593	1.377	0.726
8	125	131.635	14.954	35.798	0.593	1.377	0.726
9	50	51.479	24.052	36.222	1.655	1.428	1.841
10	50	51.479	24.052	36.222	1.655	1.428	1.841
11	37	37.169	25.538	36.262	1.062	1.611	1.848
12	37	37.169	25.538	36.262	1.062	1.611	1.848

Station: CD53-30#7CTD

Date	Time	Lat	Long	Remarks:
16.10.90	19.00	19 42.3	20 43.8	

Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	75	89.606	20.305	36.630	1.045	2.947	2.031
2	75	89.606	20.305	36.630	1.045	2.947	2.031
3	75	89.606	20.305	36.630	1.045	2.947	2.031
4	50	65.789	24.114	36.304	1.421	3.147	2.093
5	50	65.789	24.114	36.304	1.421	3.147	2.093
6	50	65.789	24.114	36.304	1.421	3.147	2.093
7	30	48.377	24.690	36.289	0.884	3.530	2.054
8	30	48.377	24.690	36.289	0.884	3.530	2.054
9	30	48.377	24.690	36.289	0.884	3.530	2.054
10	10	28.163	24.696	36.285	0.957	3.555	2.049
11	10	28.163	24.696	36.285	0.957	3.555	2.049
12	10	28.163	24.696	36.285	0.957	3.555	2.049

