UNIVERSITY OF CAMBRIDGE

DEPARTMENT OF EARTH SCIENCES

R.R.S. CHARLES DARWIN

Cruise 88

25th July - 15th August 1994
Reykjavik to Ponta Delgada

North East Atlantic Palaeoceanography and Climate Change
Community Research Project of NERC

Principal Scientist

Professor I.N. McCave

1994

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CHARLES DARWIN CRUISE 99 : TIME BREAKDOWN

Sailed Reykjavik	0800	24/7/94
Arrived Ponta Delgada	0900	15/8/94
Total Cruise Time	529 hours	
Station time	232 hours	
Down time	< 6 hours*	
Steaming & Surveying time	291 hours	

*due to CTD failure, a propeller problem, broken trigger on box corer

1. ABSTRACT

This cruise was in support of NEAPACC (the North East Atlantic Palaeoceanography and Climate Change community research project of the U.K. Natural Environment Research Council). The objectives were to study the changes in the hydrography and current flow in the region of the Iceland-Scotland Overflow on the flank of Reykjanes Ridge over the last glacial-interglacial cycle. To this end piston (6), kasten (18) and box (20) cores were obtained from Bjorn and Gardar sediment drifts between 1000 m and 3200 m water depth. At each core site bottom photographs were taken and a CTD cast was made with water samples being obtained for a) chemistry (esp. Cd, PO_4) to compare with Cd/Ca ratios in benthic foraminifera and b) filtration to obtain suspended sediment concentrations for comparison with light attenuation coefficient and nephelometer values. Sites were chosen on the basis of 3.5 kHz information and in some cases, swath bathymetry. Surface plankton tows and sampling of the continuously pumped surface seawater was made to obtain planktonic foraminifera.

2. INTRODUCTION

a. <u>Scientific Aims of NEAPACC</u>

The North Atlantic is presently thought to hold the key to several problems concerning late Quaternary climatic change. These involve the fluxes of heat in the region, one manifestation of which is the fluctuation in the volume flux of North Atlantic deep water, made by cooling saline water in the Norwegian-Greenland Sea. The region has also been sensitive to rapid climate fluctuations recorded by massive outbreaks of icebergs (Heinrich events) the Younger Dryas cooling, and Dansgaard-Oeschger events recorded in the Greenland ice sheet. The aim of NEAPACC is to examine the oceanic aspects of these climatic changes through studies of sea surface temperature via organic chemistry and biological populations, of palaeoproductivity and palaeohydrography and of palaeocirculation and current speed.

b. <u>Specific Cruise Objectives</u>

The aim was to obtain a set of high-resolution cores that would allow inference of changes in current flow, circulation, productivity, iceberg flux and ocean temperature in the region just downstream of the eastern gateway to the N.Atlantic. The flows over Iceland-Faeroe Ridge and through Faeroe Bank Channel coalesce and remove recently discharged sediment south of Iceland, depositing it farther downstream in the form of two major sediment drifts, Bjorn and Gardar.

Objectives thus were:

i) to collect high resolution cores on transects of Bjorn and Gardar Drifts; to accomplish this by use of Box, Kasten and Piston corers

ii) to survey and characterise the coring sites by 3.5 kHz acoustic sounding, swath bathymetry, and bottom photography

iii) to obtain profiles of hydrographic variables (T, S, O_2, turbidity) in order to assess conditions of sedimentation at the sites

iv) to obtain water samples near the bed for determination of PO_4 and Cd concentrations to relate to chemical properties of benthic foraminifera and to obtain water samples for filtration to determined suspended material content

v) to obtain samples of planktonic foraminifera from surface tows and underway filtration for testing population relationships to core-top material.

c. Narrative of the Cruise

Charles Darwin sailed at 8 o'clock on the 24th July on a clear sunny day from Reykjavik. This was the last time that we were to see the sun for any significant length of time until we were well south of 50°N and on our way to the Azores. We made a fair passage to the first sampling station at just over 1000m at the head of Bjorn Drift, occupied at 0600 on the 25th July. The general strategy at each station was to take an undisturbed surface sample by box corer before attempting a Kasten or piston core, and also make a full-depth CTD cast with water-bottle sampling for salinity and suspended sediment and deploy the camera to record the character of the sea bed. Although our sampling was by-and-large trouble free, at the first station we encountered a major problem. The box core taken initially penetrated soft Holocene sediments but the subsequent attempt at a Kasten core using the new 20 cm square barrel came up empty. We believed that it had penetrated but fallen over and so it was sent down again at increased speed (40m per minute entry speed). Luckily only two sections of barrel totalling 6m, were mounted on the corehead. The presumption that the bed might be hard below the Holocene was perfectly correct; the corer penetrated over 3m but the hard glacial material forced apart the sleeve which joined the two sections of barrel together, and although the lower half of the barrel came up to the surface it fell off just as it reached that point. We then sent down a single short (3m) 15cm square core barrel but with no better fortune than with the box corer, and retired from the first station to lick our wounds. Subsequent coring down Bjorn Drift at stations 2 to 5 was with the 7m long 15cm square Kasten core barrel which obtained high quality cores of increasing length. With the benefit of hindsight, the coarseness of the Glacial deposits would obviously decrease away from Iceland, and the hard bottom at station 1 was to have been expected. This series of stations took us until late afternoon on the 28th July.

We then embarked upon a set of CTD stations across the main body of the Norwegian Sea Overflow Water and also took a core at station number 7. This was originally planned to have been at the location of Vema core 29-204, however, that site appeared to us to lie within a scour channel where the likely addition of redistributed material suggested it would be imprudent to core. After a CTD at station 10 we encountered gale force winds and made a slow swath sounding transect across the head of Gardar Drift until the wind abated. Stations 11 and 12 were taken here with station 12 being a piston core at a proposed ODP site suggested to us by Delia Oppo from Woods Hole.

At 0530 on the 1st August we commenced another transect of four stations across the head of Gardar Drift just upstream from Discovery station 11902 at which core BOFS 16K had been taken in 1989. By late afternoon of 3rd August we had occupied 16 stations and had taken 11 camera dips, 18 CTD's, 11 box cores and 10 Kasten cores within the space of nine and half days sampling. The Kasten cores had all been extruded, described, sliced up into trays and sampled for water content.

Our stride now lengthened and the distance between stations increased. We made another transect of the Drift at about 59°N and at the western end of the line started to look for seamounts with potential for coring at shallower depths than the crest of the Drift, the intention being to obtain material from under the present Labrador Sea Water. The knoll at 59°N 25°W proved unsatisfactory and we sailed south to a further transect of Gardar Drift between 57° and 58°N with Franklin Seamount at its western end. This too proved unsatisfactory having virtually no sediment anywhere on the Seamount. Farther to the southwest at 57°N 28½°W Marietta Seamount had a possible coring site but only at water depths in excess of 2500m which was too deep for Labrador Sea Water. These seamounts all lie under the path of the main core of the overflow water boundary current, and it was an outside chance that there might be some regions unscoured. It is clearly not worth looking any further for such material in this region, the only remaining possibility would be to go to shallow depths on the side of Reykjanes Ridge.

We left Marietta Seamount at 1820 on the 7th August and proceeded towards the SSE to stations 21 and 22 on central portion of Gardar Drift and then zig-zagged down the Drift with the swath bathymetry system in order to ascertain the orientation of extensive mudwaves which decorate this part of the Drift. We took a final station (23) on the Drift at 07.15-23.55 on 9th August and sailed directly south to survey a small projection in the entrance to Charlie-Gibbs Fracture Zone which had the appearance of being a small drift created by flow from east to west through the fracture zone. We surveyed this and then took a core in order to examine the possibility that there was enhanced flow of southern source water from the eastern basin through to the western basin during the Glacial. This was our last coring site in the main area of operations and we proceeded to the northern end of the Median Valley of the mid Atlantic Ridge at 52°N 30°W where at 1220 on the 11th August we commenced a Swath survey down the Valley on behalf of our colleagues involved in RIDGE. We concluded that survey at 2000 on the 13th August and in the early hours of the 14th took a box core in one of the small basins on the flank of the mid-Atlantic Ridge in order to obtain some material which might contain an integrated stratigraphy of pelagic carbonates and major volcanic ashes of the

Azores. The position is not optimal for this, lying against the prevailing direction of ash dispersal.

We made good passage after that and entered Ponta Delgada early on the morning of the 15th August and were all moored up by 0900 to conclude our cruise. Details of the material obtained will be found elsewhere in this report but the summary is 25 CTD's (21 full depth), 20 box cores, 18 Kasten cores and 6 piston cores with associated 1 metre trigger cores. This will provide more than enough material to fuel NEAPACC for the next few years. My thanks go to all scientific staff, ships officers, crew and RVS technical staff who made this significant collection of material and data so successful.

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3. TOPOGRAPHY and 3.5 kHz PROFILING

a. Topography:

Our basic guide to topography and initial site selection was Sheet 1, Reykjanes Ridge and Rockall Plateau, of the Bathymetry of the Northeast Atlantic by Laughton, Roberts and Hunter. This remains a most useful guide. As the track chart shows, we made a series of crossings of Bjorn Drift, picking coring sites where the expansion of the upper reflectors was maximal, generally just on the western side of the crest. In places the current has scoured a steep scarp on the eastern side, and to the west lies a probable turbidity current channel. This accounts for sites 1 to 5.

The transition region between Bjorn and Gardar Drifts contains one channel between station 6 and 7 which may be of turbidity current origin but possibly is due to overflow current scour. Station 7 was on safer, higher ground and the next core site, station 11, on a projecting nose of sediment which may be an ODP drill site in 1995. Sampling of Gardar Drift proper began with a transect of 4 stations (Nos. 13-16) across the head of the drift. The topography here is smooth slopes with the eastern side of the drift being steeper and more reflective of the 10 kHz acoustic energy of the PDR. The Simrad

Sounder's colour display shows this reflectivity quite clearly and it is also seen in the 3.5 kHz profiles (Fig. 1).

Between stations 17 and 18 on the next drift transect, the seabed is irregular and the margin of the drift rather steep, suggesting possible slumping. To the west of station 18 the seabed is deeply scoured with depths down to 2760m (drift crest at 2550m) and with the first sign of mudwaves. Swath bathymetry shows some closed depressions, so it is likely that the scour is due to the deep boundary current.

