INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

CRUISE REPORT NO. 242

RRS *DISCOVERY* CRUISE 204
24 SEP - 06 NOV 1993

Comparative benthic biology at 21°N 31°W, photobiology and plankton distribution in the tropical eastern Atlantic Ocean

Principal Scientists
A L Rice & P J Herring

1994

DOCUMENT DATA SHEET

AUTHOR
RICE, A L & HERRING, P J et al

PUBLICATION DATE 1994

TITLE

RRS *Discovery* Cruise 204, 24 Sep-06 Nov 1993. Comparative benthic biology at 21°N 31°W, photobiology and plankton distribution in the tropical eastern Atlantic Ocean.

REFERENCE

Institute of Oceanographic Sciences Deacon Laboratory, Cruise Report, No. 242, 71pp.

ABSTRACT

Discovery Cruise 204 had three main objectives. The first was to conduct a detailed study of the benthos at the oligotrophic station of the French EUMELI Programme at 21°N 31°W for comparison with French studies at the same locality, and sites at 48°50'N 16°30'W and 31°N 21°W sampled on previous *Discovery and Challenger* cruises.

The second objective was the study of the photobiology of midwater organisms, particularly amphipods, decapods and fish, in terms of bioluminescence, behaviour and anatomy.

The third objective was an analysis of the distribution of macrozooplankton using Acoustic Doppler Current Profiler recordings and Longhurst-Hardy Plankton Recorder samples.

The main sampling programmes involved the use of the multiple corer for bacteria and meiofaunal sampling and for sediment chemistry, the spade box corer for macrofaunal abundance, the epibenthic sledge for macrofaunal and megafaunal abundances and the otter trawl for fish and other megafaunal studies. Pop-up camera systems were used for surface activity and scavenger activity, CTD and rosette sampler for water column bacteria, midwater trawls for material for photobiological studies, and Acoustic Doppler Current Profiler and Longhurst-Hardy Plankton Recorder for macroplankton studies.

KEYWORDS

ACOUSTIC DOPPLER CURRENT PROFILER, ADCP, ATLTE, BACTERIA, BAITED CAMERAS, BENTHOS, BIOGEOCHEMISTRY, BIOLUMINESCENCE, BIRDS, BOX CORER, DEMERSAL FISH, *"DISCOVERY"*/RRS - CRUISE(1993)(204), EPIBENTHIC SLEDGE, EYE ANATOMY, MACROFAUNA, MADEIRA ABYSSAL PLAIN, MEGAFAUNA, MEIOFAUNA, MESOPELAGIC FAUNA, MIDWATER TRAWL, MOLECULAR BIOLOGY, MULTICORER, NECROPHAGES, ORNITHOLOGY, OTTER TRAWL, PHOTOBIOLOGY, TROPICAL EAST ATLANTIC

ISSUING ORGANISATION

Institute of Oceanographic Sciences
Deacon Laboratory
Wormley, Godalming
Surrey GU8 5UB. UK.

Director: Colin Summerhayes DSc

Telephone Wormley (0428) 684141
Telex 858833 OCEANS G.
Facsimile (0428) 683066

Copies of this report are available from: **The Library,** *PRICE* £16.00

CONTENTS

SCIENTIFIC PERSONNEL

		Leg 1	Leg 2
RICE, Anthony L. (Principal Scientist)	IOSDL	+	
ANGEL, Martin V.	IOSDL	+	+
BEGHYN, Myriam	Univ Gent, Belgium	+	
BETT, Brian J.	IOSDL	+	
BOARDMAN, Danny	Univ Liverpool	+	
BOORMAN, Benjamin	IOSDL	+	+
BROOKS, Jeremy (Jez)	Univ Southampton	+	
COLLIN, Shaun P.	Univ Western Australia		+
DEBENHAM, Niki	Nat Hist Mus London	+	
DOUGLAS, Ronald H.	City Univ, London		+
EARDLEY, Donal	Univ Coll, Galway	+	
EDGE, David	IOSDL	+	+
GALERON, Joëlle,	IFREMER, Brest	+	
GOODAY, Andrew J.	IOSDL	+	
GRIFFIN, Nigel J.	IOSDL	+	
HARTMAN, Mark	IOSDL		+
HERRING, Peter J. (PS Leg 2)	IOSDL	+	+
HORSFALL, Ian	Univ Liverpool	+	
JOHNSON, Magnus L.	Univ Leicester	+	+
JORDAN, Stirling	RVS	+	+
KENT, Jeremy (Jez)	Univ Bristol		+
LEWIS, Derek	RVS	+	+
MARSHALL, N. Justin	Univ Sussex		+
MASON, Peter J.	RVS	+	+
MERRETT, Nigel R.	Nat Hist Mus London	+	
PARTRIDGE, Julian C.	Univ Bristol		+
PATCHING, John W.	Univ Coll, Galway	+	
PHILLIPS, Gregory R.J.	IOSDL	+	
RIPLEY, Mark	Univ Plymouth	+	
ROBERTS, Rhys	RVS	+	+
ROE, Howard S.J.	IOSDL		+
ROGERS, Alex	MBA, Plymouth		+
SCHEIBE, Stephan	Univ Hamburg, Germany	+	
SHELTON, Peter M.J.	Univ Leicester		+

THOMSON, Catherine M.	Univ Cardiff	+	+
THURSTON, Michael H.	IOSDL	+	
WALLACE Robert (Bob) F.	IOSDL	+	+
WATKINS, N. John	Univ Cardiff		+
WIDDER, Edith A.	Harbor Branch Ocean. Inst.		+

SHIP'S PERSONNEL

HARDING, M.	Master
LOUCH, A.	Mate
SYKES, S.	Second Mate
WARNER, R.	Second Mate
STEWART, D.	Radio Officer
MOSS, S.	Chief Engineer
HOLT, M.	Second Engineer
DEAN, S.	Third Engineer
JOHN, C.	Third Engineer
SLATER, I.	Trainee Engineer
TREVASKIS, M.	Bosun
LEWIS, G.	Bosun's mate
CRABB, G.	Seaman
DEAN, P.	Seaman
DICKINSON, R.	Seaman
LUCKHURST, K.	Seaman
MILLER, J.	Seaman
STAITE, E.	Catering Manager
EDWARDS, J.	Chef
MYERS, P.	Messman Steward
STEPHEN, M.	Steward
MURPHY, R.	Steward

ITINERARY

Leg 1: Depart Las Palmas, Canary Is, Friday 24 September 1993

Arrive Dakar, Senegal, Wednesday 20 October 1993

Leg 2: Depart Dakar, Senegal, Wednesday 20 October 1993

Arrive Dakar, Senegal, Tuesday 2 November 1993

Depart Dakar, Senegal, Tuesday 2 November 1993

Arrive Las Palmas, Canary Is., Saturday 6 November 1993.

OBJECTIVES

1. To obtain a suite of benthic samples and data from the oligotrophic site of the French EUMELI programme (at 21°N 31°W) for comparison with similar data from the Porcupine Abyssal Plain and the Madeira Abyssal Plain sites of the IOSDL DEEPSEAS programme (see cruise reports for *Discovery* 185 and 194 and *Challenger* 79).
2. To study the photobiology of the midwater fauna.
3. To analyse the distribution of the macrozooplankton using a combination of Acoustic Doppler Current Profiler (ADCP) recordings correlated with Longhurst-Hardy Plankton Recorder (LHPR) samples in an area expected to have a high pelagic biomass resulting from the high productivity of the Mauritanian coastal upwelling (see cruise report for *Discovery* 195).

NARRATIVE

Leg 1

The logistic chaos resulting from problems during the earlier refit in Falmouth continued to the bitter end. Because of the delay the trials cruise was rescheduled to work off the Canary Islands. On the evening before the joining scientific party were due to leave England, we learned that there was every possibility that the Spanish authorities would not allow the ship into Las Palmas because she had used up her permission to enter the port by a short visit some two days previously. Consequently, it was not until the group reached Madrid that the eventual presence of *Discovery* in Las Palmas was confirmed. Ultimately, the ship sailed from Las Palmas at 2300 GMT on Friday 24 September, 6.5 days later than planned.

The ship reached the intended work site, mainly within 3-4 n.m. of 21°3.0'N 31°11.0'W, by mid-morning on Tuesday 28. The passage had been uneventful except for a number of disconcerting discoveries. These included the apparent absence of more or less essential equipment or materials. Some of these, such as the release jaws for the RMT system, were our own fault, the jaws having been forgotten and left behind at IOSDL. Others, such as the Bathysnap weights, had been placed incorrectly in the ship's open top container

when our equipment was loaded during the confusion at Falmouth; fortunately, these weights were located and, with some difficulty, retrieved. Of much greater concern, however, was the news that a number of problems with the main winch had been identified during the trials which had taken place just 48 hours prior to our arrival at Las Palmas. These problems, and others which came to light during the cruise, were to dominate proceedings over the subsequent three weeks and, at one stage, even threatened the continuation of the cruise.

The most serious winch problem initially appeared to be the inability of the system to pay out with a load of less than about 0.8 tonnes. In view of the relative lightness of some of our over-the-side gear, and the frequent need to pay out loose wire, this would clearly be a show-stopping difficulty unless solved. An RMT trial on 26 September proved to be impossible and had to be abandoned. Accordingly, during the passage to the work area the RVS technicians addressed this problem and produced a temporary solution in the form of a wire grommet linking together all the wheels of the winch 'cobra'. The first grommet eventually stretched to the point that insufficient tension could be maintained on it and a second grommet had to be fitted. Otherwise this solution worked relatively well throughout the leg.

This problem probably would not have arisen if the cable haulers had worked properly. These consist of sets of four pairs of small diameter wheels which can be clamped onto the wire outboard of the cobra to provide the necessary tension. Two sets were fitted. Those on the CTD wire worked satisfactorily and were left in position throughout the leg. Those on the main wire, however, were initially very inefficient, caused damage to the wire and probably contributed to other winch/wire problems experienced during the cruise. Furthermore, since only one set was provided for the main warp, they had to be repositioned every time activities were switched between the stern A-frame (trawling) and the starboard gantry (coring).

A potentially even more serious problem for this cruise did not come to light for several days. This was the excessive wear, and in one case the consequent fracture, of the scroll followers on the main winch scrolling gears. Four identical followers, three on the main winch and one on the CTD winch, were fitted, with no spares since they were expected to last the life of the winch. The first, fitted to the towing cable scrolling gear, fractured after five days of use. Two of the others were subsequently transferred to this scrolling gear and wore very rapidly. Leaving the CTD winch follower for emergencies, the fitted followers would certainly not have lasted the whole of the leg and would have caused its premature termination. Fortunately, however, the technicians were able to use the aluminium-bronze end cap of an IOSDL pressure vessel to make a replacement follower which wore much less that those originally provided and which lasted, with no problems, until the end of the leg.

A blow by blow chronological account of the proceedings of the cruise would be inappropriate since all the work was carried out in the same general area and was considered to represent a single station. Instead, the remainder of the narrative will consist of three parts dealing, respectively, with the site, the work schedule and a brief chronology of the main events during the cruise, including crises and disasters.

The site

We were extremely fortunate in having access to an excellent bathymetric chart of the work area based on IFREMER Seabeam data and brought to the cruise by Joëlle Galeron; without it, we would have had to spend so much time echosounding that the sampling programme would have been seriously curtailed. The bathymetry of the region (see Fig. 3) is fairly complex, consisting of a series of undulations trending roughly 025°-205°, with ridges rising up to about 4480m and about 4 n.m. apart, alternating with depressions down to 4620m or more deep. To the northeast and southwest there are a number of abyssal hills rising 400m or more above the general level of the sea-bed. The coring operations were undertaken mainly in one of the depressions centred around 21°03' 13°10'W. Fortunately, the weather was consistently good with winds ranging from 10 to 25 kts from the northeast sector, allowing towed gears (trawls and sledges) to be fished more or less parallel to the contours.

The work schedule

The general plan was to carry out vertical wire work (multiple cores, box cores and CTDs) and free-fall deployments (Bathysnaps, Bathysnacks and traps) during the day, and the longer towed hauls (OTSBs and sledges) during the night, with RMTs in the first hours of darkness every other day. Although this routine worked fairly well, it could not be adhered to totally, partly because of the various crises that overtook us (see below) but also because of the chronic problem of maximum winch speed. Initially this was limited to no more than about 40m/min and was increased to 60m/min only in the later stages of the work period. This meant that all over-the-side activities took considerably longer than expected, cores taking about 4 hours rather than 3 and OTSBs as much as 16 rather than 12 hours. Furthermore, even with the no-load pay out solution in place and more or less working, the deck work was greatly prolonged, on one occasion, for instance, taking 25 minutes to pay out enough wire on deck to begin the deployment of the OTSB.

Nevertheless, despite these problems, the minimal sampling programme was achieved (see station list), including 13 successful multiple cores, 10 box cores, 6 OTSBs, 6 epibenthic sledges (4 coarse and 2 fine), 4 WASP runs, 6 CTDs, 11 RMTs, 2 short-term Bathysnack deployments, 3 DEMAR amphipod trap deployments and, finally, a long-term Bathysnap deployment for later recovery. The only major failures were the loss of one Bathysnap rig which failed to return, probably due to a failure of the mechanical jaws to release, and VET amphipod trap rig on which the Oceano jaws apparently failed to operate.

Chronology of 'major events'

24 September. 1200 join ship. Learn of problem with main winch. CT room door missing. 2300 sail Las Palmas.

25 September. 1000 CT room door found in hold and fitted.

26 September. 1000 RMT release gear and bathysnap weights apparently missing. Release gears turn up at IOSDL; will be sent to Dakar for leg 2.

1500 Bathysnap weights located in RVS container on inaccessible aft container pad with rubber boat on lid. Retrieved with considerable difficulty.

1900 Try RMT to test winch system. Fail, test aborted.

27 September. 0900 problem with OTSB winches fitted to after deck; not large enough to take sweeps and shackles; have to rearrange on deck.

1600 rope grommet on winch cobra works partially.

1700 longer rope under tension works better; will be replaced by wire.

28 September. 1000 arrive on station but winch not ready. Echo-sound.

1400 winch trial with RMT to test wire grommet now fitted. Works O.K. but wire jumps off main sheave when manoeuvring A-frame; lifted back with crane.

2310 first multiple corer outboard; winch works well, but slow; haul takes 4h15m!

29 September. 0900 Bathysnap buoyancy test. Frame damaged as it is retrieved over stern.

1600-1730 mended Bathysnap deployed.

1815 box core deployed but aborted at 1920 because of back tension problem on winch. Relaunch at 2125 after loss of 3 hours.

30 September. 1030 attempts to retrieve Bathysnack fail.

1 October. 0012 OTSB being deployed with 4500mwo. Second mate notices wire not running through diverter sheaves correctly. Has jumped out, wrapped itself around metal walkway and base of starboard gantry and has cut through considerable metal. Stoppered off (only one stopper on board) and recovered by 0115.

2 October. 0840 box corer pull-out exceeds SWL for wire! Excellent sample.

1845 on position to shoot epibenthic sledge, but problem with winch. Eventually shoot at 2100.

3 October. 1245 box corer being retrieved, 2200mwo, winch problem. Scroll-follower has sheared after 5 days of use. Corer held suspended for 2h 20m while faulty piece replaced with one of only three replacements on board.

1500 learn that CTD sheave bearings are badly worn and not accessible for on board maintenance.

4 October. 1500 about to launch box corer. Cable hauler will not pay out wire; roller worn out after 6 days. Check on replacement scroll follower reveals wear of 0.2mm on each of first two vertical deployments; with only about 20mm of dispensable material, does not augur well! 2h 45m delay.

5 October. Relatively trouble-free day.

6 October. 1700 scroll-follower wearing badly. One hour to fit shims to try to reduce loss; ultimately proves not to have worked.

7 October. RVS technicians estimate that we have at most 2-3 days wear left in scroll-followers on board. Will have to abort cruise if no alternative found. Technicians suggest making replacement follower from only suitable material on board - aluminium bronze end cap of IOSDL pressure vessel.

8 October. 0530 wire jumps off spooling gear during WASP recovery.

p.m. home-made scroll-follower fitted.

9 October. 1200 learn that home-made follower wearing, but should last this leg! Decide on 12 hour echo-sounding run from 1800h to allow Barbecue in celebration of end of uncertainty.

10 October. 1330 as multiple corer being launched wire jumps out of two large diverter sheaves on the starboard gantry and becomes jammed between final sheave and cheek plate. As this is being cleared it becomes apparent that the cable hauler is seriously damaging the wire, completely unlaying a 6-8 inch section as it leaves the hauler. To correct this, the hauler has to be more or less rebuilt, replacing flat section rollers with V-section ones and cutting back the Vs to grip the three strand wire more effectively. After this operation the hauler works much more efficiently, but the job takes 7.5 hours. Change programme to deploy Demar rig in the meantime.

11 October. Good day, no serious problems

12 October. 0200 on station for epibenthic sledge haul. Problem with winch control circuitry. At 0300 decide to transfer control to starboard console, but with second man in winch control room to prevent errors.

13 October. 1600 VET rig laid yesterday refuses to release. Oceano releases apparently receiving signal but motor drive not operating release.

14/15 October. Two good days, no problems on ship but in the morning of Friday 15 learn that a general strike in Senegal is likely on 19, 20 and 21 October, thus nicely bracketing our scheduled boat transfer and the arrival and departure of the exchanging personnel. Potential chaos, but can do nothing from ship. If we hear nothing to contrary from RVS must assume arrangements stand and leave work site for Dakar a.m. Sunday 17 as planned.

16 October. 1025 OTSB lifts off after 3 hours on bottom

1052 net comes fast on 400m high hill (?Mont Merrett). Load in excess of 10 tonnes.