Pressure reading faulty, offset of 15dB at 0m

Station: CD53-31#11CTD

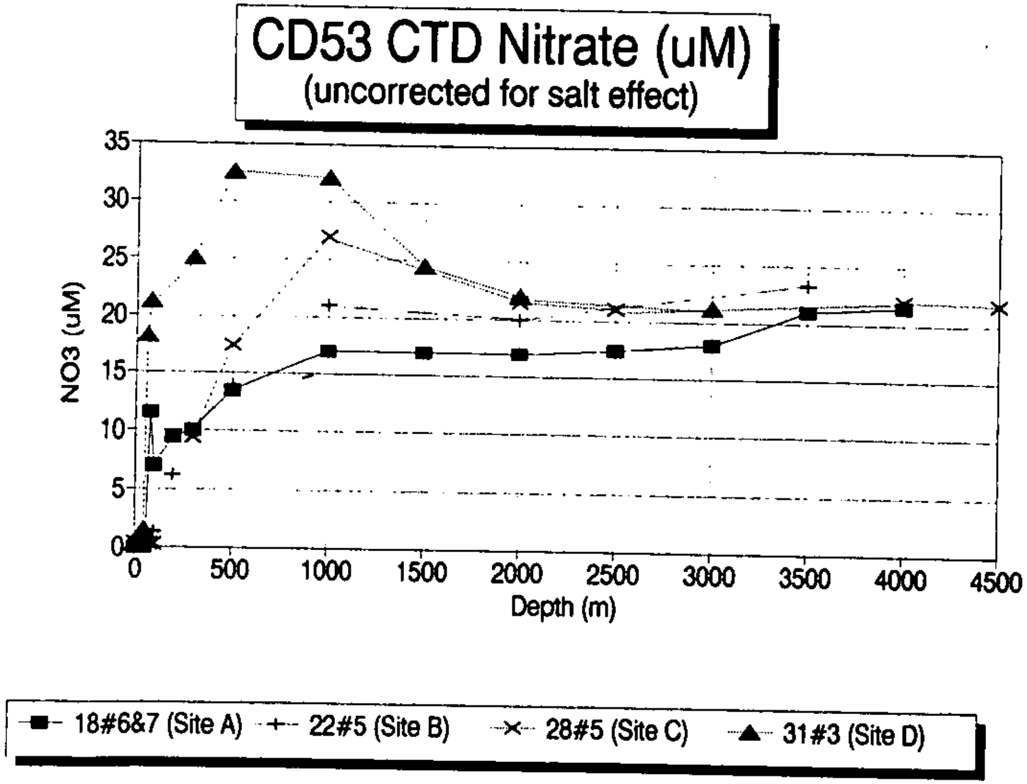
53-31 #10

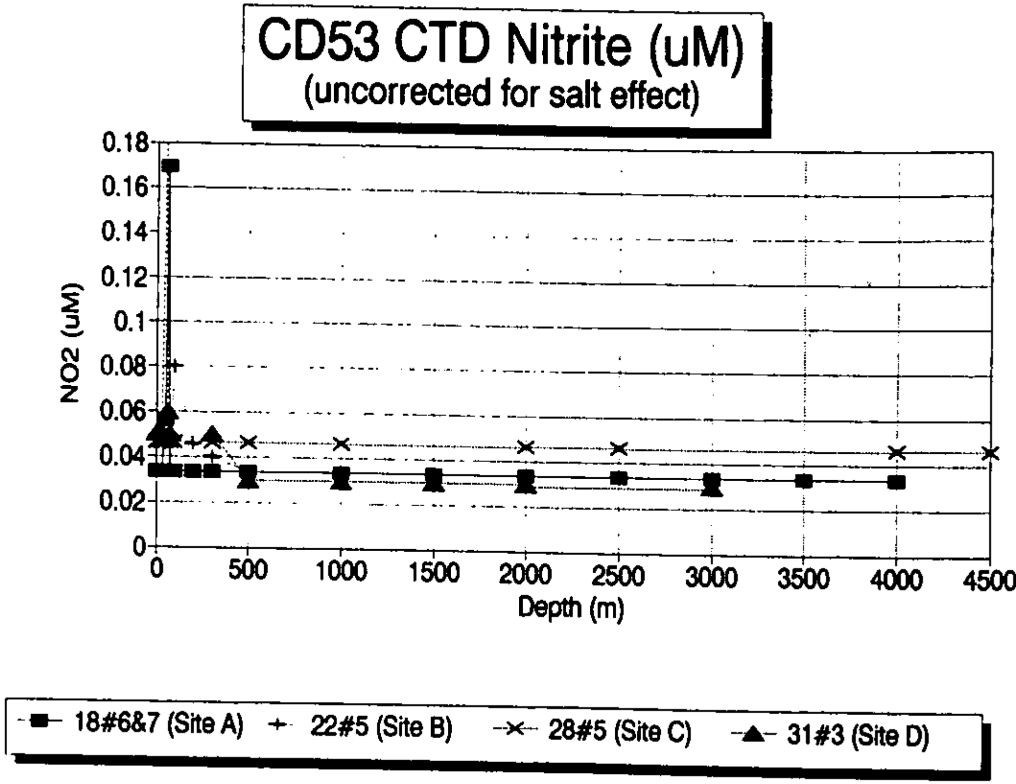
Date	Time	Lat	Long	Remarks:
19.10.90	04.09	19 00.0	20 10.0	Stable isotopes, UCNW