We examined three seamounts, the first just a knoll rising to 2400 m, the second and third were Franklin and Marietta Seamounts, but none had any coreable sites on them. I presume all seamounts in the path of the overflow current will be similarly bare. The knoll was after station 18 and the seamounts between stations 20 and 21. The formerly smooth eastern margin of the Drift is mantled with irregular mudwaves south of about 58° 10'N. On returning to the drift near site 21, mudwaves of greater regularity in height are encountered and the whole southern end of the drift is decorated with waves of 10 to 30m height (Fig. 2). These mudwaves persist along the SSW survey line between stations 23 and 24 which crosses a deepest point of 3550m lying in a depression, probably an overflow current scour, leading down to Charlie-Gibbs fracture zone.

The site of station 24, surveyed by Swath in C-GFZ, is also entirely covered in mudwaves. None of the mudwaves encountered are of the regularly climbing and migrating variety such as one seen in the Argentine Basin and on levees of turbidity current channels. Determination of the orientation of mudwaves in relation to topography will await final processing of the Swath bathymetry.

b. 3.5 kHz Profiles.

The 3.5 kHz profiler was run continuously from just south of Iceland to the MAR at 52°N. Penetration was mainly from 20 to 40m but occasionally up to 60m. There was little variation in echo character because we stayed over current-controlled sediments most of the time.

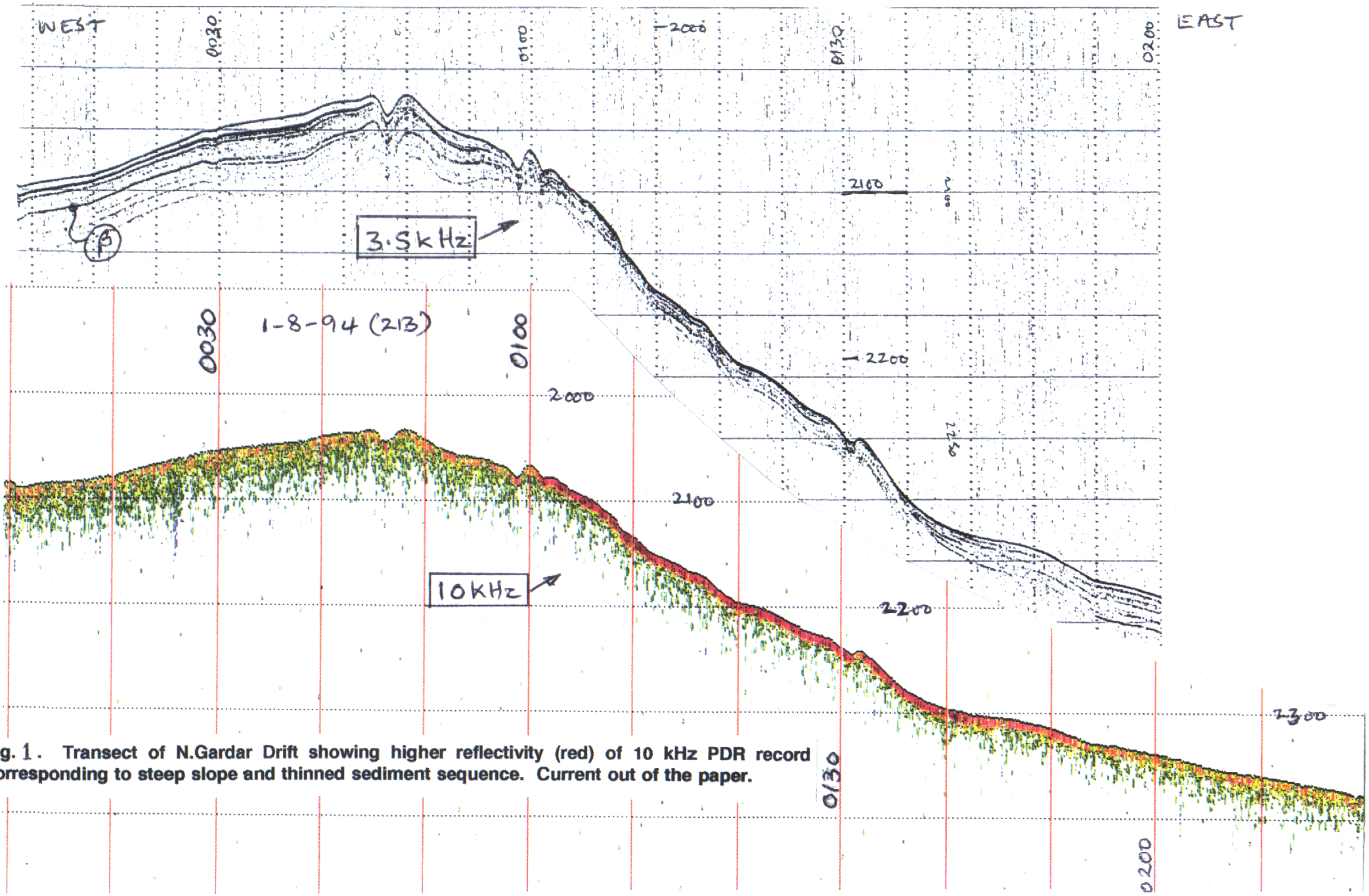

Fig. 1. Transect of N.Gardar Drift showing higher reflectivity (red) of 10 kHz PDR record corresponding to steep slope and thinned sediment sequence. Current out of the paper.

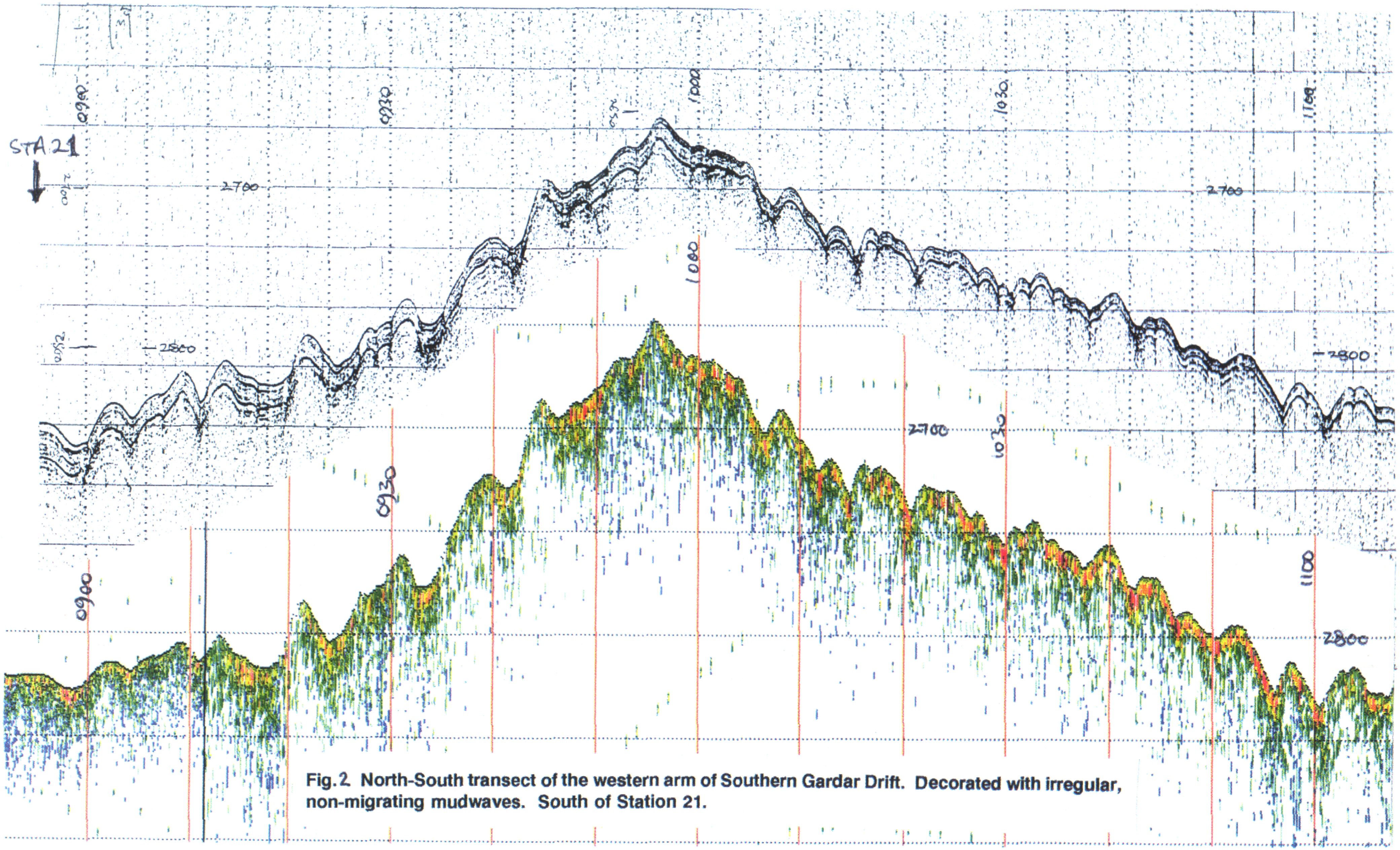

Fig. 2 North-South transect of the western arm of Southern Gardar Drift. Decorated with irregular, non-migrating mudwaves. South of Station 21.

Echo types were thus mainly types IB, IIIB and B2a of Damuth (1980) and Jacobi & Hayes (1982). Many pieces of record show a particularly well developed reflector in the region 10 to 30 m below the seabed. It is very similar to reflector β of Carter & McCave (in press) in current controlled topography of Chatham Drift east of New Zealand (Fig. 3E). There it is suggested to be caused by the glacial to interglacial lithological transition of isotope stage 8 to 7. If true it marks about 250 ka ago and the depth range implies sedimentation rates of 4 to 12 cm/ka which is about right for this area. This reflector is found over most of the area surveyed, from Bjorn Drift down to Charlie-Gibbs F.Z. (Fig. 3A-D). The potential of this horizon for delineating sedimentation patterns regionally is being examined.