1423 net comes free with about 7000 mwo after slow hauling with ship moving back onto wire.

1720 attempting to recover Demar. No response so assume corrodible link has parted. Radio signal received on bridge but RDF unable to locate rig. Find rig on surface after visual search and recover by 1940.

17 October. 1100 having received no instructions from RVS, set sail for Dakar.

18 October. Hear that gear sent to Dakar for second leg is already there and cannot be redirected so must proceed as planned.

19 October. 1400learn from agent via RVS that although strike is on, not apparently affecting airport or port so proceed with expectation of transfer on schedule tomorrow afternoon. However, Air France, with whom most joiners were travelling from Paris, are on strike. Apparently most (? all) transferred to other carriers either via Brussels or Geneva, so assume they will reach Dakar.

20 October. 1500 rendezvous with tug off Goree Island, Dakar. 17 leg one participants leave, 11 leg 2 participants join. Because of the uncertain situation in Senegal the agents have not brought dry ice and all the frozen material has to be left on the ship for return to the U.K. later.

After two days being strike bound by the Air France dispute the party eventually left Dakar at midnight on 22 October, arriving in UK 1130 23 October via Las Palmas and Madrid.

Leg 2

As a result of the Air France strike, leg 2 participants joining in Dakar were forced to change their travel arrangements. Fortunately there were no delays, and all 11 scientific personnel joining for the second leg of the cruise were embarked by boat transfer in the early afternoon of October 20th, with their personal gear and the additional requested scientific equipment (including the net release gears). Once the formalities had been completed, and the first leg scientists disembarked, the ship set off again at 1615 with Dr Herring as Principal Scientist.

Course was made for 17°N 18°W, within Mauritanian waters where permission to work had been received. A zig-zag course was run during the night (0100-0400) to calibrate the ADCP. Trials of the RMT 1+8 system with the closing codend began on station 12601 at 1100 21 October, during the first of which the monitor failed. Subsequent hauls were successful and immediately demonstrated the richness of the region in comparison with the oligotrophic station occupied during the first leg. Hauls were reduced to 1 hour in view of the large quantities of material obtained. Four hauls were carried out by 0900 22 October when the LHPR was fished to sample specific layers visible on the ADCP. The transitory nature of the layers made consistent sampling difficult, but many euphausiids were taken. Deployment of the LHPR proved difficult, as a result of the low load on the winch, with undesirable amounts of slack wire persisting for too long. This also made it unsafe to work on the afterdeck at the same time and the RMT 1+8M could not be rigged until the LHPR had been recovered. A successful first deployment of this net was achieved that evening, followed by another early a.m. on 23 October. The sea and swell had built up to 3-4m with a 30 knot wind, and, as a result, the

catches were in very poor condition and one RMT8 bucket was torn off. It was decided, therefore, to move west in search of better conditions.

Station 12602 #1 was begun at 1630 23 October (18° 33'N, 19° 10'W) using the RMT 1+8 CCE (closing codend). Three hauls were made, followed by another LHPR at 0900 24 October. Further RMT 1+8 CCE tows followed, in which problems were experienced closing the CCE at depth. The damage to the multinet left us perilously short of replacements and it was not fished again until 1200 25 October, by which time the weather was much improved. By then the ship was in visibly upwelling water and surface temperature had dropped to 21°C (from almost 30°C). All the hauls so far had been within the upper 1000m but the second multinet series (12602 #14-16) was fished from 2000-1700m in an unsuccessful attempt to obtain nemertines for Dr Rogers. All the sampling and passage during this station was undertaken on a course of 030°, bringing us gradually shorewards in the Cap Blanc region. During 26 October very dramatic changes were observed in the temperature and fluorescence traces as we came up over Cap Blanc ridge, and the water colour became very dark. An LHPR on 26 October was clogged by huge numbers of radiolarians. Problems with the RMT operation were traced to a faulty 2-jaw release gear and rectified by changing it for a 4-jaw on station 12602 #20. After #21 we had come sufficiently close inshore and course was altered to 270° at 2130 26 October. Further RMT 1+8 CCE hauls (including one to 2550m), and LHPR tows on alternate days, were made as we went westwards out of the visibly upwelling region, ending with station 12604 #1 at 0200 October 30 (20° 45'N, 21° 04'W). It was decided at this time that in view of the large amount of equipment to be off-loaded in Las Palmas, the planned departure of most scientific personnel on the date of arrival, and the fact that it would be a Sunday (7 November), it would be prudent to arrive the day before and thus have all scientific staff and crew available for container packing on Sunday morning. Course was then made southeast (150°) for the Dakar area with further RMT 1+8 CCE and LHPRs along the route, culminating in a final haul (12614#1) at 2200 1 November at the nearest allowable approach point to Dakar. Large amounts of material had been obtained by then for all participants, with the single exception of the nemertine worms only a few of which were taken. The diversity of the midwater fauna allowed work to be undertaken on even more species than had been anticipated, many of them in extremely good condition.

The ship sailed into Dakar roads 2 November and two scientific staff (Drs Herring and Widder) transferred ashore by boat in order to participate in a conference in Hawaii three days later. There had been considerable doubts raised by messages in the previous few days as to whether it would be possible to fly out of Dakar, or even disembark there at all, because of the likelihood of industrial action. The possible alternative ports of Nouadhibou and Banyuls were considered and rejected, except as "last resort" options. In the event no difficulties at all were experienced with the transfer or flights.

Dr Angel took over as Principal Scientist for the return passage to Las Palmas, during which five further RMT 1+8 CCEs were fished in order to sort out some of the difficulties that had been experienced with its operation on the run into Dakar. It was discovered that these were due to a half twist in the net and soon rectified. No further problems of any significance were experienced with the winch system during the second

leg and the repairs and maintenance procedures set up during the first leg proved to be very adequate as temporary solutions to the problems that had arisen earlier. A total of forty-nine RMT 1+8 tows, twelve RMT 1+8M and six LHPR tows were achieved in the sixteen days of the second leg. The PES fairing had been damaged on passage to Dakar and could not be risked at speed. It was brought inboard at midnight on 3 November and all speed made for Las Palmas, which was reached on Saturday 6 November after another alarm that the ship might not be allowed entry. Most of the scientific party flew home on 7 November as planned, leaving only a small group to complete the packing and changeover process. Confusion over the supply of dry ice necessitated much of the deep-frozen material collected on the first leg being left on board (for successful commercial freighting from Cadiz).

ALR, PJH

EQUIPMENT AND GEAR REPORTS

Ship-systems

Cruise 204 followed a winch trial cruise where the winches were tested and adjusted to ensure that they were made as fully operational as possible.

At the start of the cruise the following problems associated with the winch system were noted:

1. The system was unable to pay out slack wire.

2. The cable haulers although operational were not very efficient with the three by nineteen trawl cable.

3. The gantry pendulum extension required frequent bleeding to remove excess air.

Part of item one was due to a hydraulic pump failing at the end of the trials. This pump would have been used to provide fine haul/veer operations for up to six metres of cable without having to operate the winch.

During the passage to the work area the problem with paying out slack cable was addressed. This was solved as a temporary measure by placing a wire rope around all the cobra wheels, so as to lock them all together. The tension on the wire was removed once the cable haulers were unclamped. This system worked well for the duration of the cruise. With this method of control the winch system speed was restricted to 40m/min initially but increased during the cruise. Replacement of the wire rope with a wire grommet should make operational speeds of 90m/min possible.

At an early stage in the cruise the scroll follower for the trawl wire storage drum failed catastrophically under load. Followers from the other scroll shafts were used, but they also wore quickly. Early termination of winch work was avoided only by the manufacture of a new follower from the endcap of an IOSDL pressure vessel. This was of a harder material than the original ones and lasted much longer. The reason for the

premature failure of the followers was probably because the manufacturers made them from the wrong material.

The cable haulers damaged the cable by twisting it along the lays. This results in the cable jumping through the hauler and the hauler wheels wearing the cable. The twisting action also had the affect of reducing the pull that the haulers exerted on the cable. Eventually the pull was reduced to levels insufficient to draw cable from the winch, even with all cobra wheels locked together with the wire rope. The wheels on the haulers were modified increasing reliability although the cable tended to be pulled past the hauler wheels during haul.

This was the first time that the twenty tonne system had been used other than for limited tests during the trials period. Once the above problems were addressed the system proved to possess excellent speed control over the full range of loads that it encountered. The 10 tonne system was used to deploy the CTD package and it operated well. The starboard gantry was used successfully for the deployment of the CTD, multi core and box core. The aft gantry was used successfully for the deployment of a wide range of towed sampling equipment. The three auxiliary winches on the aft deck operated well for the deployments aft. The cranes operated well and proved to be useful for moving equipment around the deck and for the deployment and recovery of the towed equipment.

The non-toxic sea water supply operated continuously and reliably for the duration of the cruise.

PM

IOSDL systems

CTD

In addition to conductivity, temperature, and pressure, probes measuring oxygen, fluorescence, and optical transmission were fitted. The rig also carried a water bottle carousel equipped with 12 x 1.5 litre bottles. Seven casts were made. All were used to collect water samples for bacteriological studies. Four were made to within ten metres of the seabed (approximately 4550 metres water depth) and additionally used to test acoustic release units for the moored systems. The oxygen probe appeared to work intermittently and the transmissometer appeared to have a long time constant temperature effect. The other probes appeared to work normally.

Mooring Acoustics

Four different moored sampling systems were deployed. For relocation and recovery two different acoustic systems in three significantly different forms were used. All acoustic units were operated successfully and tested at 4,500 metres during CTD casts before being used.

Prototype Bathysnap (seabed time lapse camera system)

This was the first deployment of this design. It employed a standard IOS CR200 release unit and a standard MORS RT661CS modified at IOS to the latest mechanical specification. The units were constructed so that if either unit operated the ballast weight would be released. The unit was deployed initially for a short term trial/experiment. When asked to return to the surface both acoustic units indicated full operation but the system failed to leave the seabed. At this stage it is suspected that the mechanical linkage between the units may have jammed.

Standard Bathysnap

This was deployed with a single standard IOS CR200 acoustic units firing two pyrolease units simultaneously. It worked perfectly on a six day deployment. It was then redeployed with a single MORS RT661 electronics mounted in an IOS pressure case with a Marine Acoustics Ltd ceramic ring acoustic transducer and modified on board to fire standard pyrolease units independently using separate secure command codes. This operated perfectly on a six day deployment. It was then redeployed in this form for recovery sometime in 1994.

DEMAR (bottom amphipod trap)

This was deployed using two IOS CR200 acoustic units each firing a single pyrolease mounted on a standard release mechanism. This did two short deployments with the acoustic units being used alternately and the unfired pyrolease being used on the next deployment. A third longer term deployment released prematurely when the magnesium 'fizz' link used in series with the acoustic system corroded through in about 40 hours rather than the theoretical 60 hours.

VET (vertical amphipod trap string)

This was a standard mooring style with traps distributed from near the seabed up to the buoyancy at 1000 metres above the seabed. The anchor weight was 350 kilos but the total buoyancy was only 200 kilos. As a result of the failure of the prototype Bathysnap there were insufficient pyroleases to fulfil the planned programme so a MORS RT661CS unit in latest standard form was used. This can take a static load of 2500 kilos and release 250 kilos. Despite the considerable time and money spent on the mechanical problems of this design, and the successful wire test of the unit itself, the rig was not released. On three separate visits to the site a total of 56 release code sequences were transmitted. The unit indicated that it heard every one correctly but at no time sent a command executed pulse. The transponded range and pinger signals indicate it remained firmly attached to the anchor. AT THIS MOMENT IN TIME I CANNOT ENDORSE THE USE OF MORS RT661CS SEA UNITS IN DEPTHS GREATER THAN 3000 METRES.

Acoustic navigation

There are now three operational acoustic navigation beacons permanently installed on the seafloor in this area. This includes a French respirometer rig lost last year (20 acknowledged release commands were sent to it during the present cruise). The French respirometer and the prototype Bathysnap are close enough together to form a useful navigation baseline. At regular intervals through the cruise ranges were established for both units and the MORS based Bathysnap. Use of GPS data will allow accurate determination of positions of all units on the seabed.

GRJP

Instrumentation

WASP

The prototype WASP system, successfully tested at sea earlier in the year (*Charles Darwin* 76) was deployed five times. The WASP system now comprises an acoustic telemeter which proves control and telemetry of a commercial 200kHz altimeter, Benthos camera, Camera Alive high power twin head flash unit and photodiode flash detector. All devices are powered by three 12V 65AH pressure balanced lead acid battery packs. Operational setup of the system is now controlled via a terminal connected by a RS232 link to the acoustic telemeter prior to deployment. The telemeter provides a menu of options to set system time, camera operation interval, sensor calibration coefficients and data logging. On all deployments the unit was set for a 16 second camera operation interval and logged time, pressure, altitude and frame number logged in battery backed SRAM. On recovery the logged data was down loaded to the PC terminal and viewed with Microsoft Excel software. Some modifications to the acoustic telemeter prior to the cruise proved unsuccessful. The first deployment highlighted a problem with the acoustic transmission power making reception difficult at a range of 3km. The system was recovered and a fault found in the pulse power amplifier. The second deployment indicated a fault with the pressure transducer. At 3.5km range the telemetered pressure information showed an inversion. Instead of indicating increasing pressure as the towing cable was payed out it showed it reducing. The system was lowered to its operational height off the seabed (2 to 10m) by monitoring the onboard altimeter which has a detection range of up to 200m. The system was towed at 0.5kt for 3 hours although there was no flash operation indication. On recovery a test strip of the TMAX 400 film was developed which showed data although on some frames these were slightly under exposed. No fault was found with the flash detector. The pressure transducer and digitising card were replaced and the system redeployed. On this occasion the vehicle was towed closer to the seabed at an average height of 6m to improve the film exposure. This proved successful although problems with the pressure and flash indication remained. The flash detector had flooded and a design fault with the pressure transducer power supply was found. The flash detector was replaced and the pressure transducer power supply fault left unchanged as this would require a redesign and pressure test on return from the cruise.

For the remaining two operations a colour film was used but without flash indication. The flash indicator problem will be investigated on return to IOSDL.

Benthic sledge

The few problems which arose were cured by changing the odometer and resiting the flash detector.

OTSB

Signal reception at far range >10km is poor. Improvements should be possible by using 6" acoustic transducer and/or relay transponder attached half way along towing warp.

RMT and closing cod end

As release gears were not available during leg 1, the RMT system was fished open without problems. During leg 2 difficulties were experienced initially with the acoustic operation of the nets. Two IODSL deck units were tried and the acoustic telemeters were replaced but still problems remained. Eventually the cause was traced to aging battery packs in both deck units. In one case this dragged down the logic power supply, ultimately reducing the acoustic transmission power. The other unit suffered from the carrier frequency operating at 8.5kHz as opposed to 10kHz.

The closing cod end electronics including the auto-retractor performed well although on one occasion the auto-retractor was reluctant to operate due to mechanic friction. A problem did exist with the trawled catch becoming trapped above the first CCE ball valve. The cause was eventually found after much deliberation about the CCE electronics working correctly. In early hauls the catch was trapped in front of the first CCE ball valve and this was found to be a result of twisting of the net.

Deck control system

All deeper operations of towed gear rely on the old *Discovery* beam steering unit to obtain clear acoustic reception. I have spoken to Andy Harris about the Mk4 system designed and fitted to the *James Clark Ross* with regards to the cheaper option of purchasing just the 360° beam steering unit. He has quoted me approx £3K and it would be available almost entirely off his shelf. I would recommend this acquisition for future operations. Like the waterfall display, this would become a permanent piece of biology equipment and could be packaged together in a transit box similar to the IOSDL CTD system. The old *Discovery* unit could provide suitable backup.

The equipment supplied by RVS does not allow simple connection of a beam steering unit to the Simrad/PES fish system although discussions with Greg Phillips and RVS are underway and this may change.

DE

Multiple corer

The multiple corer was deployed 13 times and recovered a total of 141 usable cores (89.9% success rate) (Table 1). Although the gear worked well, all of the cores were short, generally around 100mm. This was probably due to the compact nature of the sediment below the surface 1-2cm which reduced the depth of penetration. From deployment #13 onwards, four extra weights (taken from the RVS corer) were added. They may have resulted in marginally better penetration although the improvement was not substantial. Because the cores were short they were prone to bubbling which disturbed the surficial sediment. This problem occurs when the core catchers are pulled away from the lower ends of the core tubes and is almost impossible to avoid. One or two cores from many deployments suffered from bubbling which was sometimes severe enough to render them useless.

The cores were used for a variety of purposes, described in other sections of this report. They can be grouped as follows: sediment organic chemistry; biochemical and nutrient studies; microbiology; nucleic acid studies; metazoan and foraminiferal meiofaunal studies; incubation of metazoans and foraminifera under *in situ* temperatures and pressures. A special set of samples was taken for analyses of meiofauna and nutrients in Hamburg as part of the MAST project. The assignment of cores for these various projects is summarized in Table 2.

AJG

Spade box corer

The box corer used during this cruise was the older and smaller of the two RVS instruments. Because of the narrow-throated blocks on midships and aft A-frames and the consequent inability to run shackles through them, it is probable that the larger corer could not be used on *Discovery*.

Thirteen deployments were made, but only ten gave good samples. In each case of failure, evidence suggested that the corer had been pulled over while on the bottom.

The protocol adopted on Cruises 185, 194 and 527 has been used for these samples. On recovery, the supernatant water was drained off through a sieve and retained material added to the 0-1cm core layer. The core surface was described briefly and photographed giving attention to specific features where appropriate. A subcore for sedimentology was emplaced and larger and/or obvious animals picked off for separate preservation. The main core was then cut into 0-1, 1-3, 3-5, 5-10, 10-15 and 15-20cm layers. Each of the four top layers was sieved on 1000, 500, 300 and 250μm meshes, whereas the 10-15 and 15-20cm layers were sieved on 1000 and 500μm meshes only. Brief notes were taken on the consistency of the core and of any obvious features within it.