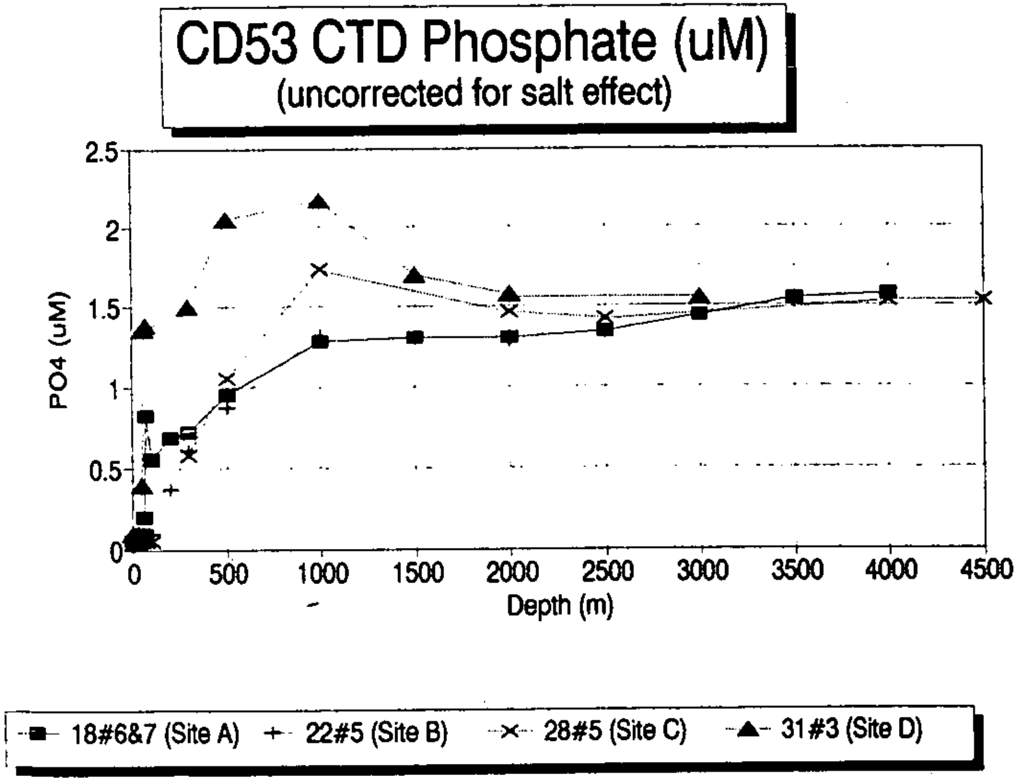
Bottle	Depth	Press	Temp	Saln	Fluor	Trans	Diss O2
1	120	122.029	15.458	35.899	0.710	1.616	0.863
2	120	122.029	15.458	35.899	0.710	1.616	0.863
3	80	82.101	16.290	35.961	0.627	1.758	0.698
4	80	82.101	16.290	35.961	0.627	1.758	0.698
5	60	62.787	17.474	36.114	0.769	1.902	0.991
6	60	62.787	17.474	36.114	0.769	1.902	0.991
7	50	51.579	25.434	36.307	1.296	2.021	1.875
8	70	70.693	16.454	35.972	0.681	2.468	0.655
9	40	43.474	25.450	36.294	1.284	2.869	1.839
10	30	32.266	25.458	36.280	1.182	2.778	1.862
11	15	17.856	25.458	36.273	1.196	2.671	1.816
12	5	8.249	25.454	36.279	1.145	2.654	1.820