Unfortunately the 3.5 kHz record on Charles Darwin is degraded by noise when the ship is running at speeds in excess of 8 to 9 knots (see Fig. 3D left at 8 knots and right at 10 knots). This was not nearly so severe a problem on the old Discovery and we suspect propeller noise, but they are said to be quiet. A cure for this problem would improve results and allow faster surveys.

PDR and 3.5 kHz records are held at the Department of Earth Sciences, Cambridge.

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4. BOTTOM PHOTOGRAPHY

We deployed the camera at 17 stations (table 1). The instrument employed was a UMEL C1800 deep-sea survey camera with C12020 single strobe (both 6000m rated) mounted in a frame to give an oblique view of the seabed and with a 0.6 m long bottom-contact trigger. A 10 kHz pinger was mounted in the camera frame. The camera is adapted to take standard 36 exposure cassettes, and Ilford FP4 Plus black and white film was used. On each run about 20 bottom contacts were attempted. At station 2 near disaster occurred when the film tore and broke. The wind-on capstan which operates a microswitch to stop the wind-on motor was thus not rotated and the motor went on turning until the camera was opened about 2 hours later. The bearings of the (sealed) motor sounded

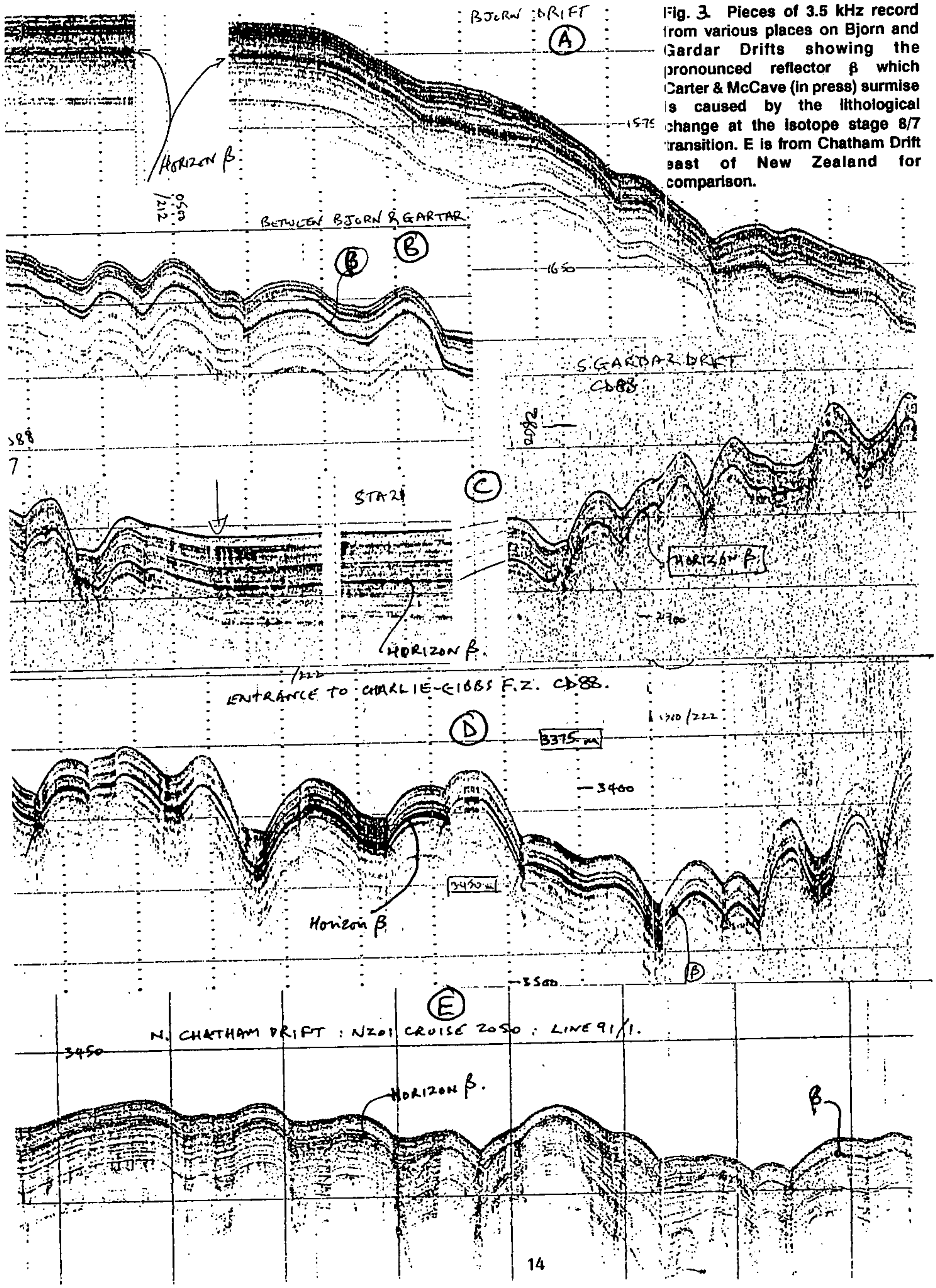

Fig. 3. Pieces of 3.5 kHz record from various places on Bjorn and Gardar Drifts showing the pronounced reflector β which Carter & McCave (in press) surmise is caused by the lithological change at the isotope stage 8/7 transition. E is from Chatham Drift east of New Zealand for comparison.

as though they would fail at any moment. However they managed a further 15 camera runs. At one other station the film was found to have nearly torn through, but not quite! The number of usable shots for each camera run is given in the log of table 1. Sedimentation conditions are well shown by the suite of pictures. Only at station 18 (Cam 13) was the nepheloid layer so dense that the bottom was invisible. At several other stations there was appreciable cloudiness.

We are extremely grateful to Mr John Humphery of the Proudman Oceanographic Laboratory, Bidston, Merseyside for the loan of the camera system.

Photographs are held at the Department of Earth Sciences, Cambridge.

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Table 1 : CAMERA DEPLOYMENT LOG

CAM.NO.	STATION	LAT(N)	(LONG(W)	DEPTH	GOOD SHOTS
1	1	62° 40.44'	22° 27.15'	1092	10
2	2	62° 23.50'	23° 12.00'	1270	2
3	3	61° 50.00'	23° 57.62'	1512	18
4	4	61° 29.88'	24° 10.00'	1627	23
5	5	61° 05.90'	24° 32.32'	1818	24
6	7	61° 13.17'	22° 32.12'	1868	20
7	11	60° 24.55'	23° 39.18	1997	20
8	13	59° 44.73'	22° 13.36'	2650	17
9	14	59° 46.49'	23° 53.61'	2360	21
10	15	59° 52.17'	23° 16.32'	2219	17
11	16	59° 46.64'	22° 38.11'	2482	14
12	17	58° 37.82'	23° 59.70'	2790	13
13	18	58° 56.78'	24° 23.85'	2547	1*
14	19	57° 33.14'	24° 42.81'	2815	14
15	21	56° 22.49'	27° 48.61'	2843	20
16	23	54° 42.12'	28° 21.67'	2872	13
17	24	52° 46.34'	30° 19.80'	3299	19

*very strong bottom nepheloid layer obscuring bed.

5. CORING OPERATIONS

a. Box Coring

We took 20 box cores with a 0.25 m^2 box corer of the type used by Hessler and Jumars (1974) with spring-loaded flaps, open on impact and closed on retrieval, to minimise bow wave. [Taxonomic note: All box corers descend from Reineck's (1958) original design. The one we used derives from the redesign supported by the US Navy Electronics Lab. (USNEL) associated with Bouma, Rosfelder and Marshall which had a 20 x 30 cm sample area (see Bouma, 1969). Hessler and Jumars (1974) increased that to 50 x 50 cm, and subsequent modifications funded by the US Sandia Laboratories make the corer we used a "Sandia Mark II" in the terminology of the cognoscenti. At RVS the instrument is known as the SMBA (Scottish Marine Biological Association) corer because that is where they got it from.]

The entry speed was initially set at 30m/min but at station 1 the core was full, 55 cm in the centre, and at station 2 rather over-full and the surface may have been lost. We therefore reined back to 15m/min and were still getting 45-50 cm (in a 55 cm corner-height box). From 11B the speed was increased to 30m/min as the bottom became firmer to the south. On two occasions the doors on one side did not shut and a scoured surface on one side resulted (Nos. 8B and 19B). Core 18B was slightly disturbed because too much wire was laid out and it fouled the corer. The standard sampling was : two 10 cm diameter drainpipes, two surface (~0.5 cm) scrapes for benthic foraminifera and the remainder of the surface 0-5 cm removed and stored in two large plastic bags. For 13B to 19B one 10 cm tube and two core-liner (6.6 cm i.e.) tubes were taken. At station 6 a sediment core was collected for an international intercalibration exercise of Pb-210 analysis, organised jointly by Dr I. Hall (Earth sciences, Cambridge) and Dr J. Thomson (Institute of Oceanographic Sciences). Bulk sediment was collected from 0.5 cm and 30-35 cm, with the aim of providing a sample supporting excess Pb-210 and a sample with Ra-226/Pb-210 in equilibrium. This material is held at Cambridge. Surface sediment samples were taken to measure the concentrations of trace metals in present day benthic foraminifera, to be related to the trace metal concentrations of near-bottom waters.

The surface scrapes taken for foraminifera chemistry were ≤1 cm deep with a diameter of 11 cm (volume ~95 cm^3). One was frozen and the other was preserved in formaldehyde solution. This solution was 10% (10% formaldehyde and 90% seawater) with sodium borate (5g per litre of formaldehyde) added to act as a buffer. For some cores, such as 11B, 15B and 18B two scrapes were preserved with the formaldehyde solution. In the case of 3B, 5B, 7B and 11B some animals found on the core top were also preserved. At the end of the cruise the frozen samples were unfrozen and preserved in formaldehyde solution.