Maximum depths of penetration of the ten good cores were in the range 32.5-40cm (mean 35.4cm). Core surfaces were creamy-biege in colour, and flat, exhibiting relatively little evidence of bioturbation - some small low mounds and occasional tubes and burrows. Small komoki occurred on all cores, sometimes in

considerable abundance. In addition, occasional larger komoki and a few xenophyophores were noted. Internal structure was consistent from core to core. The top 1cm or so was soft, but below this the sediment became very firm, resisting emplacement of subcores and making difficult sectioning of the core. This layer appeared to be fairly uniform and contained a high percentage of radiolarian tests.

Traces of vertical and horizontal burrows marked by a slightly greyer colour and even higher radiolarian content extended throughout this layer. These burrows were almost always completely occluded, and were not apparent at the surface. No trace of the organisms responsible was found. Generally at 15-17cm the consistency of cores changed abruptly to a much softer orange-red sediment with a markedly lower radiolarian content.

MHT, BJB, MVA, JG

Epibenthic sledge (BN1.5)

Both the coarse mesh (4mm, BN1.5/C) and the fine mesh (1mm, BN1.5/3F) sledges were deployed during the cruise. (Note that a suprabenthic net was only fitted to the coarse mesh sledge). The coarse mesh sledge was deployed four times (12600#19, #29, #63, #64) and the fine mesh sledge twice (12600#42, #50). The first two coarse mesh hauls (12600#19, #29) produced similar catches that were essentially as expected for this oligotrophic region - being conveniently described as 'small but perfectly formed'. The catches included one or two holothurians, but were dominated visually by crustaceans (*Plesiopenaeus*, *Glyphocrangon*, and a number of other rather damaged natant decapods). Actinians, bivalves and gastropods were dominant among the smaller forms caught.

The first fine mesh sledge deployment (12600#42) did not fish well, the net lifting off the bottom each time paying out was stopped. There was a small catch in each net, a sediment residue of pteropods and radiolarians, larger megabenthic organisms were conspicuous by their absence. The second deployment of the fine mesh sledge (12600#50) was fished with a continuous pay-out at 10m min^{-1}. This produced a somewhat better catch, with larger residues and a few specimens of larger megabenthos.

A further two deployments of the coarse mesh sledge were then made (12600#63, #64). These tows were through the coring area, rather than along the trawling track where the earlier sledges were fished. The first haul (12600#63) produced what appeared to be a very poor catch (eg large decapods were particularly sparse) despite the telemetry indicating that the sledge had fished well. The second tow (12600#64) produced a somewhat larger but nevertheless rather similar catch leading to speculation on spatial variation within the site as a whole.

Sledge photography was largely successful. Only the first run (12600#19) failed, probably as a result of the film being misrouted behind the camera pressure plate. Telemetry indicated the camera firing during descent of haul 12600#42, probably as a result of the monitor being turned on when the sledge was already over the stern and therefore at an angle.

BJB, BB, ALR

Semiballoon otter trawl

Six tows were completed successfully in soundings of 4480-4650 although early launches were complicated by the inability of the winch to pay out under light loads. Altogether these tows covered a distance of 109km, equivalent to an area of c. 9.37 x $10^5 m^2$. The net was fished with 50m sweeps. Handling the gear on deck proved very straightforward. The sweeps were paid out and hauled over blocks suspended from the quarter cranes, which gave great flexibility and control. All tows were routine except the last which re-grounded and came fast on any abyssal hill. Recovery was achieved by taking the ship astern along the warp. When the wire was close to vertical, the net broke free. This operation was managed skillfully from the bridge, and despite a substantial tear in the belly of the net, the catch together with upward of 100 l of sediment was recovered intact. Judging by evidence from the box corer, some of the sediment had come from more than 15cm below the surface. The remaining catches were small and clean. For details see reports on demersal fish and invertebrate megafauna.

NRM, MHT

Bathysnap and Bathysnack

This cruise was the first to use the new design of Bathysnap - the cylindrical frame with a dual release system. Worries about the mechanical arrangement of the dual release system prompted us to carry an old style frame with the intention of using it for the long-term deployment. After a buoyancy test the new style frame was deployed, on a trial basis, as a 24 hour Bathysnack (12600#6). On attempting to recover the system both acoustic releases indicated successful operation but the mooring did not rise. The consensus of opinion was that the release mechanism had jammed, probably by twisting during the descent. After this failure the proposed short-term Bathysnap was dropped from the programme and the old style frame used for all remaining deployments.

Two Bathysnack deployments, both with recording current meters, were completed (12600#14, #41). The first (#14) appears to have been successful, the film having run through. The second (#41), however, was a partial failure. As a result of the take-up spool clutch seizing, only c. 10m of film (approximately one day's operation) had run though. The muslin wrapped bait retrieved from both deployments yielded numerous amphipods.

A long-term Bathysnap was deployed (12600#69) in the hope that a future French cruise to the area would be able to recover the gear.

BJB

Rectangular Midwater Trawl (RMT)

The new method for launch and recovery of these systems has now been tried and tested many times, and has proved to be a relatively easy task. The greatly reduced pendulum and wind-sock effect

formed by the net are greatly reduced and so wind speed is much less a factor in deciding whether the net can be launched. However, the very slow and intermittent payout speeds possible with light loads means that the net spends a long time in the surface water; if there is any swell running this results in the net being thrashed by the sea, resulting in quite severe damage to the net. Also the large amount of deck space taken up by the bolt-on deck winches required for this and other large nets may create difficulties on multidisciplinary cruises.

The fishing of the RMT with the Closing Cod End (CCE) provided a few headaches; both 2-jaw releases proved unreliable, one cod-end was prone to jamming balls and a problem of catch hang-up was common. Release problems were solves simply by switching to a working 4-jaw release, which is permissible for material hauls. The jamming balls were solved by switching to the spare cod-end, and adjusting the ball clamps, a trick unheard of amongst biologists! The problems of catch hang-up were attributed to everything from retractors, CCE monitors, bad leads and operator error, but none of these rang quite true. It was eventually tracked down to a twisting of the net, caused when the net is recovered and redeployed in the same rotation. This seems to be a new problem caused by new launch/recovery procedures, which can be solved by watch-leaders agreeing a protocol.

BB

Longhurst-Hardy Plankton Recorder (LHPR)

Major problems have been encountered with this piece of equipment in the past. Hopefully, this trip has seen the back of these problems. Six tows of the net resulted in six good samples with only one jamming during the haul due to an exceptionally dense radiolarian swarm. The first haul had no flow record because of a faulty lead, and jamming occurred during another haul as a result of an exceptionally dense radiolarian swarm.

BB

SCIENTIFIC INVESTIGATIONS

Microbiology

The objective of this portion of the programme was to investigate the biomass, activity and community structure of microbial assemblages in the water column and sediments at the DEEPSEAS site. With one exception, all samples were taken at station 12600. CTD casts provided water column material and multicorer hauls provided both sediment and its overlying water (sediment contact water: SCW).

Biomass

Samples were preserved for subsequent onshore study by epifluorescence microscopy and photomicrography in order to determine the numbers and biovolume of bacteria present. In several cases joint subsampling of sediments was carried out with other groups so as to investigate correlations between

bacterial numbers, meiofaunal abundance and geochemistry. Water column samples were taken from CTD cast 12600#11 at depths of 15, 55, 105, 153, 503, 1006, 1505, 2005, 3007, 4009m, and 10 and 26mab in water depth of 4571m). Cores from two hauls (12600#13 cores 1-5 and 12600#49 cores 1, 2, 3, 4, 6 and 7) were sampled. In each case, subsamples were taken of 1cm horizons over the top 5 cm and a sample of the 5 - 10 cm horizon. Four of the cores from the latter station were subsampled by Myriam Beghyn (Univ of Gent) for meiofaunal studies and duplicate subsamples were taken from the other two cores. In this way it is hoped to obtain some measure of haul to haul, core to core, and subsample to subsample variation in microbial abundance. Sediment subsamples were also taken from haul 12600#27 in conjunction with the organic geochemistry group. Additionally, samples for bacterial counts were taken routinely as part of activity measurements and during sampling for nucleic acids (see below), in order to provide bacterial specific rates and levels etc.

Bacterial activity

Activity was investigated by observing the incorporation of radiolabelled compounds by samples incubated at both surface (1at) and sea bed (450 at) pressures. All incubations (with one exception) were carried out at the near-bottom temperature of 4^{o}C and were for intervals of up to c.24 hrs. Bacterial DNA production was followed by the incorporation of [methyl-^{3}H] thymidine and protein production by the incorporation of L-[4,5 -^{3}H] leucine. Incorporated radioactivity was counted on board by means of the Ryan institute's scintillation counter. Some preliminary results are presented here, though they will be reworked on-shore and subjected to a more rigorous statistical analysis. Rates quoted here are calculated per unit volume of sample, and expression of these results in the more meaningful biomass - specific form must await the onshore determination of bacterial numbers and biovolumes.

Water column activity was measured on samples from the following hauls:

Haul	Sample depth	Experiment No.
12600#2	10m over bottom	1
12600#13	Sediment contact water	3
12600#39	154m	6
12600#43	Sediment contact water	7
12600#58	154m	9a,9b

All these experiments were carried out at 4.1±0.5˚C (near bottom temperature approx. 2.2˚C) except for 9b which was carried out at 20.8-21.8˚C for the pressurised samples and 21.2-24.1˚C for the unpressurised samples. The *in situ* temperature at 154m was approx. 21˚C.

Uptake at 10m above the seabed was undetectable for both thymidine and leucine at both pressures. If thymidine uptake occurred it was at a rate <0.5 fMol/l/Hr. By comparison, results obtained with 12m over bottom water at the DEEPSEAS Northern site (48˚51'N 16˚27'W taken on *Discovery* cruise 185, 1989)

showed an uptake rate of 2.6 fMol/l/Hr at 1 At. and 1.75 fMol/l/Hr at 480 At. Uptake rates obtained with sediment contact water (SCW: exp 7) expressed in fMol/l/Hr exhibit a barophilic response, but are considerably lower than values and results obtained at the DEEPSEAS Northern site (*Discovery* 185; 1989).

	DEEPSEAS Southern site	DEEPSEAS Northern Site
Thymidine (1at)	0.7	17.0
Thymidine (in situ pressure)	5.4	31.2
Leucine (1at)	2.0	Not determined
Leucine (in situ pressure)	13.2	Not determined

In common with the DEEPSEAS Northern site (*Discovery* 185; 1989) uptake results obtained with near-surface water (150m: exp 9) do not exhibit a barophilic response.

	DEEPSEAS Southern Site	DEEPSEAS Northern Site
Uptake at 4°C		
Thymidine (1at)	1.9	17.2
Thymidine (450/480 at)	Undetectable	Undetectable
Leucine (1at)	21.9	Not determined
Leucine (450/480 at)	Undetectable	Not determined
Uptake at *in situ* temperature		
Thymidine (1at)	50.1	55.2
Thymidine (450/480 at)	16.7	6.2
Leucine (1at)	797.8	Not determined
Leucine (450/480 at)	99.7	Not determined

Sediment activity was measured on samples from the following hauls:

Haul	Horizons	Experiment No.
12600#9	0-2, 3-5	2
12600#18	0-2, 3-5, 5-10	4
12600#31	0-1, 1-2, 2-3, 3-4, 4-5	5
12600#56	0-2, 3-5, 5-10	8

The following table shows the uptake results obtained in experiment 8. All rates are in pMol/l/Hr.

	0-2cm	3-5cm	5-10cm
Thymidine (1at)	1.6	2.9	0.7
Thymidine (*in situ* pressure)	1.7	1.4	Undetectable
Leucine (1at)	12.3	7.8	2.3
Leucine (*in situ* pressure)	17.8	5.4	5.7

These results are considerably lower than those previously obtained by us and Knut Poremba at the BioCFLUX site (N.E. Atlantic) and consequently suffer from a lack of precision. There would appear to be an overall decrease in activity with increased sediment depth. There is no strong evidence for an overall barophilic community response, though activity at *in situ* pressure is of a similar order of magnitude to that found under 1at. pressure.

Community structure

Water and sediment samples were taken for onshore studies on nucleic acids (RNA and DNA). It is hoped to quantify these on a cell-specific basis, and by the use of nucleic acid probes to determine the relative presences and activities of the kingdoms Eucaryota, Archaea and Eubacteria. Large water samples (20l) were concentrated 100 fold by means of tangential flow filtration. Some samples were subjected to the initial stages of nucleic acid extraction on board, whilst others were preserved at -50°C.

DE, JWP

Large Rhizopods

As on previous cruises, any large xenophyophores or foraminifera seen on the surfaces of core samples were photographed *in situ* and preserved separately. The following seven xenophyophores were found on four box corers and one multiple core: *Homogammina* sp., two specimens resembling an unnamed species which occurs at the BIOTRANS site (12600#21), a flat *Psammina* species, possibly *P. delicata* (12600#24, 30), a folded, flower-like *Psammina* species (12600#28), *Occultammina* sp. (12600#28), ? *Reticulammina* sp. (12600#22). The folded *Psammina* species is of most interest. Similar morphotypes occur in the Pacific, for example, in the DISCOL area, but they have never been reported from other oceans. The single specimen is much smaller than the Pacific forms and certainly represents an undescribed species.

Although not common, xenophyophores appear to be more abundant here than at the MAP station, sampled during *Discovery* cruise 194, where core samples were devoid of obvious specimens. This may reflect a somewhat higher level of organic matter input. On the other hand, xenophyophores are less abundant here than at the PAP site which is located under more productive surface waters.

A consistent feature of box core surfaces was the presence of small (~5mm diameter) lumps, many of which proved to be komokiacean mudballs. Some of them apparently belonged to *Edgertonia floccula*, a species which is abundant over a wide bathymetric range in the N E Atlantic.

AJG

Foraminiferal incubation experiments

Efforts to incubate foraminifera under *in situ* temperatures and pressures were frustrated by problems with the newly modified pressure vessels. Because of the design of the end caps, and the fact that the vessels themselves were not securely fastened, they proved impossible to open without removing them from their wooden boxes. Because of the weights of the vessels, this was a time consuming and difficult task. Nevertheless, an attempt was made to incubate surficial sediment (presumed to contain live foraminifera) from multiple corer deployment #22.

Several ml of sediment were pipetted into plastic bags and a similar volume of mixed algal cultures (food) added to one bag. The second bag contained no additional food. A control sample was fixed in 3% gluteraldehyde (sodium cacodylate buffer). The bags were carefully sealed and placed into two separate vessels located in the walk-in freezer/refrigerator set at 3°C, the intention being to run the incubations for 3 days and 10 days. The end caps were tightened only very slightly to make them easier to undo. However, they proved to be too loose and rapidly decompressed, the O-ring being forced out beyond the edge of the caps in both cases. It was possible to open one of the vessels quickly, insert a new O-ring and restart the experiment having tightened the end cap more securely. This incubation was run for 7 days after which time the samples were removed and fixed in gluteraldehyde. The other vessel could not be opened in time to rescue the experiment.

Further experiments being considered futile, two of the end caps found their true vocation as travellers in the traverse gear of the main winch, a capacity in which they excelled.

AJG

Invertebrate megafauna

The megafauna was sampled primarily by six tows made with the semiballoon otter trawl (OTSB 14) in depths of 4480-4650m. As expected from earlier French investigations at this locality and our own work elsewhere in the low latitude northeast Atlantic Ocean, megafaunal biomass has proved to be very low. This is particularly true for the invertebrate fauna which forms perhaps 15% of the total biomass compared with 30-50% at higher latitudes.

In terms of biomass, catches are dominated by natantian decapods and cirrate octopods. Among the former, *Plesiopenaeus* is most important, followed by *Glyphocrangon*, *Bentheogennema*, *Pontophilus* and *Aristeus*. Eryonids, including several very large specimens, were present in every catch, and several *Munidopsis* were taken. Cirripedes, some large, were taken regularly as were pennatulaceans (*Umbellula*).

Asteroids and holothurians contribute significantly to the biomass, but in stark contrast to Porcupine Abyssal Plain samples, the maximum number of holothurians in a single catch is four. Ophiuroids occur in all catches, but in low numbers only. Some gastropods were caught, but most are smaller than the theoretical retention size of the trawl mesh. A residuum of pumice pebbles and subfossil shark teeth and cetacean earbones provided a substrate for small actiniarians and arcid bivalves, organisms which would have been lost through the mesh had they not been attached. Annelid tubes were found in all catches, but no evidence of the worms themselves was seen. Several other taxa occurred, but most are very rare, or were retained only because of their encrusting habit.

Evidence for the polluting ability of the human race was distressingly evident. Monofilament fishing line and monofilament and polypropylene netting was present in all catches, sometimes in considerable quantity, and all hauls contained the inevitable clinker. Even oceanographers are guilty - XBT wire was found in at least two hauls!

MHT

Necrophagous amphipods

Baited traps and cameras have demonstrated the existence of necrophagous organisms on and above the deep-sea floor. Although fish and natantian decapods form significant elements of the necrophage community, lysianassoid amphipods dominate in terms of numbers.

Two trap rigs designed to sample amphipods were deployed, and additional samples were obtained from Bathysnack bait parcels. DEMAR, a seafloor trap, was deployed successfully three times. The rig was equipped with an IOS release and pyros together with a nominal 60-hour soluble link as back up. The first two deployments were released by pyro after 11 and 23 hours respectively. In the third deployment the soluble link failed after at most 48 hours submersion. Radio signals indicated that the rig was at the surface, but the direction-finding capabilities of the shipboard equipment were ineffective, and it was located visually after 100 minutes of searching. VET, a vertical rig with traps set at 0.5-1000mab, was deployed with an IOS-modified Oceano release. Attempts to recover the gear after 24 and 120 hours failed when the release gear seemingly refused to motor. The rig had to be abandoned. Samples of necrophages were obtained from two Bathysnacks deployed for 138 and 106 hours respectively.