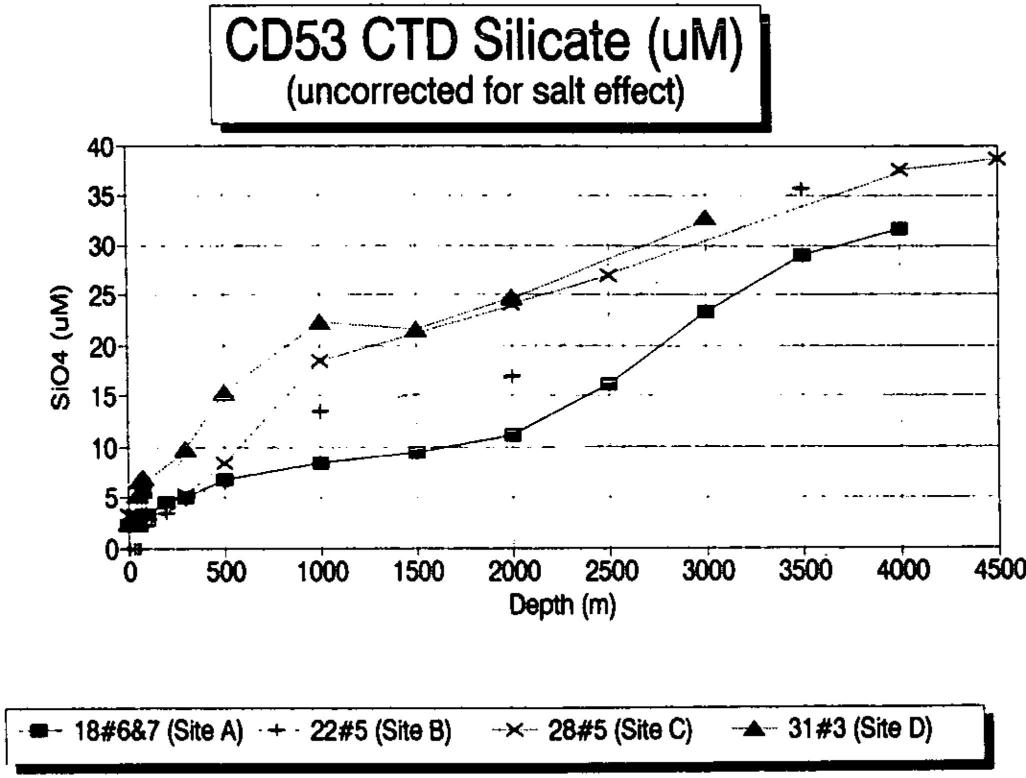
Station: CD53-31#3CTD

Depth	NO2	NO3	PO4	SiO4
4500				
4000				
3500				
3000	0.03	21.2	1.55	32.7
2500				
2000	0.03	22.0	1.57	24.70
1500	0.03	24.5	1.69	21.57
1000	0.03	32.0	2.17	22.26
500	0.03	32.5	2.05	15.30
300	0.05	25.0	1.50	9.74
200				
100				
75	0.05	21.2	1.39	6.96
60	0.06	18.2	1.36	6.61
50	0.19	1.5	0.40	5.22
30	0.05	0.2	0.10	2.43
20				
10	0.05	0.2	0.10	2.43
2	0.05	0.2	0.10	2.43


CD53 CTD Nitrate (uM)
(uncorrected for salt effect)


CD53 CTD Nitrite (uM)
(uncorrected for salt effect)


CD53 CTD Phosphate (uM)
(uncorrected for salt effect)
PO4 (uM)
2.5
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Depth (m)
18#6&7 (Site A)
22#5 (Site B)
28#5 (Site C)
31#3 (Site D)


CD53 CTD Silicate (uM)
(uncorrected for salt effect)
SiO4 (uM)
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Depth (m)
18#6&7 (Site A)
22#5 (Site B)
28#5 (Site C)
31#3 (Site D)

POC/PON

Bottle samples were also collected for POC/PON determination.
The samples were prefiltered through a 200µm mesh then through GF/F filters by vacuum filtration. Samples, taken over the whole water column, were collected at the following stations:
18#6, 18#7, 22#5, 28#5, 31#3.
Note that these casts were also used for nutrient analysis.

Thanks to all who helped with the filtering.

George Ritchie

9. RAINWATER COLLECTION

Rainwater collectors were prepared and deployed on the monkey-deck rails. The positions were chosen to preclude contamination of the water by passage over the ship's rigging wires, aerials or rails. The collectors were fixed vertically to either the port or starboard side, depending on the relative wind direction during the rain episode. Table 4 displays the opening and closing times of the collectors, ship's position and heading and other relevant information. Three samples were saved and frozen for future analysis of major ions and trace metals by Andrew Rendell at UEA. Two of these (samples 1 and 3) were of substantial volume (50-100ml), while sample 2 was only 5-10ml. A fourth sample was discarded due to its inadequate volume. larger volumes may be recovered in future by devising a method for angling the collectors into the wind during high wind conditions.

Barbara Afergan

10. RVS COMPUTING

The RVS Computer System was run continually during the cruise with no major faults. A great deal of data was collected, but the data processing load was relatively light for a BOFS cruise. Data from **em-log, gyro, MX1107** and **GPS** were combined into a navigating file using relmov and bestnav for position and track plotting.