INMcC, SJB & IRH

Table 2 : BOX CORE LOG

BOX NO.	STATION	LAT(N)	LONG(W)	DEPTH(m)	LENGTH(m)	REMARKS
NEAP 1B	1	62° 40.80'	22° 27.15'	1092	0.50	
" 2B	2	62° 23.76'	23° 12.00'	1268	0.53	surface lost?
" 3B	3	61° 52.10'	23° 56.48'	1502	0.50	
" 4B	4	61° 21.98'	24° 10.27'	1627	0.45-0.50	
" 5B	5	61° 04.50'	24° 31.76'	1826	0.45-0.40	
" 6B	7	61° 13.03'	22° 29.42'	1866	0.45	^{210}Pb
" 7B	11	60° 24.84'	23° 38.68'	1997	0.45	
" 8B	13	59° 44.50'	22° 11.95'	2649	0.40	½ scoured
" 9B	14	59° 46.96'	23° 55.40'	2361	0.40	
" 10B	15	59° 53.55'	23° 19.19'	2221	0.41	
" 11B	16	59° 47.49'	22° 39.24'	2484	0.40	
" 12B	17	58° 38.36'	23° 59.63'	2786	0.40	
" 13B	18	58° 56.41'	24° 24.02'	2546	0.40	
" 14B	19	57° 32.18'	24° 43.22'	2820	0.35	
" 15B	20	57° 40.53'	25° 38.43'	2703	0.40	
" 16B	21	56° 21.99'	27° 49.00'	2847	0.50	
" 17B	22	56° 10.15'	27° 20.53'	2734	0.40	
" 18B	23	54° 41.56'	28° 21.02'	2879	0.45	disturbed
" 19B	24	52° 45.91'	30° 20.66'	3283	0.38	½ scoured
" 20B	25	42° 29.31'	28° 24.87'	2878	0.20	

b. Kasten Coring

The CD-88 kasten coring programme utilised both the successful 15 cm square core barrel, extended in length by fitting together a 3m and 4m section, and the new 20 cm square barrel composed of 4 modular 3m sections. Design of both barrels follows Zangger and McCave (1990). Extra lead was added to the core head to provide the necessary weight for good penetration of the larger diameter and longer barrels. However the 1.5 tonne core head provided (½ tonne less than requested) was insufficient to push the 20 cm square barrel in more than 7m.

Subsampling of the cores was carried out using specially moulded styrene trays, 330 x 15 x 25 mm. These permit easy storage of slab sections, which can be viewed prior to cutting and subsampled if necessary without the need for sectioning the entire slab. No electrical conduit "drainpipe" sub-cores were taken (as on Discovery 184 for BOFS), since the conduit is expensive, more difficult to store and harder to subsample. The slabs were taken as follows:

1) Outer few mm cleaned off, trays pressed into core barrel along length.
2) Core extruded sideways, mud slabs removed in trays by cheesewire. Trays cleaned off and heat-sealed in polythene. First set of slabs stored in freezer for subsequent organic geochemistry.
3) Second set of slabs taken in same manner, but special care taken to level off surface of slabs to equal thickness. Slabs sealed and marked for X-radiography (to be carried out in Cambridge). Equal thickness across slab ensures good results on X-ray photographs. Slabs stored refrigerated at 4°C.
4) Core surface levelled off, core description made.
5) Samples taken for water content determination at 4 cm intervals, using cut-off syringes. Samples stored in screw-top jars under refrigeration.
6) Third set of slabs taken as before, to act as initial "working set".

One set of trays provides adequate material, sampled in 1 cm slices, for sedimentology, geochemistry and micropalaeontology requirements by groups in Cambridge. Material from other slabs will be available for work by other groups.

On the first deployment of the 20 cm square core barrel, only two 3m sections were rigged, with a core catcher. Following recovery of a successful box core of soft Holocene sediment, the kasten was sent down, with entry at 20m/min. The core had recovered little more than the box corer, so the material was discarded and the corer was sent down again with entry speed set at 40m/min. This took a core but broke the barrel at the joint, the lower part hanging on to the surface but then falling off before our eyes. There was evidence of penetration >3m prior to the loss, however, with mud adhering to the upper barrel section. Examination of the remaining section revealed insufficient strengthening of welded bosses for joining bolts between barrels. Work commenced to rectify this problem on the remaining 3 sections, and extra thick backing washers were added. The 20 cm corer subsequently successfully retrieved cores using both 6m and 9m of barrel. The maximum retrieved, however, was only 7.42m, due to insufficient weight in the core head to overcome the increased resistance of the larger corer.

The 15 cm square corer performed consistently well, and was mainly used with 7m of barrel. It may be possible to recover longer cores in future by adding a further 2, 3 or 4m section, as on a number of occasions the barrel returned almost full, with material remaining inside the core head itself. The maximum core length retrieved was 6.87m plus 0.13m of core catcher.

In the northern part of the transect, the core material was generally very dark greenish grey, with slight colour and textural changes downcore together with dropstone horizons. Mottling was pronounced over some intervals. Further south, the core colour became browner, and downcore variation more evident, with white, yellow, brown and green-grey layers, and some strongly burrowed horizons. Dropstones remained common. A small silty turbidite deposit was noted in core 5K at 369-383 cm, and a soft sediment injection artefact of coring was present at 265 cm in core 18K. Water-filled holes a few mm in diameter were present in some cores at different depths, which appeared to be

Table 3 : KASTEN CORE LOG

KASTEN	STATION	LAT(N)	LONG(W)	DEPTH(m)	TYPE	LENGTH(cm)
NEAP 1K	CD88/1	62°41.11'	22°27.07'	1092	20cm/6m	none
" 2K	CD88/2	62°23.71'	23°11.23'	1265	15cm/4m	300cm
" 3K	CD88/3	62°50.41'	23°57.42'	1510	15cm/4m	377cm
" 4K	CD88/4	61°29.91'	24°10.33'	1627	15cm/7m	631cm
" 5K	CD88/5	61°04.22'	24°31.87'	1826	15cm/7m	661cm
" 6K	CD88/11	60°23.37'	23°40.99'	2006	20cm/9m	572cm
" 7K	CD88/13	59°44.84'	22°12.00'	2651	15cm/7m	418cm
" 8K	CD88/14	59°47.37'	23°54.11'	2360	15cm/7m	637cm
" 9K	CD88/15	59°53.19'	23°19.81'	2222	15cm/7m	411cm
" 10K	CD88/16	59°46.93'	22°38.26'	2481	15cm/7m	623cm
" 11K	CD88/17	58°37.82'	23°59.76'	2789	15cm/7m	687cm
" 12K	CD88/18	58°56.31'	24°24.31'	2546	20cm/9m	558cm
" 13K	CD88/19	57°31.71'	24°44.85'	2817	15cm/7m	675cm
" 14K	CD88/20	57°41.15'	25°38.87'	2717	15cm/7m	670cm
" 15K	CD88/21	56°21.92'	27°48.68'	2848	15cm/7m	681cm
" 16K	CD88/22	56°10.15'	27°20.20'	2736	15cm/7m	680cm
" 17K	CD88/23	54°41.40'	28°21.20'	2880	20cm/9m	742cm
" 18K	CD88/24	52°46.02'	30°20.68'	3275	15cm/7m	664cm

washout channels following former burrows. Core 15K showed a very abrupt colour and texture change at 525 cm, with a "laminated" unit believed to be paper or tissue present from 525-528 cm. Samples of this laminated material were sent to Southampton for analysis to confirm this. The presence of waste paper at >5m depth was interpreted as evidence for repenetration of the corer! Otherwise, all cores showed good, coherent records with little disturbance and no visible evidence for hiatus or erosional interfaces.

In all, a total of 99.87m of section were recovered using the kasten corers, providing a huge quantity of material for work in Cambridge and collaboration with other groups in the future.

BM & IRH

c. <u>Piston Coring</u>

Six Piston cores were taken with a standard narrow gauge (6.6 cm i.d. liner) Kullenberg piston corer. A 1.2m gravity corer is employed on the end of the trigger chain, yielding a surface pilot core. For four cores (Nos.2-5) four 3m sections were mounted, but in two cases five sections (15m) were deployed. Despite penetration of 14-15m we did not obtain more than 11.5m from these attempts. Penetration was satisfactory with a 1 ton core head but we are not getting sufficient length. It must also be noted that most workers are now going over to wider (10-11 cm i.d. liner) corers so as to provide more material. Our systems need to be brought up to date. Material obtained is detailed in table 4 and is stored at the Department of Earth Sciences in Cambridge.

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Table 4 : PISTON CORE LOG

PC No. PILOT No.	STATION	LAT(N)	LONG(W)	DEPTH (m)	LENGTH(m) (P/PP)	SECTIONS
NEAP 1P,1PP	7	61° 12.97'	22° 30.44'	1887	11.50/	5
NEAP 2P,2PP	12	60° 24.69'	24° 08.45'	2174	10.65/0.98	4
NEAP 3P,3PP	14	59° 52.71'	23° 19.70'	2218	9.17/1.13	4
NEAP 4P,4PP	18	58° 56.66'	24° 24.96'	2549		4
NEAP 5P,5PP	20	57° 43.34'	25° 34.03'	2711	9.97/0.95	4
NEAP 6P,6PP	23	54° 41.68'	28° 21.38'	2869	10.75/1.20	5

6. CTD OPERATIONS

a. <u>Temperature and Salinity</u>

Data on salinity, temperature, oxygen and fluorescence were collected from the CTD system. All sensors functioned well throughout the cruise and a minor cabling problem was quickly dealt with by the RVS technicians. A total of 25 CTD casts were made.

On each CTD cast two Niskin bottle water samples were collected; one from the maximum depth and one at 50m. These were subsampled for salinity and will be analysed by RVS during cruise CD-89 (C. German

Principal investigator). SIS digital reversing thermometers were also used with the bottles. These data will be compared to the CTD output. No samples for oxygen were taken. These data are held at Cambridge.

IRH

b. Transmissometry and Nephelometry

Two 0.25m path-length SeaTech transmissometers (RVS Units 080D and 103D) and one Chelsea Instruments Aquatraka Mk II nephelometer were mounted in the frame carrying the CTD and rosette sampler. The transmissometers operate with light of 660 nm wave length and the nephelometer at 430 nm. There is a substantial literature relating to the SeaTech instrument and its performance in nepheloid layers (Bartz et al, 1978, McCave, 1983, Spinrad et al, 1983, Gardner et al, 1985, Bishop, 1986).