DEMAR and BSNACK catches are satisfactory, each containing some hundreds of specimens. The species constitution is more or less as expected with *Eurythenes gryllus*, *Paralicella tenuipes*, *P. caperesca*, *Orchomene* spp, *Cyclocaris* sp. and *Valettiella* sp. present in varying proportions. *P. tenuipes* is the most abundant species in all catches, with *Orchomene* spp less well represented than anticipated. Although no counts have been made, qualitative differences between the two short term DEMAR catches on the one hand and the BSNACK catches on the other seem to be confirmed by the third DEMAR drop. *Valettiella* sp., seemingly almost absent from the shorter term deployments, forms a significant proportion of the catches

from the longest DEMAR and from BSNACK. If counts confirm this pattern then we have the first indication of a possible succession of species arriving at bait.

Cuticles of predated individuals appear to be more abundant in the third DEMAR catch, suggesting that feeding on large food falls is not without hazard.

MHT

Demersal fish

Demersal fish were sampled mainly by the semi-balloon otter trawl (OTSB14). Six tows were completed within the overall sounding range 4480-4650m.

In all, the OTSB tows covered a total distance of 109km and collected 179 fish weighing 59kg. The overall species richness (22 species) was high for abyssal collections in the eastern North Atlantic and ranged from nine to 12 species per tow. Fish abundance, on the other hand, was low (21-39 per tow), giving relative densities of 0.14 to 0.28 fish per 1000m^2. Biomass was also low. The sample weight range was 3.6 to 14.7kg, resulting in relative biomass estimates of 0.02 to 0.10kg per 1000m^2. Mean fish weight was 0.33kg.

Preliminary percentage similarity analysis of the composition of the six samples indicated relatively low correlations (range 35.6-63.0%), with a mean value of 49.4%. Such values are to be expected in an area of high species richness and low abundance. Similar values (34.4-67.5%) are obtained when these results are compared with those from a previous sample (Stn 12189#1) from further east (20°N, 24°W) but from similar soundings (4550m). The present series of samples would appear to reflect the characteristics of the fish assemblage from the low latitude eastern Atlantic Ocean.

The overall catch of 22 species represented 17 genera and 8 families. The families Ophidiidae (6 species), Ipnopidae (4 species) and Macrouridae (3) dominated. Provisionally, the five most abundant species were *Bathyonus laticeps* (51 specimens), *Bathymicrops regis* (28), *Bathypterois longipes* (24), *Porogadus* sp. (10) and a seemingly undescribed xenoberycoid (10). The xenoberycoid is a very interesting fish, which occurred in all but one tow. It has characters in common both with the Gibberichthyidae and the Stephanoberycidae and is likely to represent a new genus.

A total of 41 fish were collected in both versions of the epibenthic sledge (BN1.5/C and BN1.5/3F). The small, benthic *Bathymicrops regis* was most abundant (16 specimens). Noteworthy among these catches was a specimen preliminarily identified as *Bathymicrops brevianalis* from its relatively large size, lack of bands of pigments along the body and low gill raker count. This record extends the known range of the species into the Atlantic from the Indo-Pacific, and is the fifth and largest specimen known (127mm standard length vs 115mm). This fish was taken from the catch tightly entangled in a bunch of synthetic line, with its head bent back beyond a right angle with the body. The body was stiff in rigor mortis which is a highly unusual situation among such catches and suggests death prior to being netted and before any scavenging attack had occurred.

NRM

Glycogen analysis of demersal fishes and crustaceans

The aim of this programme was to collect qualitative samples of the benthic megafauna for glycogen measurements back at the laboratory. Data from these samples would allow:

a) comparison of glycogen measurements in fresh and formaldehyde-preserved material,

and b) comparison of data from an oligotrophic area with data acquired at the eutrophic Porcupine Abyssal Plain and Porcupine Seabight sites.

These data will provide additional validation for glycogen measurement in preserved samples thus releasing a much larger data set from the collections of organisations such as IOS and the Natural History Museum, together with more basic information on the ecology of the deep sea benthic environment.

Sampling efforts were concentrated on the large and abundant organisms, namely fish and crustaceans. Samples of livers (or hepatopancreas) for glycogen determination and gonad for histological examination were dissected out. Sub-samples of each liver were then either frozen at -50°C, or preserved in 10% formalin. By preserving and freezing samples of the same liver from an individual, direct comparisons can be made of glycogen content. Two crustaceans and two fish species provided the bulk of samples obtained.

Crustacea

- *Glyphocrangon atlantica*. Samples were frozen whole or preserved as normal for the IOS collection. Previous work has been done on preserved samples of this and two other species of *Glyphocrangon*.

- *Plesiopenaeus armatus*. Samples were dissected and frozen, with the animal returned for preservation with the IOS samples. No previous work has been done on this species, but there are extensive collections at IOS, and the species is abundant at the northern sites.

Fish

- *Bathyonus laticeps, Bathypterois longipes*. Samples were dissected from some specimens and either frozen or preserved, with the remaining animals preserved in 10% formalin for the NHM. No work has been done on these species.

The numbers of samples and treatments for each species is listed in Table 3.

In addition, whole pelagic fish were collected from the trawls and RMT8 catches for teaching purposes on behalf of Dr S. Hutchinson in the Southampton University Department of Oceanography.

JB

Biochemical and nutrient studies

These studies were carried out in order to investigate some aspects of the bacterial and meiofaunal ecology by determining several parameters concerning their biomass, distribution and activity within the sediment. In addition measurements of the organic input and the availability of labile proteinaceous material were made. The studies were based on an attempt to answer the following questions:

- How large and variable are the bacterial and meiofaunal biomass and activity and what is their distribution within the sediment?

- What is the amount of organic input to the sediment and what is the potential utilization of this input?

- Which part of the protein pool is potentially available for organisms?

- Are bacterial and meiofaunal biomass and activities correlated with the amount of sedimentary organic material and the potentially available proteinaceous material?

Three sediment cores from each of six multiple corer deployments were subsampled by slicing into five 1cm thick layers down to 5cm depth with an additional deeper layer of 1cm thick out of 6-10cm depth, depending on the overall length of the cores. The three slices of each centimetre layer were combined and mixed to form a subsample equivalent to an area of approximately 80cm^2. Five replicates per analysis were taken to measure various parameters either on board (o.b.) or in the home laboratories (h.l.). Sediment for the latter was prepared and frozen at -50°C and later stored at -20°C. Analyses undertaken were:

- total biomass as protein content expressed as g-globuline equivalents (o.b.)

- labile proteinaceous material that is potentially available to organisms as an extracellularly digestible part of the total protein content expressed as g-globuline equivalents (o.b.)

- input of primary organic matter as a potential food resource by measurement of chlorophyll a as chloroplastic pigment equivalents (=CPE) (h.l.)

- active biomass by measuring adenylates (ATP, ADP, AMP)(h.l.)

- benthic respiratory potential by determining the electron transport system activity (ETSA) (not processed on board due to transport damage of the cell sonicator, but will be examined later in the home laboratory although activity may have decreased by then).

Preliminary results concerning protein contents show very low levels. They are within the range of those at some offshore stations in the highly oligotrophic Eastern Mediterranean Sea (May 1993) and are much lower than from further north within the Atlantic (i.e. BIOTRANS-area). This indicates a small input of organic material and a low amount of nutrients so that this site can be regarded as highly oligotrophic. This assumption is supported by the steep decrease of proteins with sediment depth with more than 60% within the upper 2cm and mostly no detectable proteins below 5cm. In contrast, results from stations in the coastal Mediterranean and at BIOTRANS show a less pronounced or no decrease into the sediment. The labile

proteinaceous material (36-84% of total protein at 0-5cm) show the same tendency suggesting that there will be very little or no burial of proteinacous material at the present site. Although the amounts of protein are very low there is a variability of 29% among the multiple corers and of 3-14% within one multiple corer which is in good agreement with variabilities known from other less oligotrophic areas. Therefore, it seems probable that in this highly oligotrophic area there are local accumulations of sedimentary material resulting in a patchy distribution of biomass and activity. Probably this is a result of the distinctive topography and its associated currents which are likely to be responsible for the distribution of sedimentary food input. The results of the other parameters are expected to follow the same trend as the protein contents to support the preliminary evaluation of station 12600 as a highly oligotrophic site.

Several biochemical parameters concerning sedimentary input, benthic biomass and activities were chosen to evaluate natural benthic variability. For this purpose a complete multiple corer (#43 consisting of 11 usable cores) was taken. Nine cores were subsampled identically, each with five cut off syringes down to 5cm sediment depth. From each core two syringes of 3.46cm^2 were taken for measurements of ETSA (electron transport system activity for determination of potential respiratory activity) and DNA. Three syringes each covering 1.13cm^2 were taken to measure CPE (chloroplastic pigment equivalents to estimate the input of primary organic matter) and protein and adenylates to examine total and active biomass, respectively. All subsamples were shock-frozen at -50°C, stored at -20°C and will be analyzed in the home laboratories. The subsamples for adenylates were extracted on board and frozen at -20°C and these too will be analyzed at home.

The two remaining cores were sliced into centimetre layers down to 10cm sediment depth and preserved in formalin for analyses of meiofauna.

SS

Biogeochemisty

During the course of Cruise 204 the chemistry group was able to collect, and prepare for analysis, 2 cores from each of 7 multicorer drops. In addition to this, work was carried out on a complete set of cores from a single drop as part of a joint experiment with the groups from the Natural History Museum and University College Galway.

The seven pairs of cores were all sectioned down to 10cm where possible using a specially designed core extruder with 5mm resolution. These sections were subsequently frozen in the -50°C freezer, dried using our on board freeze-drier and then returned to -50°C for storage.

From the additional multicorer drop, 11 of the 12 cores were undisturbed. Five of these 11 were sectioned as described above. The remaining 6 were sectioned at 1 cm intervals down to 5cm, homogenised using a vortex mixer, and split between NHM, UCG and ourselves for analyses. For homogenisation the sections were placed in centrifuge tubes along with a set amount of artificial seawater, and mixed until the samples had achieved an even consistency. UCG were allocated 1-2mls of the homogenised sample, with

the remainder being split 50/50 between the NHM and ourselves. This protocol represents the first opportunity for different groups within the MAST II Deepseas Project to work on the same samples.

DB, IH

Midwater sampling

Leg 1: Eleven RMT 1+8 combination nets were fished at station 12600. All were rigged in the open configuration because the release gears had not been loaded on board. The maximum depth fished was 1150m on the first haul when problems with the sheave caused the net to plummet but nine of the other ten hauls were fished at night in the upper 500m and the tenth was a daytime haul down to 800m. The hauls were primarily for physiological work and in general reflected the paucity of this oligotrophic area. Fishes in the catches were largely myctophids and *Cyclothone* with small *Chauliodus*, *Argyropelecus* and *Gonostoma* also frequent. Additional stomiatoids were represented by several specimens of *Eustomias* and *Photostomias.* Only a very few ceratioids were taken and because the net was fished open the catch condition was poor. One very large specimen of *Odontostomops*, an *Idiacanthus*, a small *Diretmus* and a large but very damaged *Dolichopteryx* were among the few highlights.

Decapod crustaceans were a major component of the catch particularly *Oplophorus*, and, to a lesser extent, *Systellaspis*, *Acanthephyra*, *Sergia* and *Sergestes.* Euphausiids were not abundant, probably because most of the hauls were fished below their likely nighttime population maximum.

Few squid were taken and these were largely very small juveniles (*Pyroteuthis*, *Abraliopsis* and cranchiids) but did include two *Spirula* in one haul.

Leg 2: All the biological sampling on this leg was aimed at the midwater zooplankton and micronekton and three sampling gears were used, namely the RMT1+8 (with the closing codend), the multiple RMT1+8, and the Longhurst-Hardy plankton recorder. The RMTs were fished primarily for physiological material, 13 between 1000m and 2000m, the remaining 48 in the upper 1000m. Operation of the closing codend produced material in excellent condition from all depths.

A feature of almost all the trawl samples was the large volume of material, in marked contrast to the small samples generally obtained on the first leg. In the 700-1000m depth range the medusae *Atolla* and *Periphylla* were prominent, along with numerous ctenophores of the *Beroe* type. Nemertines were actively sought but were largely confined to the deep samples and even there were taken only occasionally.

The decapod crustaceans were represented by very large numbers of *Systellaspis debilis*, particularly in the shallow night samples, and *Oplophorus spinosus*. The latter species was absent from the more inshore stations. Of the other oplophorid shrimps both *Systellaspis cristata* and *S. braueri* were taken, with at least five or six species of *Acanthephyra* and numerous specimens of *Notostomus* and *Meningodora*. *Ephyrina* was present only rarely and *Hymenodora* occurred only in the deep samples. *Gennadas* and species of *Sergia*

and *Sergestes* were abundant, while *Funchalia*, *Bentheogennema*, *Parapandalus* and *Plesionika* sp. were also taken.

Mysids were numerous, with at least two species of *Gnathophausia*, many *Eucopia*, *Boreomysis* and other deep mysids including *Petalophthalmus.* A species of *Euchaetomera* was common in several samples. Euphausiids were numerous in the shallower samples while *Bentheuphausia* and the large *Thysanopoda cristata* occurred deeper.

A good variety of cephalopods were taken, including *Vitreledonella*, *Brachioteuthis*, *Spirula*, *Lepidoteuthis*, *Chiroteuthis*, *Bathyteuthis*, *Octopoteuthis*, *Cranchia* and *Liocranchia.* Particularly remarkable was the capture of five *Vampyroteuthis* in one trawl, and one large *Todarodes* in another.

Fishes were represented by a very wide variety of species, in addition to the widely distributed *Cyclothone*, *Argyropelecus* and *Sternoptyx.* Many myctophids were taken, with particularly good specimens of *Diaphus* and *Electrona. Gonostoma* spp. were frequent, with occasional *Margrethia*, *Bonapartia*, *Valenciennellus* and *Polyipnus.* Stomiatoids included *Stomias*, *Chauliodus*, *Idiacanthus*, *Photonectes*, *Eustomias* and *Borostomias* among the identified specimens. One *Pachystomias* and a few *Malacosteus* and *Aristostomias* were also captured. *Melanocetus* was the commonest ceratioid, but a few *Ceratias*, *Chaenophryne* and other oneirodids were also taken. Several *Howella*, searsiids, scopelarchids, *Nemichthys*, *Serrivomer*, *Poromitra*, *Melanonus* and *Omosudis* were caught, as well as one *Stylephorus*, a few small *Opisthoproctus*, and occasional *Eurypharynx* and *Anoplogaster.*

Other animals of note were the pelagic holothurian *Galatheathuria*, the crustacean *Nebaliopsis*, a deep species of the ostracod *Gigantocypris*, and several specimens of the *Danaella/Chevreuxiella* group of amphipods.

The fishing gear worked perfectly throughout and the handling system necessary for the new aft configuration of *Discovery* proved very effective, albeit requiring additional deck support for the auxiliary winches.

PJH

ADCP profiling

Continuous ADCP profiles were made and logged throughout the cruise and the data were processed ready for further analysis at Wormley. The BIOEXEC programmes were used to provide four-hourly backscatter profiles throughout the cruise. Relative backscatter was very much higher on the second leg (closer to the continental slope) than on the first. Variability was especially marked during periods of upwelling when normal diel migrations were completely masked by presumed frontal effects. A near real time colour plot of relative backscatter was developed during the second leg which significantly enhanced our ability to target complementary biological sampling. Six tows were made with a Longhurst Hardy Plankton Recorder to depths of 400m to provide biological validation of the backscatter. Three layers were typically

present during the day, at least one was made up of euphausiids and one was probably pteropods. On three occasions the LHPR jammed on very dense concentrations of Radiolaria. A continuous log was kept to monitor the temperature of the ADCP deck electronics and the time drift, and two calibration runs were made.

MVA, MH, HSJR

Nemertine worms

The objective of this cruise was to collect pelagic nemerteans from the proposed cruise area (E and NE of the Cape Verde Is). Samples taken by the RMT 1+8 CCE and multi net systems from depths shallower than 800 metres depth yielded few specimens. Most specimens were taken below this depth, the richest tows coming from 1800m and 2500m.

A total of 17 specimens of nemerteans constituting 14 species were captured during the cruise. The external morphology of these animals was noted and where possible specimens were photographed. They were then relaxed in 0.15% phenoxetol solution prior to fixation in 10% formalin. After 24 hours specimens were transferred to a 1:2 mix of 10% formalin and Steedman's sorting solution. Tissue samples were taken from three specimens and preserved for DNA sequencing at a later date. Fixed specimens will be sectioned and described. As only 93 species of pelagic nemerteans have been described the 14 collected on this cruise represents a substantial number and may well contain a number of undescribed taxa. Only one species, *Phallonemertes murrayi* was identified positively from external morphology.

Notes were taken of two specimens of a bright orange parasite from the decapod *Sergestes* sp. prior to fixation. These are of an undescribed taxon which may be from the phylum Platyhelminthes or Nemertea. These specimens will also be sectioned and described subsequent to the cruise.

As relatively few specimens of nemerteans were captured, specimens of melamphaeid fish, mainly the species *Scopelogadus beanii*, were taken, measured, weighed and their digestive tracts removed and preserved in formalin. Stomachs from 42 specimens were preserved. There are few (or no) data on the diet of these fish and gut contents will be examined subsequent to the cruise.