CTD data was processed using proctd (calibration from RVS OSG). Raw CTD files were named ctdr53nn and processed files ctdp53nn. CTD#6 was abandoned due to bad weather, and CTD#11 was not logged by the RVS system due to incorrect hardware configuration (not plugged in). However, the data was logged by the CTD local display system and has been transferred for later decoding. **Thermosalinograph** (TSG103), **surface instrument pack, ADCP, multimet** and **autoanalyser** (AUTOD) data were collected on-line, and a system devised to transfer and process **pCO$_2$** data by hand. Hardcopy data and plots were distributed, but some difficulties were experienced when trying to print graphics files from "third party" packages across the network from the IBM-PS2. A solution was found, but this proved to be slow and inefficient. Data backups and complete **GF3** set were made with no apparent failure of the tape transports.

Adrian Fearn

Table 4. Rainwater sampling

	Date	Sample number	GMT	Collectors opened/ closed	P/S, I/II (or location) mast collectors	Latitude	Longitude	Rel. wind direction	Rel. wind speed	Ship heading	Ship speed	Wet start of rain? y/n	Rain type	Intermittent rain (were collectors not covered) no times when not raining	Samples compromised in any way PLEASE BE PRECISE - see sampling guide (spray/smoke/overhead cables/oil rigs/incineration ships)	Any other remarks (include temp, closure for station - 'TCFS', and give station code)	Sample saved y/n
1	25/9	/	[illegible]	open	[illegible]	N 32°13' 35	15°45' 3W	120°	12	310	8	Y	Light Drizzle	–		[illegible] T = [illegible]	
2	26/9	/	[illegible]	close	"	31°56.7N	[illegible] 3	130°	13	[illegible]	[illegible]	–	–			no sample collected	N
3	27/9	1	[illegible]	open	"	37°59 N	17°55' W	40°	25	150	10	Y	[illegible]			T = 19°C	
4	[illegible]	1	[illegible]	[illegible]	"	37°50 [illegible]	[illegible]	40°	25	152	10	-	"			"	
5	27/9	1	[illegible]	close	"	37°3 [illegible]	[illegible]	[illegible]	15	151	[illegible]	–	[illegible]	[illegible]		[illegible]	
6	[illegible]	1	[illegible]	open	"	[illegible]	[illegible]	50°	13	[illegible]	[illegible]	[illegible]	[illegible]			T = [illegible]	
7	27/9	1	[illegible]	close	"	[illegible]	[illegible]	50°	12	161	[illegible]		--		[illegible]	Approx 50 ml	Y
8	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	very heavy [illegible]		[illegible]		
9	[illegible]	2	[illegible]	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-		[illegible]		[illegible]	
10	[illegible]	2	[illegible]	open	"	[illegible]	[illegible]	[illegible]	25	160	10	Y	[illegible]				
11	[illegible]	2	[illegible]	close	"	[illegible]	[illegible]	[illegible]	[illegible]	160	[illegible]	-	–		[illegible]	[illegible] closed everywhere	Y
12	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70°	[illegible]	[illegible]	13	Y	[illegible]				
13	[illegible]	3	[illegible]	close	"	[illegible]	[illegible]	70°	[illegible]	[illegible]	17	[illegible]	-	[illegible]	N	[illegible]	Y
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11. MECHANICAL EQUIPMENT REPORT

Considering the long periods of continual usage of the main handling equipment, the gear performed extremely well. No major breakdowns were experienced; only one hydraulic hose on the double-barrelled winch and some hose damage to the Hiab 360 sea crane being encountered during the whole cruise.