The previous problem of a jumpy calibration showing up as a variable clear water minimum which could be well predicted by an accurate reading of the air value before deployment described in reports of Discovery 184 and Darwin 84 cruises (McCave, 1989; Statham, 1994), was not encountered on this occasion. The values of the clear water minimum attenuation coefficient, calculated with the manufacturers air value were consistent and probably very precise. However for at least one instrument they were wrong. Clear sea water at 660 nm has a percent transmission per 0.25m of 91.3%, corresponding to an attenuation coefficient $c_w = 0.364$ according to SeaTech, and c_w is 0.358 according to Bishop (1986). There is a fairly well established calibration converting c to concentration C in µg/l where $C \approx 1200 (c-c_w)$ (Gardner et al, 1985). By this, $c = 0.507$ corresponds to $C \approx 172$ µg/l whereas the clear water concentration should be about 8-12 µg/l (Brewer et al, 1976), given by $c \approx 0.365$ to 0.374 depending on c_w value adopted.

As will be clear from table 6, we had difficulty in obtaining a consistent air value. The data are erratic for both instruments. The values are correlated with $r = 0.78$ suggesting some common response to local environment (fog, spray etc.).

It is possible to get reasonable values for c, but not in a defensible way. For example, on CTD 22 (table 5) the clear water minimum is well defined and low for both 080D and 103D.

Table 5 : Optical data for clear water, CTD 22

Unit	c_{min}	Voltage	Air value(B)	c_{min}(corr)	
080D	0.506	4.409	a. 4.461	0.403)	too
			b. 4.634	0.394)	high
			c. 4.622	0.387	high
103D	0.478	4.437	a. 4.680	0.368	about right
			b. 4.678	0.365)	low
			c. 4.666	0.357)	too low

[In this table c_{min} is obtained using the manufacturers air value (A), i.e. no correction, assuming A = B in $V_{corr} = (A/B)\ (X-Z)$
where X is the measured voltage and Z is the zero offset (Z = 0 for 103D and 0.003V for 080D). Attenuation coefficient $c = 4 \ln (5/V_{corr})$.]
The air values are a, highest, b top two, c top three averaged.

One cannot obtain simultaneously acceptable values for each instrument via the same method, e.g. use of the highest air value measured or average of the top three values. Only if there were an offset of ~0.04 V for unit 103D could its maximum value of c = 0.368 be raised to that of 080D, c = 0.403, which is far higher than reasonable. To bring 080D down to 103D would require an impossible negative offset. The "best" value in the above set is probably c_{min} = 0.368 for 103D obtained from the highest air value. With Bishop's value of c_w = 0.358, this c_{min} is about equivalent to C = 12 μg/l. Thus for this set of deployments, unit 103D with $V_{corr} = 1.027\ V_{meas}$ gives the most accurate transmission data. Unit 080D data cannot be simply aligned with that from 103D by numerical factor.

There is thus a problem of quality control with the optical light transmission data obtained by RVS-operated instruments, and this problem must have affected data taken from 1989 to 1994 at least.

The nephelometer measured scattered light at 90° to the axis of the beam, a relatively insensitive region of the scattered light field.

The wavelength of 430 nm is also not optimal for detection of particles in seawater. Nevertheless the instrument shows satisfactory sensitivity by comparison with the transmissometer, though it should be remembered that it is more sensitive to the smaller particles in the size spectrum (Zaneveld, 1974; McCave, 1986). The clear water minimum values from the nephelometer do not display the same consistency as those from the transmissometer (the correlation of the two sets is 0.08), and there are jump offsets between casts 11 and 12 and 14 and 18 (table 6). These jumps define groups with means of 3.549 ± 0.013, 3.352 ± 0.0.010 and 3.425 ± 0.015. These means provide a way to standardize the data, but the jumpiness of the output is disturbing. As noted by Gardner et al (1985) the transmission minimum occurs at a shallower depth than the scattering minimum, a feature of these casts also. Gardner et al (1985) were not able to determine whether this difference was due to a response to different particle properties or an effect of temperature or pressure on one or both instruments. We used a different nephelometer, but the range of possibilities is still too large for us to eliminate any. Bishop (1985) identified a temperature effect on the SeaTech transmissometer. However on a down cast that gives a higher than true attenuation at shallower depths as the instrument is warmer than surrounding seawater. Only if this effect is even more pronounced for the Aquatracka nephelometer would this provide an explanation. It may do so as the nephelometer minima on deep casts were very deep, just above the obvious bottom nepheloid layer.

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Table 6 : Transmission : air values (volts) and C,Ne minima

CTD cast No.	080D	103D	n	C_{min}*(80D)	Ne_{min}(V)
1	-	-	-	0.624	3.543
2	4.041	4.050	56	0.528	3.559
3	3.966	4.138	33	0.519	3.552
4	4.460	4.602	96	0.510	3.548
5	4.641(1)	4.680(1)	-	0.513	3.552
6	4.627(2)	4.172	117	0.512	3.553
7	3.882	2.890	136	<0.516	3.571
8	4.572	4.611	109	0.508	3.558
9	3.736	3.998	41	0.521(?)	3.538
10	4.376	4.559	445	0.507	3.522
11	4.491	4.608	62	0.510	3.540
12	4.526	4.603	302	0.507	3.343
13	3.702	3.624	173	0.507	3.352
14	4.577	4.643(3)	73	0.507	3.363
18	4.555	4.521	25	0.507	3.441
19	4.420	4.608	233	0.506	3.432
20	4.599(3)	4.676(2)	105	0.505	3.435
21	4.526	4.283	62	0.504	3.403
22	4.424	4.548	34	0.506	3.425
24	4.474	4.598	48	0.508	3.405
25	4.238	4.288	89	0.509	3.432
Mfr.	4.762	4.810	-	-	-

*C is obtained assuming the manufacturers air value for all cases.
c_{min} is the value at the clear-water minimum on the down cast.
The top three values are numberd (1), (2), (3).
(n) gives the number of values averaged to yield the indicated air values.

c. Suspended Sediment Filtration

Water samples were collected to determine the concentration of suspended particulate material gravimetrically and examine the composition of suspended particles using scanning electron microscopy. Sampling was carried out in layers of high optical turbidity and intervening clear waters at a total of 57 depths from 16 CTD stations.

The samples were collected using 10 1 Niskin bottles fired in pairs followed by filtration of their contents under clean conditions, through individual pre-weighed (to 10^{-6}g) 0.4 µm, polycarbonate (Cyclopore) membranes. The membrances were rinsed with 5 washes of 25 ml sub-boiling distilled water to remove sea salt, air dried and stored in sealed polystyrene petri dishes to await laboratory analysis. All critical handling steps were performed within a Class-100 laminar flow hood.

These loaded membranes will be weighed and examined by scanning electron microscopy for particle types at Cambridge. The analytical blank will be estimated from a total of 15 membranes subjected to an identical handling protocol but with no sample filtration.

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Table 7 : FILTRATION LOG

CTD CAST	STA.	FILTER No.	DEPTH(m)	VOLUME FILTERED(1)	COMMENTS
2	2	6	1260	21.00	
2	2	7	1220	20.65	
2	2	9	1150	20.80	
2	2	10	579	20.60	
3	3	8	1485	21.15	
3	3	40	1356	20.70	
3	3	39	1250	21.15	
3	3	38	992	20.70	
4	4	37	1620	20.45	
4	4	36	1390	20.40	
4	4	34	1300	20.00	
4	4	35	1000	10.5?	
5	5	33	1802	10.60	
5	5	32	1784	10.55	
5	5	31	1743	10.45	Damaged filter
5	5	44	1641	21.15	
5	5	43	1162	20.80	
5	5	42	1802	10.25	
7	7	41	1829	10.35	
7	7	45	1790	10.45	
7	7	46	1704	21.15	
7	7	47	1651	20.95	
8	8	48	989	21.25	
8	8	49	2020	21.20	
8	8	50	1868	19.65	
8	8	52	1350	21.20	
10	10	53	2580	10.50	
10	10	54	2541	10.60	
10	10	55	2442	20.95	

CTD CAST	STA.	FILTER No.	DEPTH(m)	VOLUME FILTERED(l)	COMMENTS
11	11	11	1985	21.05	
11	11	12	1850	20.75	
11	11	56	1300	21.20	
12	13	13	2632	21.10	
12	13	14	2536	21.02	
12	13	15	2065	21.00	
14	15	16	2211	20.55	
14	15	17	2109	20.95	
14	15	18	1836	20.85	
16	15	19	2166	20.90	
16	15	20	2048	20.75	
16	15	21	1774	21.20	
16	15	57	1723	20.45	
17	15	30	2396	21.05	Misfired
17	15	61	2198	20.85	Misfired
17	15	62	2000	21.35	
17	15	63	1601	21.25	
18	16	64	2538	10.40	
18	16	65	2438	10.50	
18	16	66	2098	21.15	
18	16	67	1796	21.10	
19	17	59	2486	21.25	
19	17	68	2188	21.10	
20	18	69	2337	20.80	
20	18	70	2236	20.60	
23	21	58	2252	20.35	
23	21	60	2135	21.30	

d. Water Column Chemistry

The objective of this work is to determine the trace metal concentration of near-bottom water at the sites where sediment cores are taken. This will enable us to better understand the relationship between the trace element content of the water and that of the contemporaneous benthic foraminifera (which were sampled using the box corer). It is important to do this as one of the unanswered questions in palaeoceanography is what are the factors controlling the uptake of trace metals into foraminiferal calcite.

Water was collected using 10 litre Go Flo bottles mounted on a CTD/rosette sampler. Upon recovery, unfiltered water samples were taken for salinity and phosphate analysis. The samples for phosphate were immediately frozen. Water was filtered through a 0.4 µm Nuclepore membrane filter for trace metal analysis. The water filtration was done using an enclosed system of silicone rubber tubing, teflon tubing, fittings and filter holders. The filtered water was collected in polypropylene bottles. All the components of the system were precleaned in acid. One litre of filtered seawater was collected from each Go Flo bottle and acidified with HCl (6M, 1ml). At station 24 unfiltered seawater was also acidified for trace metal analysis.

Water was collected from 10m above the sea floor at most stations. Two Go Flo bottles were used to obtain replicates. At station 15 a 15-point water column profile was collected. In this case only one Go Flo was fired at a given depth.