AR

Bioluminescence behaviour in calanoid copepods

Investigations of bioluminescence behaviour in net-captured, mesopelagic organisms were carried out using the Mixed Light Imaging System (MLIS), a two camera video system which records stop-action images of animal behaviour, superimposed on intensified images of their bioluminescence. Continuing work begun during the 1990 Photobiology Cruise, emphasis was on investigating stimulus-specific triggers for bioluminescence behaviours in calanoid copepods. These included *Gaussia princeps*, *Euaugaptilus magnus*, *Pleuromamma xiphias*, *Megacalanus princeps* and *Disseta palumboi*. During the 1990 cruise, our primary means of stimulating bioluminescence was with an electric field. Our goal during this cruise was to investigate the effects of more environmentally relevant mechanical stimuli. Working with both free-swimming

and tethered copepods, mechanical stimuli were applied using a frequency-controlled, vibrating probe. In general an individual copepod's mechanosensory encounter radius appeared to be much smaller than anticipated and in general it appeared that direct contact was required to elicit an escape behaviour. In the vast majority of trials the probe proved to be insufficient to elicit bioluminescence displays. Exceptions occurred when the copepod contacted the aquarium wall during a rapid escape. Using computer image analysis techniques, escape behaviours will be quantified in terms of speed, acceleration and direction. Comparisons will be made between bioluminescent and non-bioluminescent escape patterns.

EAW

Visual behaviour in hyperiid amphipods

Animals were filmed in a small aquarium in which a small movable blue LED or array of blue LEDs was placed. Illumination in the downwelling direction could be provided and activity filmed with IR camera and illumination. The following types of behaviour were noted:

a) "Buzzing". Individuals would swim around the LED in a way rather similar to a fly or moth buzzing around a light bulb.

b) Dropping away. If the LED was brought close to an individual near the top of the tank, all species would occasionally turn on their backs and sink.

c) Rotating. Various species were seen to swim slowly upwards in the tank rotating on their body axis.

d) "Zoom in". *Phrosina* in particular was observed swimming slowly towards the LED, when it was held motionless, with part of the eye fixated on the LED.

e) Barrel turning. *Phronima* was observed turning its salp barrel, in response to a moving LED, in order to keep the light source within the field of view out of the end of the barrel.

f) Tracking. *Phrosina* and *Platyscelus* were particularly good at this behaviour. It involved tracking a moving LED by swimming in its direction of motion. It appears these species are trying to fixate the LED with part of their dorsal eye.

The following crustacean material has been prepared for transmission electron microscopy (TEM).

a) The dorsal and ventral retinae of *Phronima*, *Phrosina*, *Platyscelus* and *Brachyscelus* to trace neural projections to the lamina ganglionaris from the retina.

b) *Scypholanceola* reflector eyes.

c) *Chevreuxiella* antennal reflectors.

d) *Sapphirina* eyes.

Colour video of many of the species mentioned, and others was made.

NJM

Crustacean eye structure

A collection of various oceanic crustaceans was made including decapod species of the genera *Acanthephyra, Gennadas, Hymenodora, Meningodora, Notostomus, Oplophorus, Parapandalus, Plesionika, Sergestes, Sergia* and *Systellaspis*, and various mysids and euphausiids. A simplified key was produced to aid identification of the commonest species encountered.

I sought much advice during this cruise and tried a variety of fixing techniques, settling finally on Karnovsky which preserves the eye structure for both light and electron microscopy, which I plan to examine in Bristol. Visual pigment extracts of three species were also made, one of which was scanned on board. The remainder will be analysed in Bristol with the eventual aim of microspectrophotometry.

A general collection reflecting the diverse range of oceanic fauna was made for the University of Bristol.

JK

Decapod eye structure and function

Our objectives during the cruise were:

1) assess the possibilities of carrying out intercellular electrophysiology at sea and continue the development of a portable set up,

2) expand the study of eyeshine in natantian mesopelagic decapods,

3) obtain a wide range of decapod eyes for histological (light and electron microscopy) processing,

4) obtain photophores from *Systellaspis debilis* and *Oplophorus spinosus* for a histological study.

Many difficulties were encountered in the attempt to assess the spatial and spectral capabilities of decapods. However artificial interference was reduced to insignificant levels so that preparations would usually respond well to simple light stimuli. V/LOG I curves were obtained from some animals. Unfortunately responses were not reliable or long lived enough to provide useful data on the temporal or spectral capacity of the decapods utilized (*Oplophorus spinosus, Systellaspis debilis* and *Acanthephyra pelagica*). However, the system looks very promising and a number of planned modifications should make the system fully suitable for use in the field and at sea.

Eyeshine measurements were made on a large number of decapod shrimps (as well as a few species of mysid and one euphausiid). Eyeshine was recorded using a video-camera and videotape recorder for later analysis with image analysis techniques. Images were stored of eyeshine at 20 degree intervals around the antero-posterior and dorso-ventral axes of the eyes. Clear differences in levels of eyeshine, and size of the eyeshine patch were noted in different parts of the eyes. In most cases differences in reflective efficiency

could be attributed to regional differences in the reflectivity of the tapetum. In a number of cases lack of lateral and dorsal eyeshine was attributable to absence of the tapetum in lateral and dorsal regions. This was true of many species including *Plesionika martia* and some but not all species of *Gennadas*. Such holes in the tapetum were observed in rough dissections of partially fixed eyes. With careful observation of rough dissected tapeta it was possible to see wavelength specific (green/blue) effects where the tapetum was thinnest. Also it was noted that in recently fixed eyes of *Acanthephyra*, eyeshine was green. An eye was fixed for histological study from each individual animal measured for eyeshine. To test the idea that eyeshine patterns change with development, a range of sizes of *Systellaspis debilis* and *Oplophorus spinosus* were obtained and eyeshine measurements were taken.

Representative material for light and electron microscopical analysis of tapetal and general eye structure was obtained from over 100 specimens of benthic and pelagic shrimps. This material was dark-sorted and fixed immediately using Karnovsky's fixative and osmium tetroxide. It was dehydrated and embedded on board using Spurr resin.

Material for a comparative study of photophores in *Systellaspis debilis* and *Oplophorus spinosus* was obtained for later analysis by transmission electron microscopy. This is part of a continuing study in cooperation with Dr M.S. Nowel of Providence College, Rhode Island.

Several specimens of eyed amphipods (*Eurythenes*, *Paralicella*, *Orchomene*, *Valettiella*) from baited bottom traps have been fixed. It is hoped that collaboration with Mr M. Thurston (IOSDL) will elucidate the structure of the eyes of these species and provide a contrast with those of decapods.

PMJS, MJ, PJH

Lateral line systems in anglers and other fishes

Four species of angler fish (*Melanocetus johnsoni*, *Oneirodes carlsbergi*, *Cryptopsaras couesi* and *Chaenophryne draco*) have been collected and fixed for scanning electron microscopy (SEM). I hope to map distribution and sensitivity direction and look at the ultrastructure of these organs.

A number of other fish with interesting lateral line systems were also fixed for SEM. They are *Cyema* sp., *Eurypharynx pelecanoides*, *Melanonus zugmayeri* and *Scopelogadus* sp.

NJM

Visual systems of mesopelagic fishes

The visual systems of mesopelagic fishes are well developed and it is clear that vision is central to the behaviour of these ecologically important animals. As a result of the extraordinary ocular modifications and the exceptional light environment of deep-sea fish, vision has been a focus of investigation for several decades. During this cruise we have addressed several related aspects of deep-sea fish visual physiology.

Visual Pigments

Most mesopelagic fishes have a single visual pigment in rod-like photoreceptors with a peak sensitivity (λ_{max}) between 470 and 490nm. However, some 10% of species have two visual pigments or pigments with unusual λ_{max} values. During the cruise we have collected some 450 retinae from 43 species of meso- and bathypelagic fishes for the measurement of visual pigment absorbance spectra both by spectrophotometry (on board ship and in London) and microspectrophotometry (in Bristol). These collections are directed at the following topics.

(1) The measurement of visual pigments in species never before examined. Twelve were collected and will be measured on return to the UK.

(2) The characterisation of visual pigments of fishes with unusual red-emitting photophores. The malacosteid "loose jawed" fishes, *Malacosteus niger* and *Aristostomias* spp, and the melanostomiid fish *Pachystomias microdon* have far red-emitting photophores that are unlikely to be visible to most deep-sea fishes. Before this cruise it was known that these fishes had greater long-wave sensitivity than most deep-sea fish, but that the match between their photophore emission and their visual pigments was still poor. Using a simple macrospectrophotometric method that minimises retinal disruption we have shown on this cruise that *Aristostomias* and *Pachystomias* have additional long-wave sensitive visual pigments (λ_{max} c. 585-610nm) as well as those previously described with λ_{max} 515-551nm. The longwave pigment suggests an efficient match to photophore spectral emission.

(3) The determination, in those species which from our previous work we know to have more than one visual pigment, of where in the retina the different pigments are localised and hence which part of the visual field they are serving. Fifteen examples of four species (*Bathylagus euryops*, *B. berricoides*, *B. longirostris*, *Howella brodiei*) were collected and retinae were dissected into different regions which will be analysed separately.

(4) The measurement of the photosensitivity spectra of deep-sea fish visual pigments by controlled bleaching at different wavelengths. Visual pigment photosensitivity spectra are generally assumed to follow their absorbance spectra, but this is likely not to be the case at short wavelengths, particularly in the UV. As UV light is known to penetrate the open ocean to considerable depths we need to know how visual pigment photosensitivity and absorbance spectra are related before we can appreciate the spectral matching (or lack of it) of deep-sea fish visual pigments to the ambient light. Controlled bleaches at various wavelengths were conducted on retinal extracts of the viper fish, *Chauliodus sloani*, which is known from previous work to have a single visual pigment with a λ_{max} of 485nm. The data resulting from this experiment will be used to construct a photosensitive curve. Other visual pigments will be treated similarly for comparison on return to the UK.

(5) The measurement of regeneration rates of deep-sea fish visual pigments. The regeneration of deep-sea fish visual pigments when exogenous 11-cis or 9-cis retinal is added to the bleached pigment is low

but has not been quantified. It may be that the low light levels encountered at depth has "allowed" the evolution of visual pigments that regenerate only slowly. Collections of numerous retinae from a wide range of species will be used for regeneration rate quantification in the UK.

(6) The sequencing of deep-sea fish opsin encoding genes. Retinae were collected from 70 individuals of 7 species, fast-frozen and maintained at -50°C. In Bristol, mRNA will be extracted, cDNA synthesised and probed for opsin encoding genes which will then be sequenced. Although crude, this collection technique was used on *Challenger* cruise 94 and has yielded usable mRNA from demersal deep-sea fishes.

Ocular lenses

Many deep-sea lenses containing significant amounts of short-wave absorbing pigments whose function is far from clear. To date, 11 distinct types of ocular pigments have been characterised in deep-sea fish lenses using spectrophotometric methods but, due to lack to material for analysis, only one (Kynurenine, from *Stylephorus chordatus*) has been identified chemically. During the cruise ocular lenses from 8 individuals of 6 species were collected and pigments will be identified using spectrophotometry, NMR and HPLC.

Retinal anatomy

A total of 47 retinae from 18 species were collected and fixed in a variety of ways for later histological analysis by Prof. H-J. Wagner (University of Tübingen, FRG). A glutaraldehyde/paraformaldehyde fixative was used to preserve specimens for standard electron microscopy. Tissue was immersed in Zamboni's fixative for later immunohistochemistry and retinae placed in a mixture of 1% osmium tetroxide and 1.25% potassium permanganate will be used for cellular staining by the Golgi method.

Reflections of deep-sea animals (with Dr N.J. Marshall, University of Sussex)

In order to understand the vision of deep-sea animals information is needed about the spectral reflections of the objects (animals) in the deep-sea. These data will be married to available data on the spectral distribution of light in the deep-sea and to the spectral sensitivities of deep-sea animals. Spectral reflection measurements have been made from samples of various species of fishes and crustaceans.

JCP, RHD

Visual structure and function of mesopelagic fishes

Mesopelagic fishes possess a plethora of bioluminescent adaptations to camouflage their appearance during vertical migration. In order to investigate the unique visual adaptations peculiar to the mesopelagic environment a series of observations were made.

Retinal ganglion cell topography (in collaboration with Dr. J. C. Partridge, University of Bristol)

An analysis of the retinal ganglion cell distribution provides a measure of the spatial resolving power of the eye which may vary in different regions of the visual field. Regional increases in retinal ganglion cell and photoreceptor densities provide increased visual acuity along a defined visual axis, specific to each species. During the cruise, 62 species from 25 families (100 individuals) of mesopelagic fishes were collected from depths between 200 and 2000 metres. One eye of each individual was excised and fixed in 4% paraformaldehyde in 0.1M phosphate buffer for between 30 and 40 minutes. After the removal of the cornea and lens, the retina was washed in buffer overnight and isolated from the optic capsule and the retinal pigment epithelium before being wholemounted onto a 5% gelatinised microscope slide. Upon return to Australia, each retina will be rehydrated and the ganglion cells stained preferentially with cresyl violet, and an iso-density contour map constructed to analyse their distribution.

Comparative morphology of retinal specialisations (in collaboration with Dr J.C. Partridge, University of Bristol)

Structural modifications of the retina that putatively provide increased acuity/sensitivity and depth perception are often associated with regions of increased ganglion cell and photoreceptor density. Some retinal modifications possibly also magnify or distort an image to aid the maintenance of visual fixation. These include foveae (single and multibank), retinal diverticula and accessory retinae. In some cases the structure of these specialisations, has been well described but has not been quantified with respect to the increased acuity or sensitivity compared with the non-specialised regions of the retina. On RRS *Challenger* Cruise 94, a new retinal specialisation was discovered in the temporal retina of species of the Alepocephalidae and Searsiidae. Termed a monticle, it comprises an elevated mound of retinal tissue with a deep concavity at its apex filled with a tissue plug most probably of Muller cell origin. In order to investigate the morphology of retinal specialisations, the opposite eye of the 62 species examined for retinal topography were fixed in 4% glutaraldehyde, 2.0% paraformaldehyde in 0.1 M cacodylate buffer for light and electron microscopy. An additional 10 eyes of *Searsia koefoedi* were frozen for investigation of refractive index variations within the retinal monticle.

Retinal and corneal ultrastructure (in collaboration with Prof. H. B. Collin, University of New South Wales)

Retinal and corneal tissue from the 62 species of fishes fixed for electron microscopy will also be available for studies of comparative morphology. Retinal material will provide vital evidence of the various types of photoreceptors, information on the organisation and structure of the retinal ganglion cells and the arrangement of pigment granules (comprising a retinal tapetum) found within the retinal pigment epithelium and choroid of some species. Tissue from the anterior eye (spectacle and cornea) will provide information on the existence of corneal and iridescent filters (known to absorb differentially specific wavelengths of light in

shallow water species), and the maintenance of high intraocular pressures (comparing the relative thickness of each tissue layer) for animals migrating up to 1000 metres each day.

Comparative ultrastructure of the pineal organ (in collaboration with Prof. M. A. Ali, University of Montreal)

The brain and surrounding cranium of two individuals of *Gonostoma elongatum* and *Chauliodus sloani* were fixed for electron microscopy for ultrastructural analysis of the brain and pineal organ. Examination of the development of the pineal and the presence of a well developed cranial "window" may elucidate the mechanisms controlling the large vertical migrations made by these two mesopelagic species.

Retinal immunocytochemistry (in collaboration with Prof. Koroku Negishi , Nippon Medical School and Prof. H.-J. Wagner, University of Tübingen)

The eyes of 7 species from 7 families of fish (including one species of elasmobranch) were fixed in Zamboni's fixative and washed in phosphate buffed saline. Antibodies for specific neurotransmitters and rod precursor cells will be used to identify retinal neurons responsible for the development of regions of increased rod photoreceptor densities.

Binocular visual pathways

The brains of 4 species from 4 families of fishes were fixed in 4% paraformaldehyde in 0.1M phosphate buffer for preliminary studies of binocular visual pathways using the lipophilic dye DiI. This label diffuses up the lipid bilayer of fixed nerve tissue. Of particular interest is the tracing of retinal ganglion cell axons and their terminal fields within the family Alepocephalidae. In *Alepocephalus rostratus*, the optic nerve of each eye is split into two discrete nerve bundles; one nerve putatively comprising axons from the specialised (monticular) retina and the other nerve comprising axons from the non-specialised retina.

Retinomotor movements (in collaboration with Dr. R. Douglas, City University)

The eyes of 2 individuals of *Poromitra megalops* were fixed in 4% paraformaldehyde in 0.1 M phosphate buffer for light microscopy. Fish were maintained in either constant light or constant dark for 2 hours. After resin embedding and sectioning of the retinae, the relative positions of the retinal pigment epithelium and the photoreceptors will be analysed for evidence of retinomotor movements.

SPC

Molecular biology of coelenterazine bioluminescence

Coelenterazine is the most common luciferin found in marine bioluminescent animals, and is present in phyla ranging from Protozoa to Chordata. Our objectives related to three different aspects of coelenterazine biochemistry. Work on board was primarily concerned with quantitative assays of coelenterazine in a wide range of organisms, based on the reactivation of the calcium activated photoprotein aequorin from

recombinant apo-protein, prepared using the pET bacterial expression system. This assay proved both more sensitive than that used previously and experimentally reliable.

Environmental and developmental control of bioluminescence.

The decapod *Systellaspis debilis* undertakes both diel and ontogenetic vertical migrations and populations were sampled at their day and night depths to investigate whether there is any differential expression of luminescence. No significant differences were observed in the coelenterazine content; mRNA assays will be conducted on the material in Cardiff. Developmental differences were examined by sampling a range of sizes of the species and eggs at different stages of embryogenesis. Substantial increases in the coelenterazine content were measured, indicating that this luciferin is not a dietary requirement in this species but is synthesized *de novo*. Very large amounts of luciferin were present in both the hepatopancreas and the stomach wall.