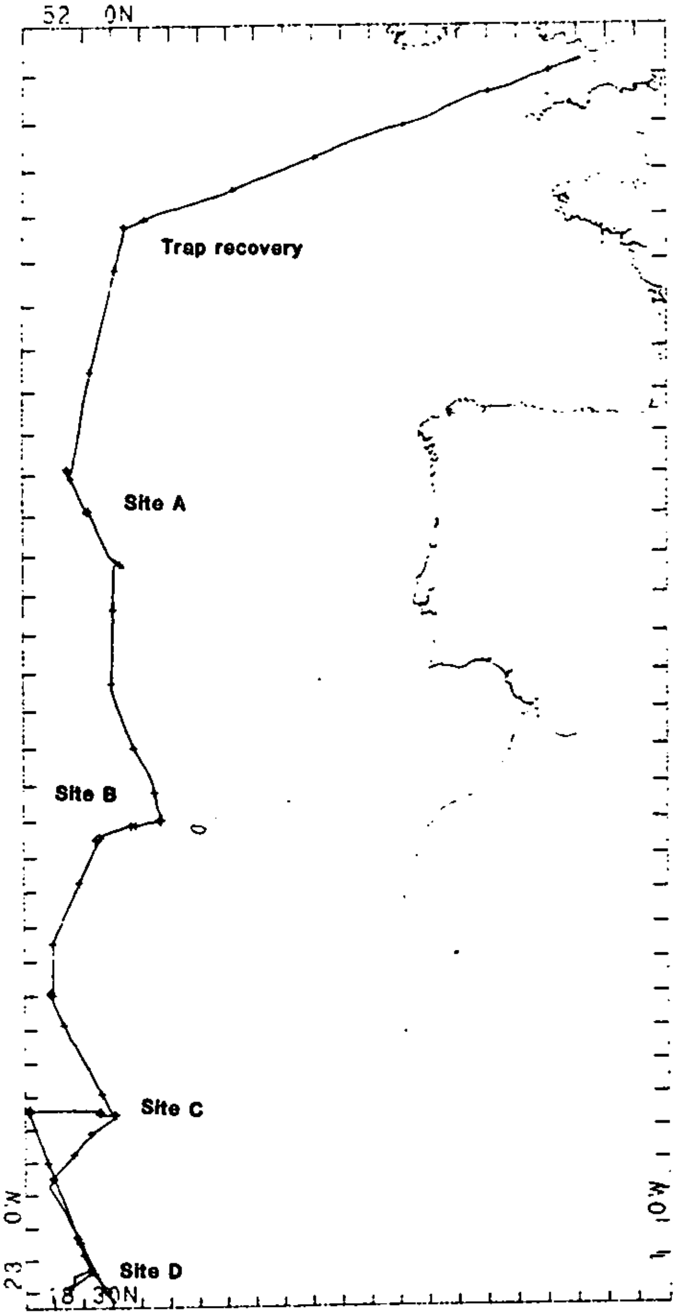
Continual usage was made of the four main winches. Besides the usual spooling problems on the CTD winch, the only other point to bring to notice was a problem encountered when piston coring. When veering the winch wire on the coring winch, the hammerlok swivel between the main warp and the coring pennant had a tendency to "stick" in the spurling pipe sheaves. With the winch being driven this caused loose turns to result on the winch drum.

The sampling equipment all performed well with no damage or loss occurring. The only exception being the Calvert box corer which initially gave considerable problems. Modifications to box seals and type and method of release are recommended (see Box core report, Wakefield, above).

Lastly, the main problem encountered during the cruise was the deployment of the CTD, camera and box core over the piston/Kasten core hydraulic bucket. Even during moderate sea conditions this could be a hazardous exercise. Due to the multi-disciplined nature of the cruise, swopping between deployment devices was a regular occurrence. It was not possible to move the core bucket due to available deck space and the need to rig the relevant corer for the next deployment. Careful consideration should be given to this problem as it presents a safety hazard to both equipment and personnel.

Kevin Smith
Graham Shimmield

11. CRUISE TRACK



MERCATOR PROJECTION

GRID NO. 2

SCALE 1 TO 20000000 (NATURAL SCALE AT LAT 0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 47

Charles Darwin (CD53) Cruise Track

12. ACKNOWLEDGEMENTS

Some cruises are more succesful than others. To operate a truly multidisciplinary expedition is demanding on all those taking part. This cruise was one of my most enjoyable, thanks entirely to the officers and crew of the RRS *Chareles Darwin* and the scientists that took part. We all had diverse and strange interests(!), but as a group there was an important task to be done and everyone pulled their weight. My thanks to you all.

As a footnote: remember the primary aim of this cruise was to collect samples - so get into the laboratory and be busy!