The Go Flo bottles were collected from Southampton University before the cruise and considerable work was done on them before they were loaded onto the ship. They were dismantled and any damaged o-rings and seals were replaced. All parts were cleaned in Decon 90, the Teflon taps were cleaned in HCl (50%) and HNO_3 (10%) and the moving parts were lightly sanded and coated in a Teflon layer. The first CTD cast was used to test the bottles and to rinse them in seawater before use. Despite this work on the bottles only No. 12 would fire from full cock. Nos. 5, 6 and 9 would fire from half cock, but 5 and 6 would not always close properly because the black rubber cord was too perished. No. 23 would not fire at all and the remaining two bottles were in too bad a condition to deploy.

The firing positions and depths of the Go Flo bottles are given in table 8.

CB, SJB, & ACW

Table 8 : Positions and depth of bottles samples for trace metals

CTD CAST	STATION	LAT(N)	LONG(W)	WATER DEPTH(M)	FIRING DEPTH(M)	NO.OF BOTTLES FIRED
1	1	62°40.55'	22°27.04'	1092	50	4(test)
2	2	62°24.00'	23°12.85'	1270	1260	2
3	3	61°50.51'	23°56.41'	1505	1485	2
4	4	61°29.83'	24°10.39'	1627	1620	2
5	5	61°05.20'	24°32.75'	1820	1802	2
7	7	61°13.27'	22°30.17'	1869	1849	2
8	8	60°51.96'	22°40.83'	2033	Test Fire	3
11	11	60°24.80'	23°38.96'	2000	1985	2
12	13	59°44.93'	22°11.40'	2650	2632	2
13	14	59°46.42'	23°53.47'	2360	2400*	2
"	"	"	"	"	50	1(test)
14	15	59°53.09'	23°19.75'	2221	2211	1
"	"	"	"	"	2109	1
"	"	"	"	"	1837	1
"	"	"	"	"	1647	1
15	"	59°53.23'	23°19.46'	2223	1240	1
"	"	"	"	"	1041	1(misfired)
"	"	"	"	"	850	1
"	"	"	"	"	53	1
16	"	59°53.09'	23°19.67'	2223	446	1
"	"	"	"	"	250	1
"	"	"	"	"	152	1
"	"	"	"	"	23	1
17	"	59°52.48'	23°18.13'	2223	1445	1
"	"	"	"	"	1194	1
"	"	"	"	"	449	1
"	"	"	"	"	253	1
18	16	59°46.68'	22°38.03'	2477	2465	2
19	17	58°38.07'	24°00.01'	2789	2771	2
20	18	58°56.50'	24°24.26'	2546	2538	2
21	19	57°31.74'	24°45.71'	2810	2787	2
22	20	57°41.84'	25°38.04'	2713	2680	2
23	21	56°22.11'	27°48.67'	2847	CTD Failed	
24	23	54°41.84'	28°21.43'	2866	2847	2
25	24	52°46.81'	30°18.75'	3270	3425*	2

*wire angle excessive.

7. PLANKTON SAMPLING

Surface water plankton samples were collected during the cruise using two techniques: (i) plankton tows and (ii) filtering pump samples (Table 9).

Plankton tow samples were obtained from oblique tows between 0 and 100 metres depth using a nylon plankton net with a 80 cm diameter mouth opening and 200 µm mesh aperture. The plankton nets were deployed and the samples collected with the ship underway at a towing speed of 1 to 2 knots.

Surface water pumped through the "non-toxic" supply was filtered using a 100 µm mesh plankton net whilst the research vessel was moving between coring stations. These filtered samples collect plankton from near surface water (6m depth). During recovery the samples were examined using a light microscope in order to quantify the amount of collected material. The duration of sampling was adjusted in light of this in order that sufficient material was present to provide a valuable data set. Plankton tow and pumped samples were preserved in a buffered formalin solution (5%). Samples are held by Dr M.R. Chapman in Cambridge.

MRC

Table 9 : PLANKTON SAMPLING LOG

Plankton Tows	Julian Day	Start	Start Position	End	End Position
NEAP 1PT	208	01.55	61°49.85'N 23°57.89'W	02.45	61°49.70'N 23°59.10'W
" 2PT	212	17.37	60°22.97'N 23°40.80'W	18.15	61°22.54'N 23°41.96'W
" 3PT	221	23.07	54°41.11'N 28°21.56'W	23.54	54°41.12'N 28°19.87'W
" 4PT	223	07.11	52°46.96'N 30°18.25'W	08.05	52°46.98'N 30°16.61'W
Pump Samples					
NEAP 1PS	210	20.20	61°12.18'N 22°28.96'W	20.13	60°22.05'N 22°45.87'W
" 2PS	215	18.36	59°32.59'N 23°05.73'W	09.41	58°37.76'N 23°59.68'W
" 3PS	217	08.02	58°55.43'N 24°58.58'W	20.20	57°33.12'N 24°42.83'W
" 4PS	219	12.13	57°31.07'N 27°45.17'W	02.42	56°21.98'N 27°48.64'W
" 5PS	220	20.50	56°06.18'N 27°19.67'W	08.32	54°41.91'N 28°21.39'W
" 6PS	222	00.31	54°36.21'N 28°24.84'W	20.51	52°45.89'N 30°20.72'W
" 7PS	223	09.12	52°46.98'N 30°16.61'W	18.24	50°53.14'N 29°57.99'W
" 8PS	223	18.42	50°49.59'N 29°57.58'W	09.28	48°22.82'N 27°55.21'W
" 9PS	224	09.51	48°18.78'N 27°53.30'W	17.14	47°04.11'N 27°29.93'W
" 10PS	224	17.30	47°01.40'N 27°29.94'W	04.03	45°19.22'N 27°59.10'W
" 11PS	225	04.18	45°18.41'N 27°59.61'W	12.35	44°17.59'N 28°30.98'W
" 12PS	225	12.51	44°14.88'N 28°32.36'W	23.58	42°31.54'N 28°24.70'W
" 13PS	226	00.17	42°29.25'N 28°24.97'W	10.47	41°04.60'N 27°40.59'W
" 14PS	226	11.10	41°02.28'N 27°39.52'W	00.19	38°42.27'N 26°32.02'W

8. EQUIPMENT PROBLEMS

In general most of the equipment from RVS and Cambridge functioned well enabling significant collection of data. Items mentioned here are also to be found in the individual discussions of previous sections.

(i) We were unable to obtain plankton tows from specific depths because the requested pneumatic wire depressor was not loaded in Barry.

(ii) After additional lead has been inserted the core head still weighed only 1.5 tonnes rather than the 2 tonnes requested. As a result the new 20 cm square barrel would not penetrate more than 7m.

(iii) Other countries are able to take wide-diameter (~10 cm i.d.) piston cores of 15 to 18m length (not using giant piston core technology), whereas we are stuck on a maximum of about 11m narrow bore (~6.5 cm i.d.) cores (even with 15m of barrel mounted). I suggest technical consultation with our colleagues in Germany, Holland and USA and, for giant piston coring, Prof. Lancelot in France.

(iv) The Cambridge 20 cm kasten corer needs to be of heavier gauge steel, and the connectors should be more robustly attached to the barrel and fitted with neoprene seals.

(v) Occasional misfires of the upper doors on the box-corer have always been a problem with this design, but the frequency has been small enough that it is not a serious problem.

(vi) The torn film which resulted in the motor running continuously nearly ended the bottom photography programme on the second deployment. A circuit that would prevent the motor running for more than say a minute would prevent this sort of damage.

(vii) Transmissometer unit 080D cannot be made to yield reasonable attentuation coefficients for clear water save by using air voltages significantly less than the highest values measured. RVS practice should include a standing order to clean transmissometer windows and measure air values prior to all deployments. Use of these predeployment constants should be standard in computation of the attentuation coefficient by the RVS staff logging the CTD data. Quality control can then be exerted by inspection of the clear water minimum value. Away from continental margin settings this should be less than about 0.370.

(viii)The degradation of the 3.5 kHz records at speeds over 8 knots on *Darwin* is a problem thought to be ship-related rather than due to tow-fish design because problems are (or were before rebuilding) much less severe on *Discovery*. An investigation by RVS technical staff and brief report for Principal Scientists will allow better planning of cruises and scheduling of ship speeds during survey work.

These comments are offered in a constructive spirit with the hope that operations that are generally safe, efficient and yield good results can be further improved.

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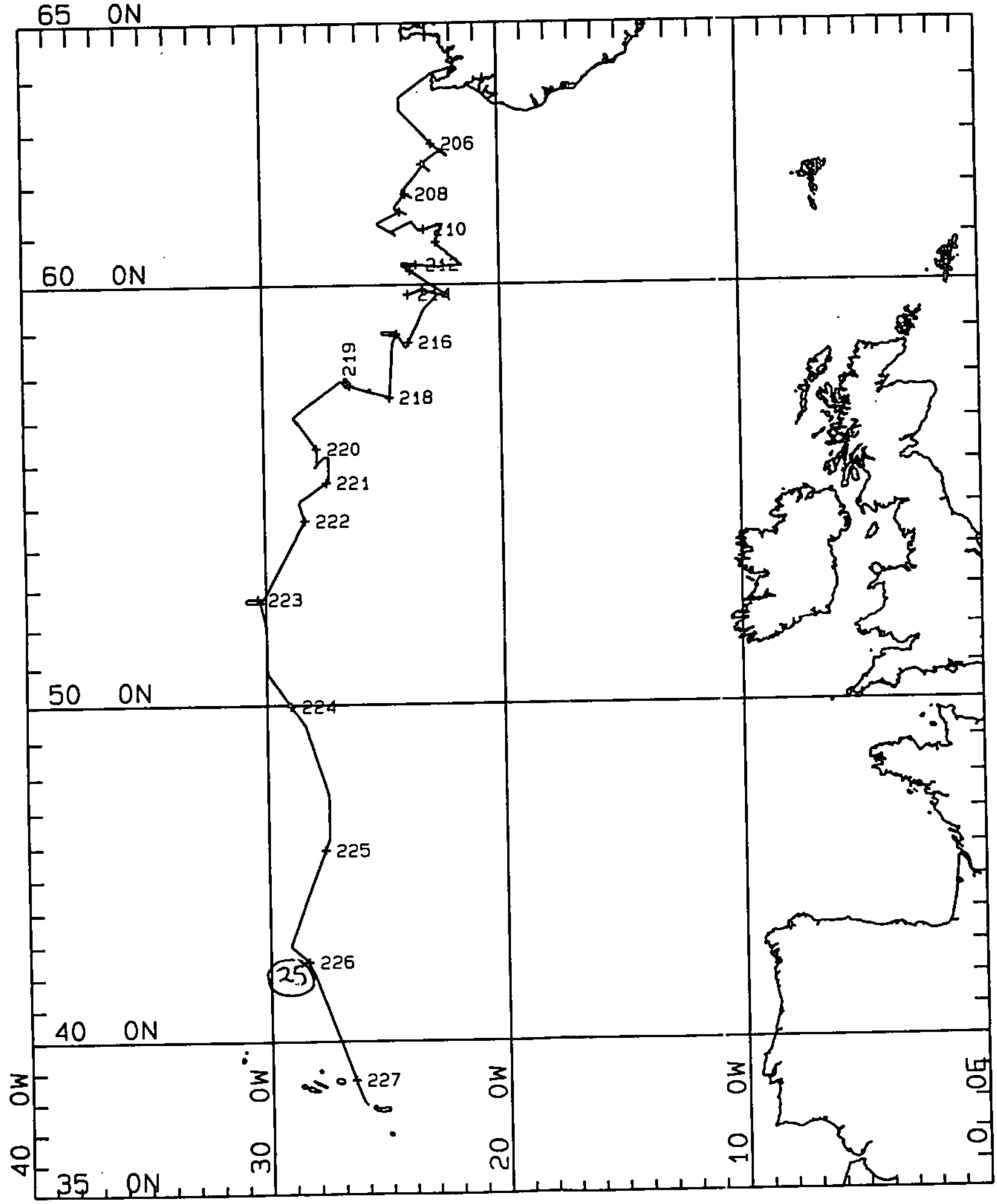