The stability of coelenterazine

Coelenterazine is a very unstable compound and it is reported to be stabilized by sulphation in one or two coelenterates and squid. We have prepared bulk samples of tissue from a number of decapod crustaceans (*Systellaspis, Oplophorus, Acanthephyra* and *Sergestes*) in order to carry out comparative acid methanol extractions followed by TLC and column chromatography in Cardiff. This will identify any such sulphate stabilization in these animals.

The distribution of coelenterazine

Tissue samples from a very wide variety of organisms have been assayed for coelenterazine, including a number of species not known to be bioluminescent. We have confirmed or identified coelenterazine as the luciferin in species of ostracod, copepod, decapod, squid, octopod and fish, and have demonstrated that coelenterazine is present in the tissues of a considerable number of non-luminous species. It is not clear whether this is simply a dietary accumulation or whether the compound has an additional function in these species. Tissue distribution studies have shown that the liver or hepatopancreas is the main site of accumulation, and often the photophores themselves contain relatively small amounts of coelenterazine. Marked disparities were found in the coelenterazine content of photophores of similar size in particular groups of fish.

CMT, NJW, PJH

Ornithology

Observation periods lasted ten minutes, and were spaced throughout daylight hours at 90 minute intervals when practical. Complete consistency was achieved only rarely, and six observations per day were made on average during the 25 days of the first leg. In addition, casual sightings were recorded.

The cruise can be considered in three parts, on station close to 21°05'N 31°10'W, and the periods of steaming to and from this position.

Las Palmas - work area (3 days, 17 observations). Cory's shearwaters (*Calonectris diomedea*) were seen in small numbers while still in sight of the Canary Islands, but only unidentified storm petrels thereafter.

Work area (19 days, 112 observations). Seven species were seen during 40 observations (36%). Most of the species records (29/44) were of juvenile herring gulls (*Larus argentatus* subsp), at least three but probably not more than four individuals being involved. Leach's storm petrels (*Oceanodroma leucorhoa*) were seen on five occasions including eight individuals at one observation. Other species confirmed were greater shearwater (*Puffinus gravis*), red-billed tropic bird (*Phaethon aethereus*), pomarine skua (*Stercorarius pomarinus*), Atlantic gull (*Larus argentatus atlantis*) and Sandiwch tern (*Sterna sandvicensis*).

Work area - Dakar (3 days, 22 observations). Isolated records of the northern soft-plumaged petrel (*Pterodroma mollis* subsp.), Leach's storm petrel and juvenile herring gull were obtained prior to the last day of the passage. When in sight of Cap Vert, Leach's storm petrel, pomarine skua and long-tailed skua (*Stercorarius longicaudus*) were seen. Single individuals of Scop's owl (*Otus scops*), wheatear (*Oeanthe oeanthe*) and willow warbler (*Phylloscopus trochilus*) were found on board on the final day of the leg.

Overall 151 ten minute observations were made, during 49 (32%) of which birds were seen. During 14 (9%) observations more than a single individual was seen, but at only 5 (3%) were more than one species present.

In view of the great distance from land and the oligotrophic nature of the working area, the low numbers and diversity of birds seen is unsurprising.

MHT

SUMMARY AND CONCLUSIONS

The 26 days allotted to leg 1 of the cruise proved adequate to achieve almost all of the projected programme and the necessary passage time. This was despite time lost as a result of persistent operational problems with the main winch. Fortunately, no time was lost to bad weather. The programme for leg 2 was more open-ended and the 17 days of sampling and passage time allowed all participants to achieve their objectives.

Benthic sampling during leg 1 was the first to be undertaken under the MAST II programme and provided a good suite of samples for participating partners and for comparison with results obtained by the French EUMELI programme. Midwater sampling, particularly during leg 2, generated an abundance of material for a wide range of photobiology studies. The highly oligotrophic nature of the EUMELI site was demonstrated dramatically by the small catches both in midwater and on the sea floor. This contrasted

strongly with the more productive waters over the continental slope and rise further to the east which were sampled during leg 2.

The combination of benthic and midwater sampling during leg 1 demonstrated yet again the practicability of meshing together different but complementary prime objectives.

ALR, PJH

ACKNOWLEDGEMENTS

As always, it is a pleasure to acknowledge the whole-hearted help, interest and encouragement shown by the Master and ship's company. The achievement of so much during the cruise was a result of their willing and skilled assistance. In addition, we are deeply indebted to the RVS and IOS technicians for their sterling work and for the long hours required of them to operate and modify a new and under-tested winch system.

ALR, PJH

TABLE 1

Multiple corer deployments

Stn 12600	Recovered	Usable	Length (mm)	Comments
#3	12	11	70-85	2 cores bubbled
#5	11	10	85-105	
#9	12	11	50-80	
#13	12	11	112-125	4 extra weights added. 1 core lost on deck.
#18	12	8	105-135	Several of "usable" cores disturbed.
#22	10	10	90-105	1 core disturbed.
#27	12	11	90-112	1 core bubbled.
#31	12	11	90-115	4 cores bubbled.
#37	12	11	73-105	Several cores bubbled.
#43	12	11	90-105	3 cores bubbled.
#49	12	12	75-110	Several cores bubbled.
#56	12	12	100-130	1 core bubbled slightly.
#59	12	12	90-115	1 core bubbled.

TABLE 2

Fate of multiple corer samples from Stn 12600. Individuals responsible for the different projects are identified as follows: DB = D. Boardman; MB = M. Beghyn; ND = N. Debenham; DE = D. Eardley; AG = A.J. Gooday; IH = I. Horsfall; JP = J. Patching; MR = M. Ripley, SS = S. Scheibe

Station 12600	#3	#5	#9	#13	#18	#22	#27	#31	#37	#43	#49	#56	#59
CHEMISTRY (DB, IH, MR)	2	2	2	2	-	-	11	2	-	-	2	3	-
NEMATODES (ND)	1	1	1	-	1	1	-	-	1	-	-	-	1
FORAMS (AG)													
Subcores (3.46cm^2)	2	-	1	-	-	1	-	1	-	-	-	1	-
Total cores	2	1	3	-	-	2	-	1	-	-	-	3	11
Incubations	-	-	-	-	-	2	-	-	-	-	-	-	-
GENT (MB)													
Meiofauna	1	1	2	2	1	2	-	2	-	-	2	-	-
Nutrients	1	1	-	1	1	-	-	-	-	-	1	-	-
Bacteria, C/N, Chlo	1	1	1	1	1	1	-	1	-	-	1	-	-
Incubations	-	-	-	-	-	-	-	-	7	-	-	4	-
GALWAY (JP, DE)													
Uptakes	-	-	1	-	1	-	-	1	-	-	-	1	-
Total counts	-	-	-	2	-	-	-	-	-	-	2	-	-
Nucleic Acid Studies	1	-	-	1	-	1	-	-	-	-	1	-	-
SCW[1]	-	-	-	3	-	-	-	-	-	4	-	-	-
BIOCHEMISTRY[2] (SS)	-	3	-	3	3	-	-	3	3	-	3	-	(10)
MAST	-	-	-	-	-	-	-	-	-	11	-	-	-

[1] SCW = Sediment contact water
[2] Samples analysed for CPE, ATP, protein, digestible proteins, water content, ETS activity

TABLE 3

Numbers of samples and treatments of megafaunal species taken for glycogen analysis

Species	Treatment		
	Frozen	Frozen and preserved from same animal	Preserved
Glyphocrangon atlantica	23		
Plesiopenaeus armatus	17		
Histiobranchus bathybius		1	
Conocara salmoneum		2	
Bathysaurus mollis		1	
Bathypterois longipes		4	5
Barathrites sp.		1	
Bassozetus sp. 2		2	
Bathyonus laticeps	1	20	4
Chalinura profundicolus		7	
Nematonurus armatus		5	

TABLE 4

Summary of sampling programme

	Leg 1	Leg 2
BN1.5/3F	2	
BN1.5/C	4	
BOX CORER	13	
BSNACK	3	
BSNAP	1	
CTD	7	
DEMAR	3	
LHPR		6
MLT CORER	13	
RMT 1+8	11	
RMT 1+8 with CCE		49
RMT 1+8M		12
VET	1	
WASP	4	

STATION LIST

Gear codes used in station list

BN1.5/3F	Epibenthic sledge, triple fine mesh nets
BN1.5/C	Epibenthic sledge, coarse mesh
BOX CORER	Spade box corer
BSNACK	Bathysnack, baited pop-up camera system
BSNAP	Bathysnap, pop-up camera system
CCE	Closing cod end
CTD	Neil Brown conductivity/temperature/depth instrument
DEMAR	Bottom amphipod trap
LHPR	Longhurst Hardy plankton recorder
MLT CORER	Multiple corer
MS	Rosette sampler on CTD
NN	Neuston net
OTSB14	Semi-balloon otter trawl
RMT1	1m^2 rectangular midwater trawl
RMT1M	Multiple 1m^2 rectangular midwater trawl
RMT8	8m^2 rectangular midwater trawl
RMT8M	Multiple 8m^2 rectangular midwater trawl
VET	Vertical amphipod trap string
WASP	Wide angle survey photographic instrument

Positions for OTSB14 and BN1.5 deployments are gear positions, those for pop-up gear (BSNACK, BSNAP, DEMAR, VET) are ship positions at start of free-fall, and all others are ship positions.

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12599 # 1	26/ 9	24 56.2N 24 56.2N	22 49.2W 22 49.2W	CTD MS	0- 250	1532-1557	All w/b's @ 250m	
12600 # 1	28/ 9	20 54.0N 20 58.1N	31 10.7W 31 7.8W	RMT1 RMT8	0- 700	1400-1648	Materials haul, catch discarded	
12600 # 2	28/ 9	21 4.3N 21 4.2N	31 10.3W 31 10.0W	CTD MS	0-4550	1830-2215	w/b's all at 22mab	4572
12600 # 3	29/ 9	21 4.4N	31 10.0W	MLT.CORER	4583-4583	0121-	12 short cores V. glutinous	4583
12600 # 4	29/ 9	21 5.7N	31 11.3W	BOX CORER	4607-4607	0527-	No strong pull-out, but good core	4607
12600 # 5	29/ 9	21 2.5N	31 10.9W	MLT.CORER	4548-4548	1300-	11 cores, but one disturbed	4548
12600 # 6	29/ 9	21 2.7N	31 11.4W	BSNACK	4548-4548	1727-	Failed to pop-up although releases OK	4548
12600 # 7	29/ 9	21 2.4N	31 11.5W	BOX CORER	4549-4549	2252-	Bad sample	4549
12600 # 8	30/ 9	20 53.9N 20 57.7N	31 13.6W 31 9.1W	RMT1 RMT8	0- 350	0235-0500	Materials haul, catch discarded	
12600 # 9	30/ 9	21 1.9N	31 11.7W	MLT.CORER	4545-4545	0805-	12 good cores	4545
12600 #10	30/ 9	21 3.2N	31 11.0W	BOX CORER	4543-4543	1230-	Good but slighly oblique core	4543

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600 #11	30/ 9	21 3.9N 21 4.1N	31 11.1W 31 11.5W	CTD MS	0-4582	1450-1915	w/b @ 10 &26mab and standard depths	4592
12600 #12	1/10	20 53.6N 21 2.1N	31 13.5W 31 7.5W	OTSB14	4490-4600	0502-0825	Good catch Tow dist. 18.894 km.	
12600 #13	1/10	21 2.2N	31 11.4W	MLT.CORER	4544-4544	1722-	with 4 extra weights; 12 good cores	4544
12600 #14	1/10 7/10	21 1.1N	31 10.8W	BSNACK	4549-4549	1953-1443		4549
12600 #15	1/10 2/10	21 2.9N 21 4.0N	31 8.6W 31 2.2W	RMT1 RMT8	0- 260	2210-0015	Materials haul, catch discarded	
12600 #16	2/10	21 2.2N	31 12.6W	BOX CORER	4557-4557	0841-	Good core	4557
12600 #17	2/10	21 2.7N 21 3.1N	31 11.7W 31 11.6W	CTD MS	0-4548	1110-1439	All w/b's @ 2000m; acoustic test	4565
12600 #18	2/10	21 3.0N	31 12.5W	MLT.CORER	4560-4560	1627-	12 cores; 5 disturbed	4560
12600 #19	3/10	20 58.8N 21 3.7N	31 9.6W 31 6.3W	BN1.5/C	4582-4627	0020-0250	No odometer Tow dist. 10.807 km.	
12600 #20	3/10	21 5.8N 21 10.0N	31 2.9W 30 58.1W	RMT1 RMT8	0- 799	0632-0902	Materials haul, catch discarded	
12600 #21	3/10	21 4.5N	31 9.6W	BOX CORER	4551-4551	1218-	Good core	4551

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600 #22	3/10	21 3.3N	31 10.8W	MLT.CORER	4542-4542	1942-	12 good cores	4542
12600 #23	4/10	20 53.1N	31 13.8W	OTSB14	4480-4565	0546-0846	Traces lost positions estimated	
		21 1.5N	31 8.8W				Tow dist. 17.809 km.	
12600 #24	4/10	21 4.2N	31 9.4W	BOX CORER	4491-4491	1922-	Good core	4491
12600 #25	5/10	21 5.2N	31 8.6W	WASP	4515-4570	0016-0315		
		21 6.1N	31 6.7W				Tow dist. 3.735 km.	
12600 #26	5/10	21 7.8N	31 3.9W	RMT1	0- 300	0555-0820	Materials haul, catch discarded	
		21 11.3N	30 58.9W	RMT8				
12600 #27	5/10	21 3.7N	31 10.4W	MLT.CORER	4558-4558	1137-	12 good cores	4558
12600 #28	5/10	21 4.8N	31 11.1W	BOX CORER	4613-4613	1518-	Good sample including Xenophyophore	4613
12600 #29	5/10	20 59.1N	31 9.5W	BN1.5/C	4542-4630	2340-0200	Odometer 6.600km	
	6/10	21 3.7N	31 6.4W				Tow dist. 10.161 km.	
12600 #30	6/10	21 2.4N	31 10.3W	BOX CORER	4544-4544	0900-	Good sample	4544
12600 #31	6/10	21 2.5N	31 12.0W	MLT.CORER	4548-4548	1457-	12 good cores	4548
12600 #32	6/10	21 3.6N	31 10.0W	BOX CORER	4545-4545	1955-	Good sample	4545

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600	7/10	20 51.7N	31 14.9W	OTSB14	4503-4576	0515-0740		
#33		20 57.8N	31 10.4W				Tow dist. 13.822 km.	
12600	7/10	21 3.4N	31 10.2W	RMT1	0- 986	1735-2200	Materials haul, catch discarded	
#34		21 13.9N	31 4.3W	RMT8				
12600	7/10	21 8.3N	31 7.5W	NN	0- 0	1945-2030	Non-standard haul preserved for Synopia	
#35		21 10.0N	31 6.6W					
12600	8/10	21 2.5N	31 12.0W	WASP	4478-4560	0130-0500		
#36		21 3.8N	31 9.0W				Tow dist. 5.759 km.	
12600	8/10	21 3.1N	31 11.9W	MLT.CORER	4581-4581	1100-	12 cores, but 3 disturbed, 1 v.short	4581
#37								
12600	8/10	21 3.9N	31 12.9W	CTD	0-4550	1400-1745	All w/bs within 7-9mab	21 4559
#38		21 3.8N	31 12.8W	MS				
12600	8/10	21 3.9N	31 12.7W	CTD	0- 150	1806-1826	All w/b's at 150m	4559
#39		21 3.9N	31 12.7W	MS				
12600	8/10	21 4.6N	31 13.2W	BOX CORER	4569-4569	2104-	Highly slanted, discarded	4569
#40								
12600	9/10	21 4.6N	31 11.6W	BSNACK	4615-4615	0103-1107		4615
#41	14/10							
12600	9/10	20 57.1N	31 10.0W	BN1.5/3F	4570-4580	0616-0716	No odometer	
#42		20 58.6N	31 8.9W				Tow dist. 3.371 km.	
12600	9/10	21 3.4N	31 10.7W	MLT.CORER	4550-4550	1438-	12 good cores	4550
#43								