MERCATOR PROJECTION

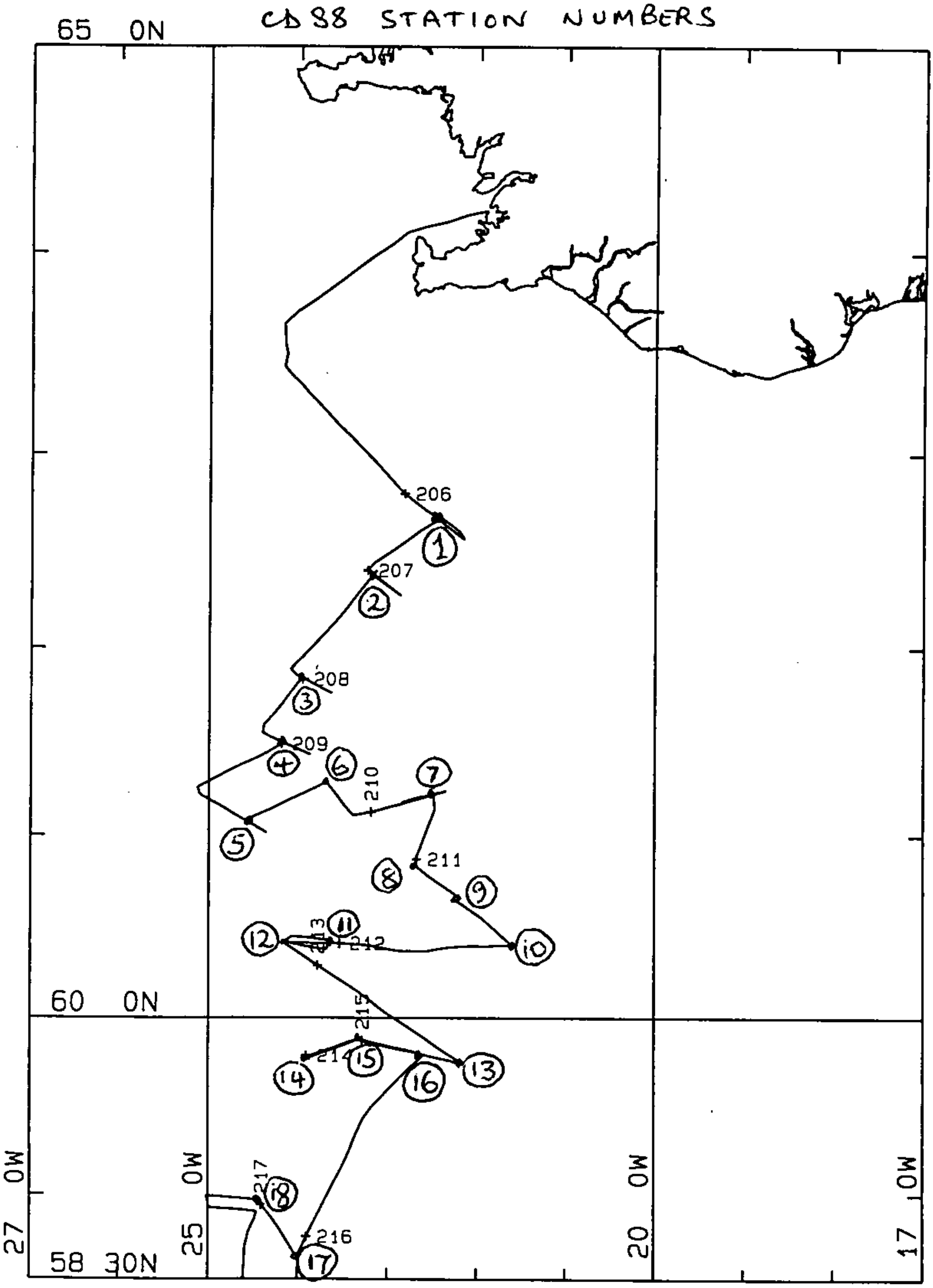
GRID NO. 1

SCALE 1 TO 17500000 (NATURAL SCALE AT LAT. 50)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin 88

CD 88 STATION NUMBERS



MERCATOR PROJECTION

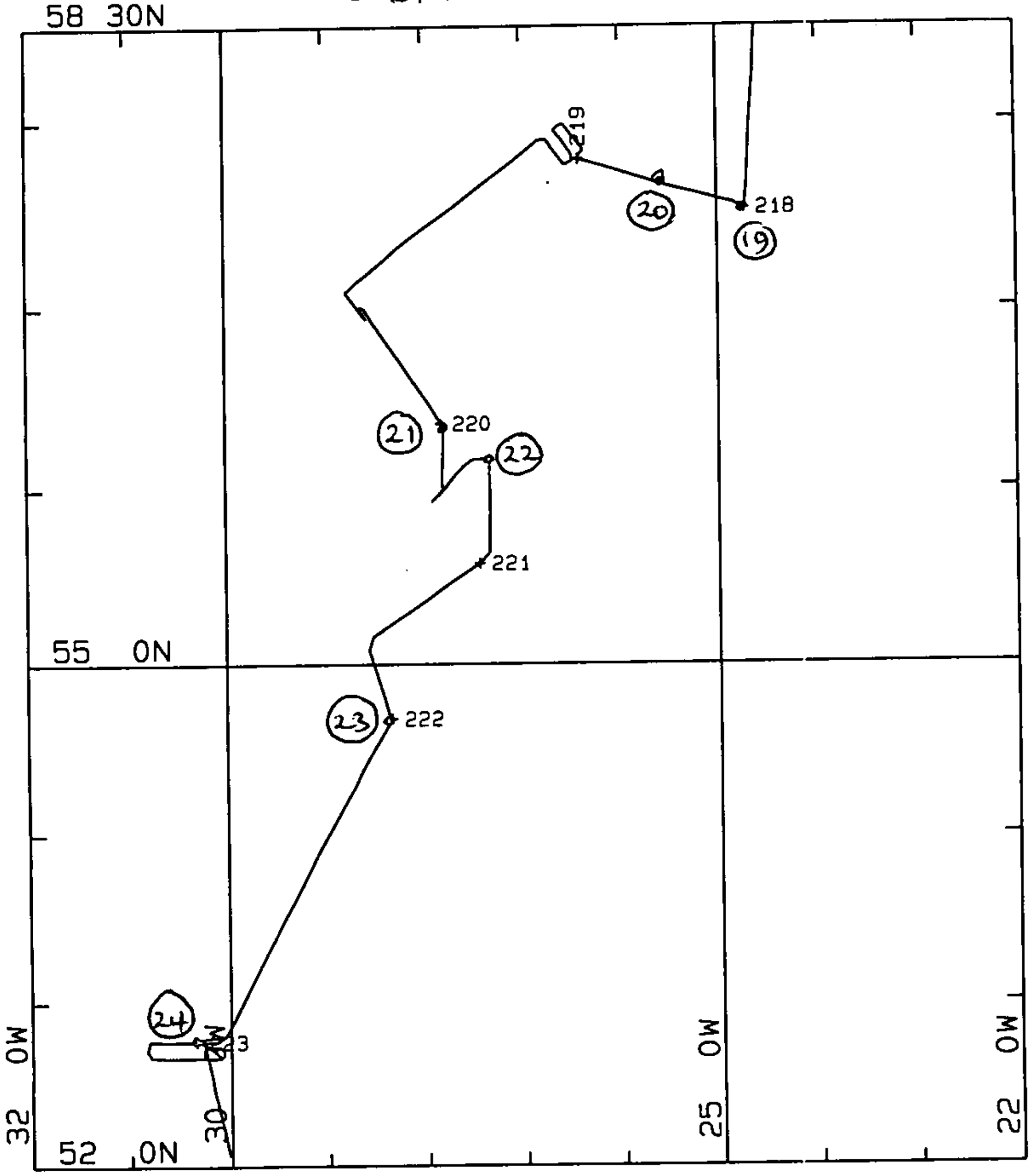
SCALE 1 TO 4000000 (NATURAL SCALE AT LAT. 58)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO. 1

RRS Charles Darwin 88 - Northern Area

CD88 STATION NOS.