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600 #44	9/10 10/10	21 5.2N	31 6.6W	DEMAR	4540-4540	1917-0602	21 05.19'N 31 06.61'W	4540
12600 #45	10/10	21 3.4N	31 9.8W	BOX CORER	4524-4524	1120-	Good core	4524
12600 #46	10/10 11/10	21 1.2N	31 13.0W	DEMAR	4555-4555	1809-1706	Good catch. 21 01.22'N, 31 13.00'W	4555
12600 #47	10/10	20 42.4N 20 43.3N	31 24.0W 31 20.3W	RMT1 RMT8	0- 390	2148-2330	Materials haul, catch discarded	
12600 #48	11/10	20 58.7N 21 8.8N	31 17.4W 31 12.8W	OTSB14	4570-4625	0628-0950	Tow dist. 20.278 km.	
12600 #49	11/10	21 3.1N	31 11.4W	MLT.CORER	4553-4553	2228-	12 fairly good cores	4553
12600 #50	12/10	20 56.4N 20 59.7N	31 11.1W 31 7.8W	BN1.5/3F	4550-4610	0652-0922	No odometer Tow dist. 8.471 km.	
12600 #51	12/10	21 4.4N	31 7.2W	VET	4582-4582	1600-	Traps set up to 1000mab, release failed	4582
12600 #52	12/10	21 4.7N	31 10.8W	BOX CORER	4588-4588	1816-	Good core, thickest yet	4588
12600 #53	12/10	21 8.0N 21 12.9N	31 10.8W 31 7.6W	RMT1 RMT8	0- 250	2055-2305	Materials haul, catch discarded	
12600 #54	13/10	21 0.5N 21 1.0N	31 9.1W 31 7.5W	WASP	4568-4584	0216-0516	Tow dist. 3.057 km.	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600 #55	13/10	21 3.9N	31 10.3W	BOX CORER	4561-4561	0925-	Failed	4561
12600 #56	13/10	21 2.2N	31 11.2W	MLT.CORER	4546-4546	1331-	12 excellent cores	4546
12600 #57	14/10	21 3.1N 21 9.9N	31 11.4W 31 6.0W	OTSB14	4520-4640	0152-0430	Tow dist. 15.545 km.	
12600 #58	14/10	21 4.7N 21 4.8N	31 11.3W 31 11.3W	CTD MS	0- 150	1130-1150	12 bottles fired at 150m	
12600 #59	14/10	21 2.1N	31 11.8W	MLT.CORER	4540-4540	1524-	12 good cores	4540
12600 #60	14/10	21 5.1N	31 12.9W	DEMAR	4569-4569	2023-	Fizz link released mooring early	4569
12600 #61	14/10	21 6.3N 21 8.9N	31 11.4W 31 5.4W	RMT1 RMT8	0- 200	2037-2254	Materials haul. Residue preserved	
12600 #62	14/10	21 6.9N 21 7.7N	31 10.4W 31 8.4W	NN	0- 0	2100-2145	Non-standard tow preserved for Synopia	
12600 #63	15/10	20 59.3N 21 4.8N	31 12.3W 31 10.0W	BN1.5/C	4540-4600	0330-0642	No odometer Tow dist. 10.921 km.	
12600 #64	15/10	21 1.4N 21 8.8N	31 11.2W 31 8.1W	BN1.5/C	4540-4600	1503-1756	No odometer Tow dist. 14.734 km.	
12600 #65	15/10	21 11.5N 21 5.9N	30 58.6W 31 2.8W	RMT1 RMT8	0- 400	2105-2335	Materials haul, catch discarded	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12600	16/10	20 56.0N	31 11.5W	OTSB14	4500-4610	0726-1025		
#66		21 3.5N	31 5.3W				Tow dist. 17.468 km.	
12600	16/10	21 8.0N	31 10.5W	WASP	4580-4620	2217-0206	Colour film	
#67	17/10	21 8.9N	31 7.4W				Tow dist. 5.708 km.	
12600	17/10	20 59.0N	31 15.8W	RMT1	0- 375	0508-0740	Materials haul, catch discarded	
#68		21 1.0N	31 10.6W	RMT8				
12600	17/10	21 2.0N	31 11.3W	BSNAP	4550-4550	1045-	Long-term deployment.	4550
#69								
12601	21/10	17 5.4N	18 0.4W	RMT1	500- 700	1410-1612	Materials haul, catch discarded	
# 1		17 11.0N	17 57.8W	RMT8		Day		
				CCE				
12601	21/10	17 18.9N	17 56.4W	RMT1	700- 900	1928-2027	Materials haul, catch discarded	
# 2		17 22.6N	17 56.6W	RMT8		Dusk		
				CCE				
12601	22/10	17 31.8N	17 54.8W	RMT1	214- 268	0045-0145	Materials haul, catch discarded	
# 3		17 35.2N	17 54.1W	RMT8		Night		
				CCE				
12601	22/10	17 40.5N	17 50.2W	RMT1	380- 500	0525-0625	Materials haul, catch discarded	
# 4		17 42.5N	17 48.4W	RMT8		Night		
				CCE				
12601	22/10	17 45.6N	17 46.2W	LHPR	0- 290	0900-1203		
# 5		17 55.2N	17 44.6W			Day		
12601	22/10	18 2.0N	17 48.7W	RMT1M/1	960-1200	1920-2021	Materials haul, catch discarded	
# 6		18 4.8N	17 48.7W	RMT8M/1		Dusk		

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12601 # 7	22/10	18 4.8N 18 7.9N	17 48.7W 17 48.4W	RMT1M/2 RMT8M/2	900- 960	2021-2120 Night	Materials haul, catch discarded	
12601 # 8	22/10	18 7.9N 18 11.4N	17 48.4W 17 48.3W	RMT1M/3 RMT8M/3	800- 900	2120-2225 Night	Materials haul, catch discarded	
12601 # 9	23/10	18 23.9N 18 26.9N	17 47.1W 17 46.4W	RMT1M/1 RMT8M/1	1405-1530	0410-0510 Night	Materials haul, catch discarded	
12601 #10	23/10	18 26.9N 18 30.5N	17 46.4W 17 45.4W	RMT1M/2 RMT8M/2	1295-1405	0510-0620 Night	Materials haul, catch discarded	
12601 #11	23/10	18 30.5N 18 33.6N	17 45.4W 17 44.7W	RMT1M/3 RMT8M/3	1195-1315	0620-0721 Dusk	Materials haul, catch discarded	
12602 # 1	23/10	18 34.4N 18 36.5N	19 10.1W 19 9.3W	RMT1 RMT8 CCE	480- 600	1712-1813 Day	Materials haul, catch discarded	
12602 # 2	23/10	18 41.0N 18 43.3N	19 8.6W 19 8.4W	RMT1 RMT8 CCE	430- 500	2213-2313 Night	Materials haul, catch discarded	
12602 # 3	24/10	18 45.9N 18 48.0N	19 9.2W 19 8.9W	RMT1 RMT8 CCE	105- 150	0219-0319 Night	Materials haul, catch discarded	
12602 # 4	24/10	18 51.5N 18 54.2N	19 7.5W 19 5.8W	RMT1 RMT8 CCE	780- 895	0555-0725 Night	Materials haul, catch discarded	
12602 # 5	24/10	18 56.5N 19 9.1N	19 4.9W 18 57.6W	LHPR	0- 360	0904-1203 Day		

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12602 # 6	24/10	19 10.3N 19 13.3N	18 57.6W 18 55.7W	RMT1 RMT8 CCE	0- 530	1342-1457 Day	Materials haul, catch discarded	
12602 # 7	24/10	19 19.5N 19 20.8N	18 50.7W 18 49.7W	RMT1 RMT8 CCE	450- 550	1857-1927 Day	Materials haul, catch discarded	
12602 # 8	24/10	19 25.6N 19 27.0N	18 45.5W 18 44.7W	RMT1 RMT8 CCE	0- 67	2217-2247 Night	Materials haul, catch discarded	
12602 # 9	25/10	19 30.5N 19 33.0N	18 41.5W 18 40.6W	RMT1 RMT8 CCE	180- 210	0124-0224 Night	Materials haul, catch discarded	
12602 #10	25/10	19 39.4N 19 41.6N	18 36.8W 18 35.4W	RMT1 RMT8 CCE	990-1020	0622-0721 Dawn	Materials haul, catch discarded	
12602 #11	25/10	19 47.6N 19 49.8N	18 31.1W 18 29.9W	RMT1M/1 RMT8M/1	890-1060	1335-1433 Day	Materials haul, catch discarded	
12602 #12	25/10	19 49.8N 19 52.3N	18 29.9W 18 28.5W	RMT1M/2 RMT8M/2	800- 875	1433-1535 Day	Materials haul, catch discarded	
12602 #13	25/10	19 52.3N 19 55.1N	18 28.5W 18 28.2W	RMT1M/3 RMT8M/3	700- 800	1535-1635 Day	Materials haul, catch discarded	
12602 #14	25/10	20 4.9N 20 8.3N	18 27.0W 18 27.0W	RMT1M/1 RMT8M/1	1840-2000	2110-2210 Night	Materials haul, catch discarded	
12602 #15	25/10	20 8.3N 20 11.9N	18 27.0W 18 26.6W	RMT1M/2 RMT8M/2	1790-1840	2210-2310 Night	Materials haul, catch discarded	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12602 #16	25/10 26/10	20 11.9N 20 15.4N	18 26.6W 18 26.8W	RMT1M/3 RMT8M/3	1710-1790	2310-0010 Night	Materials haul, catch discarded	
12602 #17	26/10	20 24.9N 20 26.9N	18 20.6W 18 19.1W	RMT1 RMT8 CCE	20- 350	0705-0805 Dawn	Materials haul, RMT8 catch retained	
12602 #18	26/10	20 0.0N 20 0.0N	18 0.0W 18 0.0W	LHPR	0- 365	0935-1230 Day	System jammed by Radiolarians	
12602 #19	26/10	20 38.0N 20 42.0N	18 9.9W 18 10.4W	RMT1 RMT8 CCE	0- 400	1315-1508 Day	Net failed to close; catch discarded	
12602 #20	26/10	20 43.1N 20 45.0N	18 13.8W 18 14.8W	RMT1 RMT8 CCE	510- 600	1651-1751 Day	Materials haul, catch discarded	
12602 #21	26/10	20 47.6N 20 50.0N	18 15.3W 18 15.1W	RMT1 RMT8 CCE	690- 800	1930-2030 Dusk	Materials haul, catch discarded	
12603 # 1	27/10	20 53.6N 20 55.7N	18 47.7W 18 46.7W	RMT1 RMT8 CCE	215- 275	0105-0205 Night	Materials haul, catch discarded	
12603 # 2	27/10	20 59.5N 21 1.6N	18 43.0W 18 40.6W	RMT1 RMT8 CCE	640- 750	0531-0630 Night	Materials haul, catch discarded	
12603 # 3	27/10	21 9.1N 21 12.9N	18 42.7W 18 41.2W	RMT1 RMT8 CCE	1600-1800	1037-1207 Day	Materials haul, RMT8 residue retained	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12603 # 4	27/10	21 20.3N 21 22.6N	18 38.2W 18 35.9W	RMT1 RMT8 CCE	500- 600	1558-1713 Day	Materials haul, catch discarded	
12603 # 5	27/10	21 24.1N 21 23.7N	18 36.7W 18 40.5W	RMT1 RMT8 CCE	130- 195	2129-2230 Night	Materials haul, catch discarded	
12603 # 6	28/10	21 25.7N 21 28.1N	18 42.7W 18 42.4W	RMT1 RMT8 CCE	760- 850	0127-0227 Night	Materials haul, catch discarded	
12603 # 7	28/10	21 29.2N 21 30.4N	18 53.1W 18 56.6W	RMT1 RMT8 CCE	480- 530	0633-0733 Dawn	Materials haul, catch discarded	
12603 # 8	28/10	21 27.9N 21 24.6N	19 9.0W 19 12.6W	RMT1 RMT8 CCE	1850-2000	1155-1326 Day	Materials haul, RMT8 catch retained	
12603 # 9	28/10	21 18.6N 21 8.6N	19 18.8W 19 29.9W	LHPR	0- 250	1628-1935 Dawn		
12603 #10	28/10	21 7.4N 21 5.5N	19 31.5W 19 33.6W	RMT1 RMT8 CCE	180- 240	2045-2145 Night	Materials haul, catch discarded	
12603 #11	29/10	21 0.9N 20 58.5N	19 35.4W 19 36.9W	RMT1 RMT8 CCE	570- 650	0116-0216 Night	Materials haul, catch discarded	
12603 #12	29/10	20 52.9N 20 52.2N	19 43.7W 19 47.6W	RMT1 RMT8 CCE	910-1015	0617-0745 Dawn	Materials haul, catch discarded	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12603	29/10	20 46.9N	19 57.9W	RMT1	2350-2550	1213-1416	Materials haul, RMT8 catch retained	
#13		20 44.7N	20 3.0W	RMT8		Day		
				CCE				
12604	30/10	20 46.2N	21 0.5W	RMT1	120- 230	0020-0120	Materials haul, catch discarded	
# 1		20 45.3N	21 3.1W	RMT8		Night		
				CCE				
12605	30/10	20 35.1N	20 58.5W	RMT1	340- 450	0403-0503	Materials haul, catch discarded	
# 1		20 33.2N	20 56.8W	RMT8		Night		
				CCE				
12606	30/10	20 20.4N	20 47.2W	RMT1	550- 630	0750-0850	Materials haul, catch discarded	
# 1		20 19.1N	20 45.2W	RMT8		Dawn		
				CCE				
12606	30/10	20 18.3N	20 43.9W	LHPR	0- 400	0955-1257		
# 2		20 8.1N	20 34.2W			Day		
12606	30/10	20 6.8N	20 32.8W	RMT1	175- 250	1344-1444	Materials haul, catch discarded	
# 3		20 5.2N	20 31.4W	RMT8		Day		
				CCE				
12606	30/10	20 0.4N	20 28.2W	RMT1	590- 750	1652-1753	Materials haul, catch discarded	
# 4		19 58.1N	20 26.8W	RMT8		Day		
				CCE				
12607	30/10	19 28.9N	20 13.1W	RMT1	320- 380	2258-2358	Materials haul, catch discarded	
# 1		19 26.4N	20 11.8W	RMT8		Night		
				CCE				
12608	31/10	19 6.6N	19 59.5W	RMT1	150- 250	0308-0408	Materials haul, RMT8 residue retained	
# 1		19 4.0N	19 58.1W	RMT8		Night		
				CCE				

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12609 # 1	31/10	18 43.2N 18 41.1N	19 47.9W 19 46.8W	RMT1 RMT8 CCE	720- 740	0732-0832 Dawn	Materials haul, catch discarded	
12609 # 2	31/10	18 23.2N 18 19.2N	19 37.0W 19 34.7W	RMT1 RMT8 CCE	1060-1200	1230-1400 Day	Materials haul, RMT8 catch retained	
12610 # 1	31/10	17 49.6N 17 47.0N	19 19.3W 19 18.3W	RMT1 RMT8 CCE	615- 700	1857-1957 Dusk	Materials haul, catch discarded	
12610 # 2	31/10	17 45.1N 17 42.7N	19 17.4W 19 16.0W	RMT1 RMT8 CCE	180- 220	2225-2325 Night	Materials haul, catch discarded	
12611 # 1	1/11	17 23.3N 17 20.3N	19 4.9W 19 3.9W	RMT1 RMT8 CCE	95- 130	0222-0327 Night	Materials haul, catch discarded	
12612 # 1	1/11	17 15.5N 17 19.2N	18 56.0W 18 54.5W	RMT1 RMT8 CCE	1050-1105	0632-0803 Dawn	Materials haul, catch discarded	
12612 # 2	1/11	17 22.8N 17 38.0N	18 53.5W 18 49.8W	LHPR	0- 400	0933-1236 Day	System jammed at c. half way	
12613 # 1	1/11	17 25.8N 17 23.6N	18 46.8W 18 47.5W	RMT1 RMT8 CCE	460- 550	1445-1547 Day	Materials haul, catch discarded	
12614 # 1	1/11	16 34.2N 16 37.0N	18 26.2W 18 25.6W	RMT1 RMT8 CCE	620- 890	2200-2300 Night	Materials haul, catch discarded	

STN.	DATE 1993	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12615 # 1	3/11	17 48.5N 17 51.4N	17 40.1W 17 40.0W	RMT1 RMT8 CCE	200- 240	0945-1050 Day	Materials haul, catch discarded	
12615 # 2	3/11	17 55.0N 17 56.4N	17 39.9W 17 40.0W	RMT1 RMT8 CCE	200- 270	1217-1247 Day	Materials haul, catch discarded	
12615 # 3	3/11	18 3.2N 18 7.9N	17 39.8W 17 39.7W	RMT1 RMT8 CCE	1650-1870	1535-1736 Day	Materials haul, catch discarded	
12615 # 4	3/11	18 13.8N 18 16.4N	17 39.5W 17 39.5W	RMT1 RMT8 CCE	200- 260	2036-2135 Night	Materials haul, catch discarded	
12615 # 5	3/11	18 18.8N 18 21.0N	17 39.4W 17 39.5W	RMT1 RMT8 CCE	250- 310	2240-2325 Night	Materials haul, catch discarded	

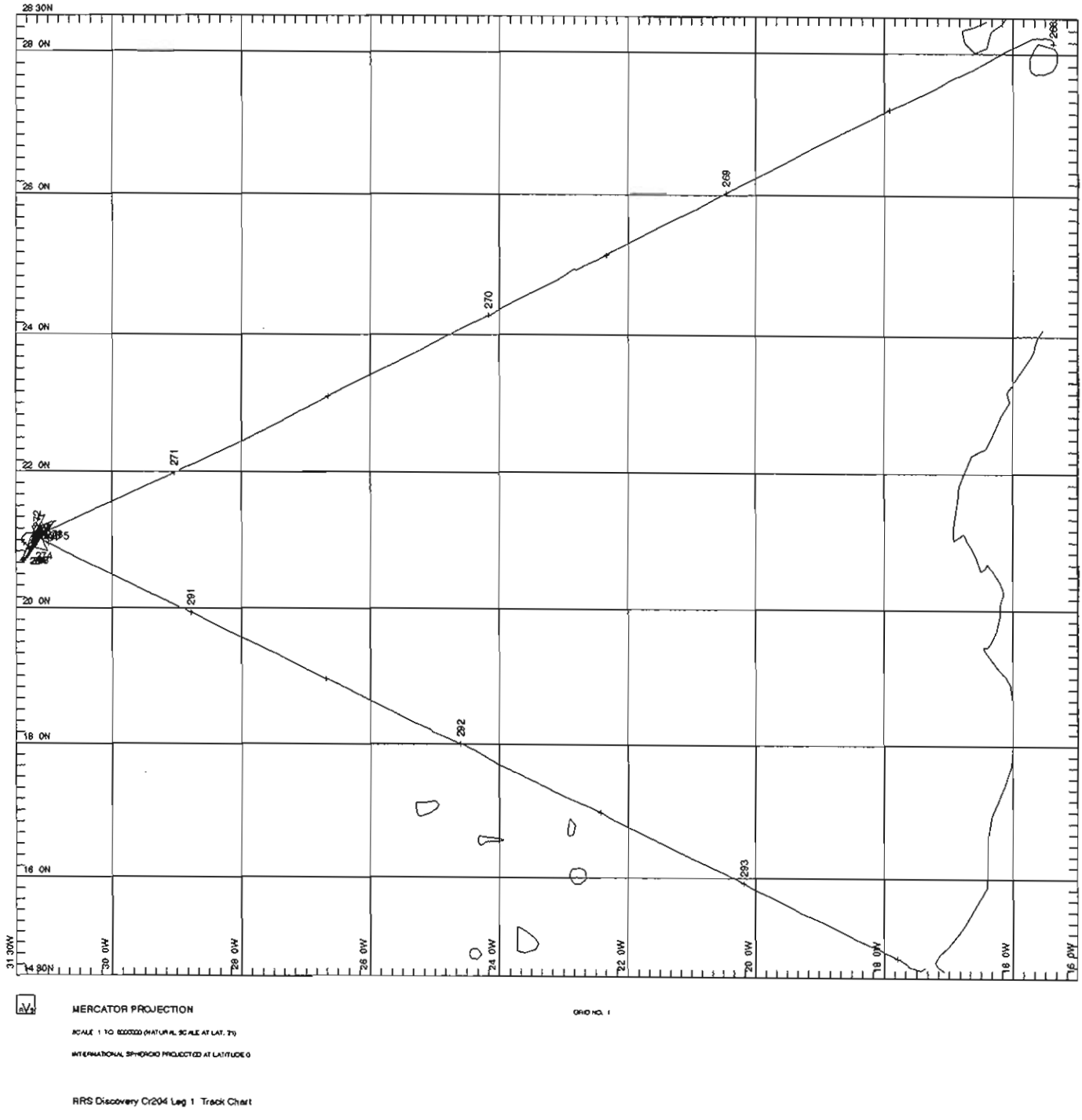

Figure 1. Track chart, RRS *Discovery* Cruise 204, Leg 1 24 Sep - 20 Oct 1993. The position at the start of each day is marked with the Julian day number.