MERCATOR PROJECTION

GRID NO. 1

SCALE 1 TO 4000000 (NATURAL SCALE AT LAT. 58)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin 88 - Southern Area

R.R.S. CHARLES DARWIN CRUISE 88 - STATION LOG

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /1	CTD 1	CTD	206	25/7	08.32*	62° 40.55'	22° 27.04'	1092	
	Cam 1	Camera	"	"	11.40*	62° 40.44'	22° 27.15'	1092	
	NEAP 1B	Box Core	"	"	13.50*	62° 40.80'	22° 27.15'	1092	
	NEAP 1K	Kasten-20	"	"	17.06*	62° 41.11'	22° 27.06'	1092	bent barrel. (2 sect, one lost)
CD88 /2	CTD 2	CTD	207	26/7	04.30	62° 24.00'	23° 12.85'	1270	
	Cam 2	Camera	"	"	07.45	62° 23.50'	23° 12.00'	1270	
	NEAP 2B	Box Core	"	"	09.57	62° 23.76'	23° 12.00'	1268	
	NEAP 2K	Kasten-15	"	"	11.47	62° 23.71'	23° 11.23'	1265	4 m barrel.
CD88 /3	CTD 3	CTD	207	26/7	21.30	61° 50.51'	23° 56.41'	1505	
	Cam 3	Camera	208	27/7	00.25	61° 50.00'	23° 57.62'	1512	
	NEAP 1PT	Plankton tow	"	"	01.55-02.45	61° 49.85'	23° 57.89'	-	
	NEAP 3B	Box Core	"	"	06.38	61° 52.10'	23° 56.48'	1502	
	NEAP 3K	Kasten-15	"	"	09.18	62° 50.41'	23° 57.42'	1510	

Times and positions are : for CTD when it is deployed; for Camera at first bottom bounce; and for cores at the impact on the bottom. -20 and -15 signify 20 and 15cm square Kasten barrels.

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /4	NEAP 4B	Box Core	208	27/7	17.04	61° 21.98'	24° 10.27'	1627	
	NEAP 4K	Kasten-15	"	"	18.32	61° 29.91'	24° 10.33'	1627	7 m barrel.
	CTD 4	CTD	"	"	20.07	61° 29.83'	24° 10.39'	1627	
	Cam 4	Camera	"	"	22.42	61° 29.88'	24° 10.00'	1627	
CD88 /5	NEAP 5B	Box Core	209	28/7	09.10	61° 04.50'	24° 31.76'	1826	
	NEAP 5K	Kasten-15	"	"	11.00	61° 04.22'	24° 31.87'	1826	7 m barrel.
	Cam 5	Camera	"	"	14.08	61° 05.90'	24° 32.32'	1818	
	CTD 5	CTD	"	"	15.37	61° 05.20'	24° 32.75'	1820	
CD88 /6	CTD 6	CTD	209	28/7	20.10 ?	61° 17.40'	23° 41.20'	1849	
CD88 /7	CTD 7	CTD	210	29/7	07.10	61° 13.27'	22° 30.17'	1869	
	NEAP 1P	Piston Core	"	"	13.00	61° 12.97'	22° 30.44'	1869	5 sections
	Cam 6	Camera	"	"	15.52	61° 13.17'	22° 32.12'	1868	
	NEAP 6B	Box Core	"	"	18.22	61° 13.03'	22° 29.42'	1866	
CD88 /8	CTD 8	CTD	211	30/7	00.19	60° 51.96'	22° 40.83'	2033	
CD88 /9	CTD 9	CTD	211	30/7	04,36	60° 39.68'	22° 12.53'	2300	

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /10	CTD 10	CTD	211	30/7	09.05	60° 23.63'	21° 35.50'	2601	
CD88 /11	CTD 11	CTD	212	31/7	05.48	60° 24.80'	23° 38.96'	2000	
	NEAP 7B	Box Core	"	"	08.51	60° 24.84'	23° 38.68'	1997	
	Cam 7	Camera	"	"	10/54	60° 24.55'	23° 39.18'	1997	
	NEAP 6K	Kasten-20	"	"	15.17	60° 23.37'	23° 40.99'	2006	9 m barrel.
	NEAP 2PT	Plankton Tow	"	"	17.37- 18.15	60° 22.97' 60° 22.54'	23° 40.80' 23° 41.96'	- -	
CD88 /12	NEAP 2P	Piston Core	212	31/7	21.38	60° 24.69'	24° 08.46'	2174	
CD88 /13	CTD 12	CTD	213	1/8	06.24	59° 44.93'	22° 11.40'	2650	
	NEAP 8B	Box Core	"	"	09.52	59° 44.50'	22° 11.95'	2649	
	NEAP 7K	Kasten-15	"	"	12.13	59° 44.84'	22° 12.00'	2651	
	Cam 8	Camera	"	"	14.43	59° 44.73'	22° 13.36'	2650	
CD88 /14	NEAP 8K	Kasten-15	214	2/8	00.07	59° 47.37'	23° 54.11'	2360	
	NEAP 9B	Box Core	"	"	02.43	59° 46.96'	23° 53.40'	2361	
	CTD 13	CTD	"	"	04.05	59° 46.42'	23° 53.47'	2364	
	Cam 9	Camera	"	"	07.43	59° 46.49'	23° 53.61'	2360	

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /15	CTD 14	CTD	214	2/8	11.00	59° 53.09'	23° 19.75'	2221	
	NEAP 10B	Box Core	"	"	13.54	59° 53.55'	23° 19.19'	2221	
	NEAP 9K	Kasten-15	"	"	15.57	59° 53.19'	23° 19.81'	2222	
	CTD 15	CTD	"	"	17.37	59° 53.23'	23° 19.46'	2223	
	CTD 16	CTD	"	"	19.46	59° 53.09'	23° 19.67'	2223	shallow cast
	NEAP 3P	Piston Core	"	"	21.26	59° 52.71'	23° 19.70'	2218	
	CTD 17	CTD	"	"	22.42	59° 52.48'	23° 18.13'	-	to 1450 m
	Cam 10	Camera	215	3/8	01.25	59° 52.17'	23° 16.32'	2219	
CD88 /16	NEAP 11B	Box Core	215	3/8	09.30	59° 47.49'	22° 39.24'	2484	
	NEAP 10K	Kasten-15	"	"	11.36	59° 46.93'	22° 38.26'	2481	
	CTD 18	CTD	"	"	12.31	59° 46.68'	22° 38.03'	2477	
	Cam 11	Camera	"	"	15.30	59° 46.64'	22° 38.11'	2482	
CD88 /17	CTD19	CTD	216	4/8	01.05	58° 38.07'	24° 00.01'	2789	
	NEAP 12B	Box Core	"	"	04.31	58° 38.36'	23° 59.63'	2786	
	NEAP 11K	Kasten-15	"	"	06.33	58° 37.82'	23° 59.87'	2789	
	Cam 12	Camera	"	"	09.08	58° 37.82'	23° 59.70'	2790	

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /18	CTD 20	CTD	216	4/8	13.16	58° 56.50'	24° 24.26'	2546	
	Cam 13	Camera	"	"	16.57	58° 56.78'	24° 23.85'	2547	
		Sound Vel.	"	"	18.37	58° 56.29'	24° 24.02'	2547	
	NEAP 13B	Box Core	"	"	21.05	58° 56.41'	24° 24.02'	2546	
	NEAP 12K	Kasten-20	"	"	23.07	58° 56.31'	24° 24.31'	2546	9 m barrel.
	NEAP 4P	Piston Core	217	5/8	04.00	58° 56.66'	24° 24.96'	2549	
CD88 /19	Cam 14	Camera	217	5/8	20.04	57° 33.14'	24° 42.81'	2815	
	NEAP 14B	Box Core	"	"	23.25	57° 32.18'	24° 43.22'	2820	
	NEAP 13K	Kasten-15	218	6/8	01.42	57° 31.71'	24° 44.85'	2817	
	CTD 21	CTD	"	"	02.56	57° 31.74'	24° 45.71'	2810	
CD88 /20	NEAP 15B	Box Core	218	6/8	09.25	57° 40.53'	25° 38.43'	2703	
	NEAP 14K	Kasten-15	"	"	11.29	57° 41.15'	25° 38.87'	2712	
	CTD 22	CTD	"	"	13.11	57° 41.84'	25° 38.04'	2713	
	NEAP 5P	Piston Core	"	"	17.37	57° 43.34'	25° 34.02'	2711	
CD88 /21	NEAP 16B	Box Core	219	7/8	00.50	56° 21.99'	27° 49.00'	2847	
	NEAP 15K	Kasten-15	"	"	03.13	56° 21.92'	27° 48.68'	2848	

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /21	CTD 23	CTD	219	7/8	04.35	56° 22.11'	27° 48.67'	2847	abandoned @ 1200 m
	Cam 15	Camera	"	"	07.26	56° 22.49'	27° 48.61'	2843	
CD88 /22	NEAP 16K	Kasten-15	220	8/8	14.25	56° 10.15'	27° 20.20'	2736	
	NEAP 17B	Box Core	"	"	18.10	56° 10.15'	27° 20.53'	2734	
CD88 /23	CTD 24	CTD	221	9/8	08.03	54° 41.84'	28° 21.43'	2866	
	NEAP 18B	Box Core	"	"	11.46	54° 41.56'	28° 21.02'	2879	
	NEAP 17K	Kasten-20	"	"	14.20	54° 41.40'	28° 21.20'	2880	9 m barrel.
	Cam 16	Camera	"	"	17.59	54° 42.12'	28° 21.67'	2872	
	NEAP 6P	Piston Core	"	"	21.16	54° 41.68'	28° 21.38'	2869	5 section.top empty.
	NEAP 3PT	Plankton Tow	"	"	23-07- 23.54	54° 41.11'- 54° 41.12'	28° 21.56'- 28° 19.87'	-	
CD88 /24	NEAP 19B	Box Core	222	10/8	21.52	52° 45.91'	30° 20.66'	3283	
	NEAP 18K	Kasten-15	223	11/8	00.17	52° 46.02'	30° 20.68'	3275	
	Cam 17	Camera	"	"	03.16	52° 46.34'	30° 19.80'	3299	
	CTD 25	CTD	"	"	04.56	52° 46.81'	30° 18.75'	3270	
	NEAP 4PT	Plankton Tow	"	"	07.11- 08.05	52° 46.96' 52° 46.98'	30° 18.25' 30° 16.61'	-	

Station No./	CTD/ Core No	Instrument /Operation	Day	Date	Time(Z)	Latitude(N)	Longitude(W)	Depth(m) (uncorr)	Remarks
CD88 /25	NEAP 20B	Box Core	226	14/8	01.25	42° 29.31'	28° 24.87'	2878	