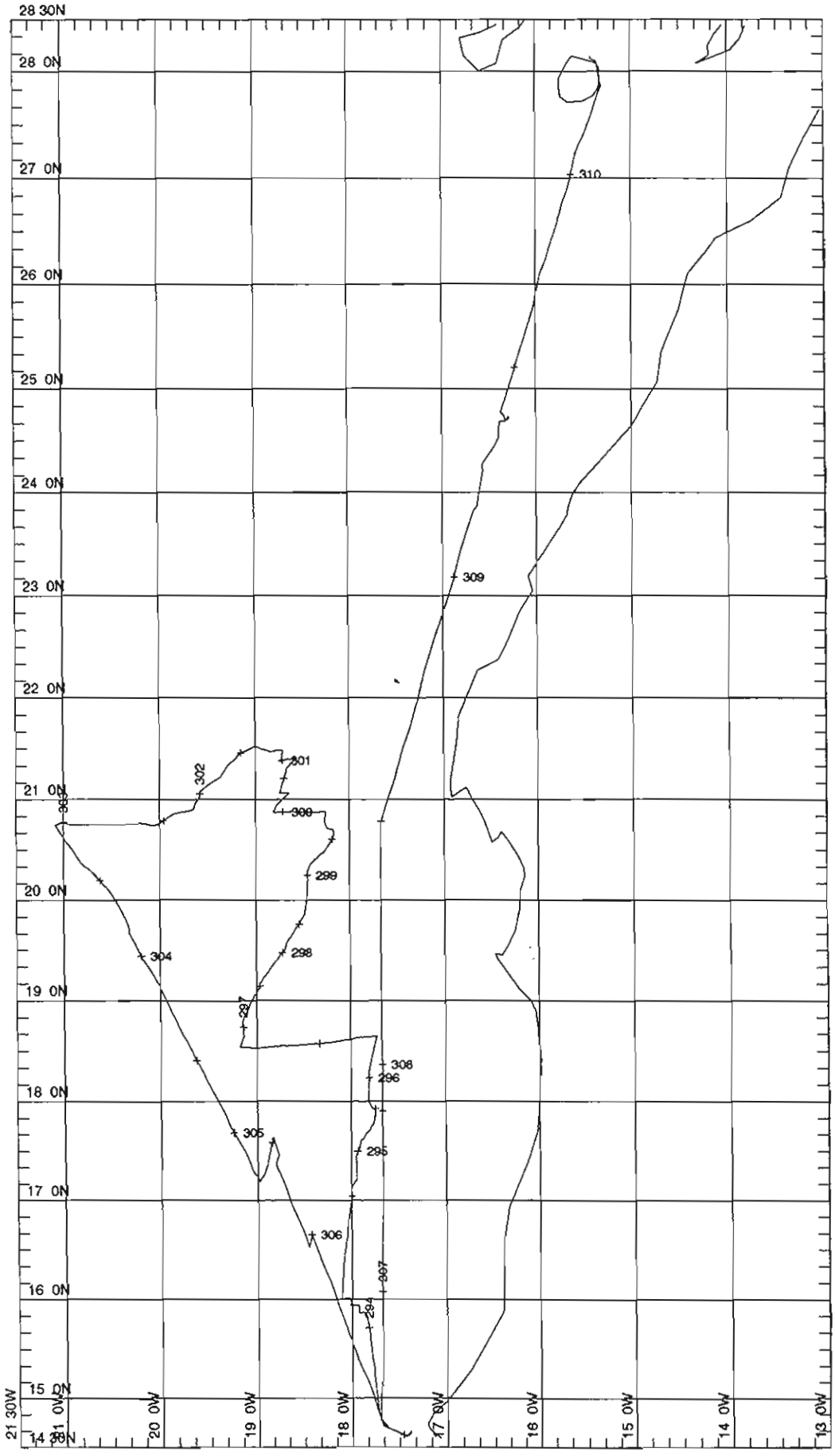

Figure 2. Track chart, RRS *Discovery* Cruise 204, Leg 2 20 Oct - 6 Nov 1993. The position at the start of each day is marked with the Julian day number.

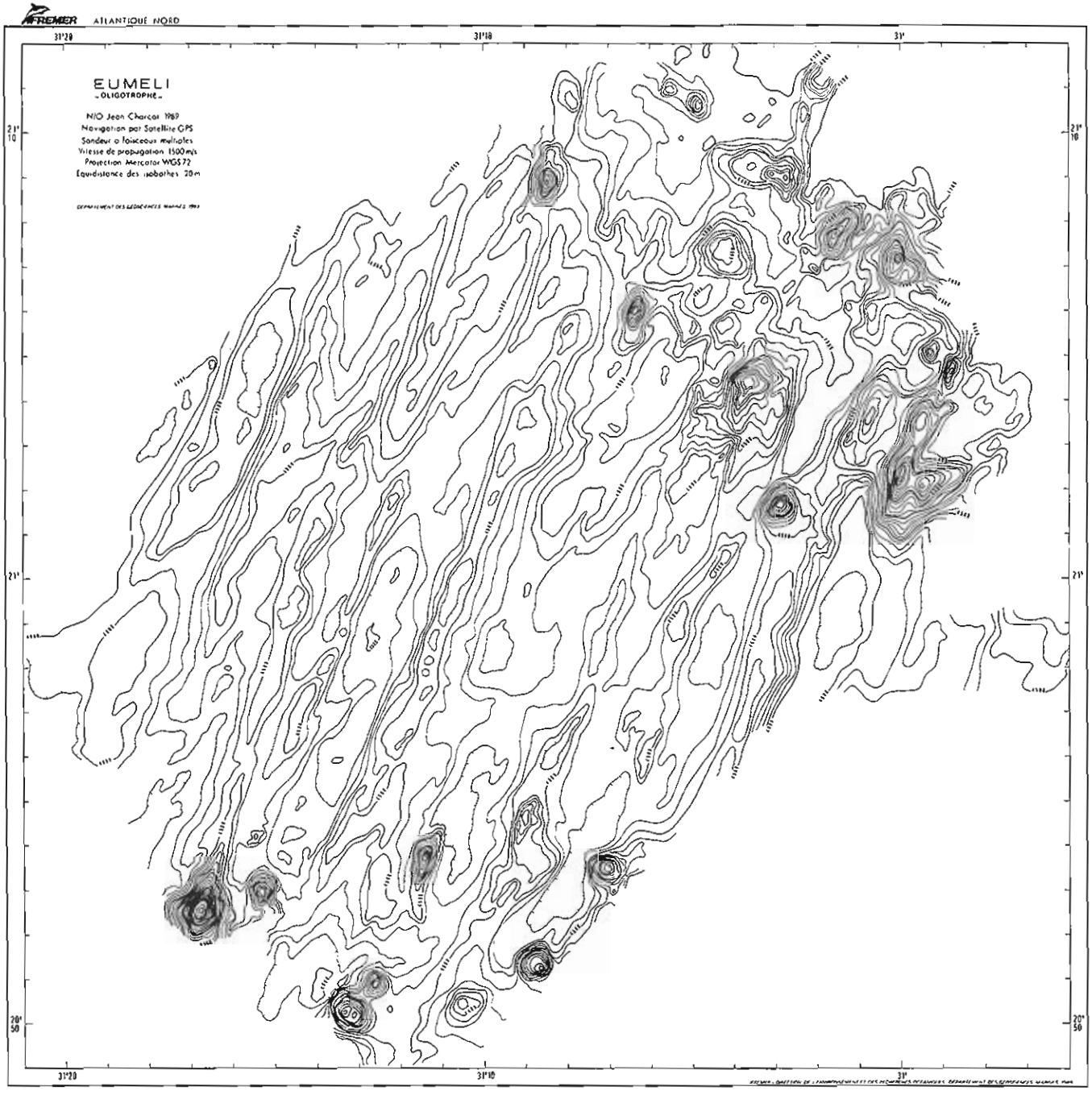

Figure 3. Bathymetry of the benthic sampling area (station 12600) centred on 21°03'N 31°11'W. Soundings obtained during IFREMER EUMELI 1 cruise, Gérard Auffret chief scientist, Serge Monty artist.

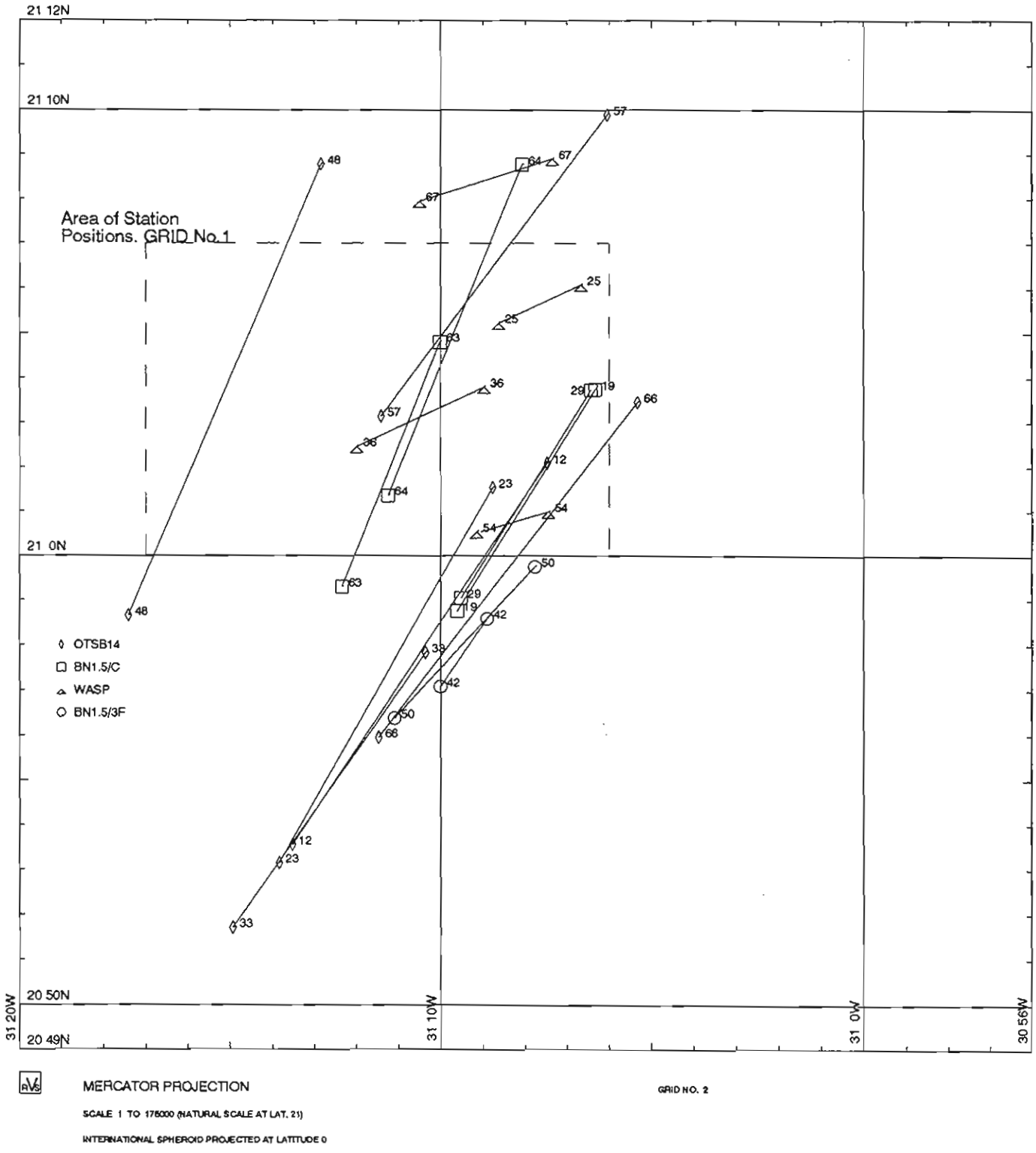

Figure 4. Gear tracks for otter trawl, epibenthic sledge and WASP hauls. Pecked box encloses positions of vertical and free-fall deployments (see Figure 5).

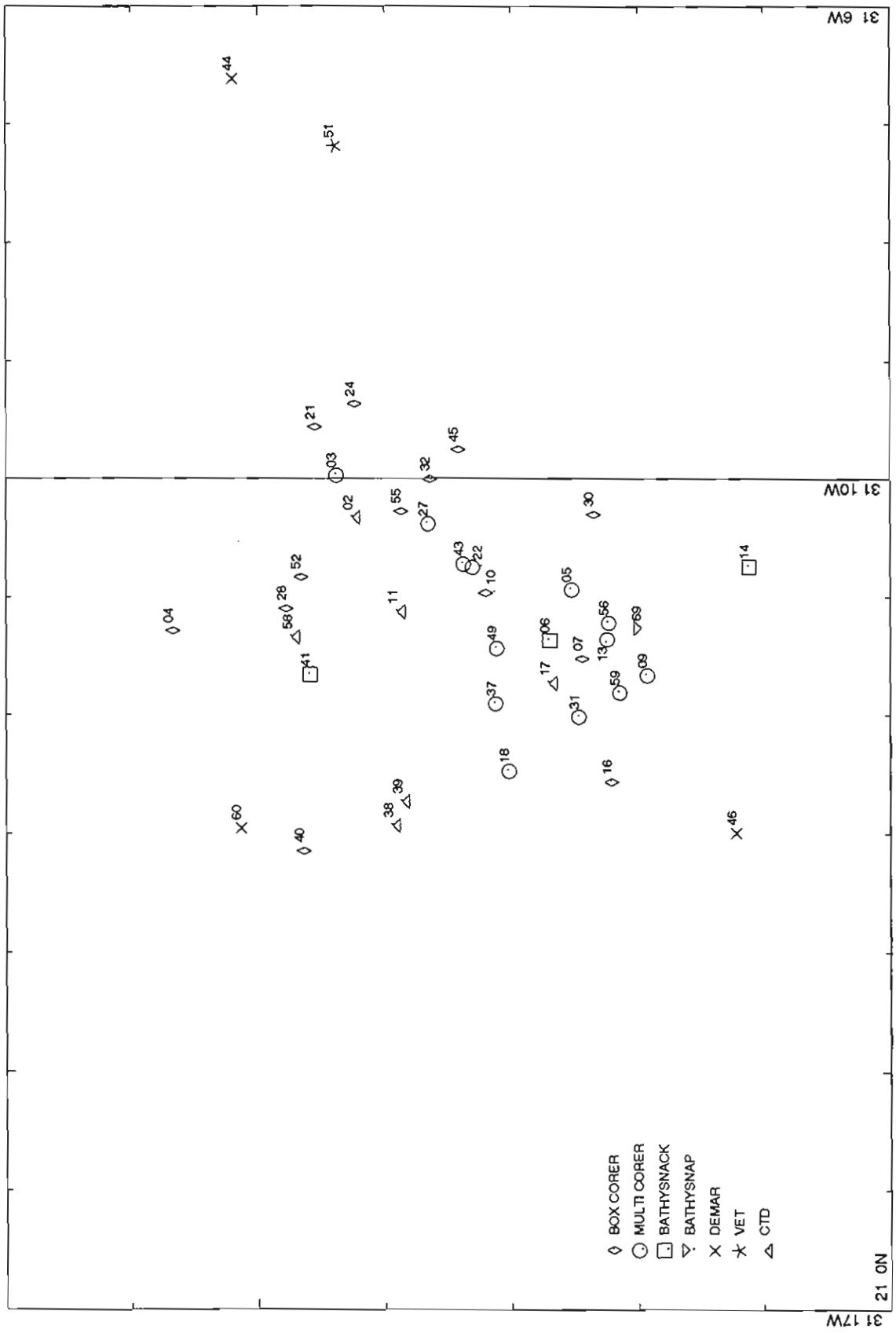

Figure 5. Positions of multiple corer, box corer, Bathysnap, Bathysnack, trap and CTD deployments.