IOS

DEACON LABORATORY

RRS DISCOVERY

CRUISE 175

18 JUNE – 15 JULY 1988

INVESTIGATIONS OF THE FLUX OF BIOGEOCHEMICAL MATERIAL AND ITS TRANSFORMATION BY THE MIDWATER BIOTA AT THE BIOTRANS SITE (*c.* 47°N, 20°W)

CRUISE REPORT NO. 204

1988

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

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Cruise 175

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Investigations of the flux of biogeochemical material and its transformation by the midwater biota at the BIOTRANS site (*c.* 47°N, 20°W)

Principal Scientist

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ABSTRACT

Discovery cruise 175 can be considered as a prelude to and test run for parts of the BOFS (Biogeochemical Ocean Flux Studies) sampling programme. It encompased a multidisciplinary approach to investigation of the flux of biogeochemical material and its transformation by the midwater biota. The BIOTRANS site (ca. 47°N, 20°W) was chosen as it will be one of the primary sampling site during the BOFS experiment.

Attempts were made to assess a) the sedimentation rates of particles using sediment traps; b) the vertical distribution of particles (8-256µm), using the in situ particle counting system FIDO; c) the vertical distribution and diel migrations of plankton and micronekton; d) the vertical distribution (0-300m) of bacteria, phytoplankton and their pigments, and nutrients in conjunction with measurements of the physical structure of the water column; e) flagellate grazing potential.

In addition, large volume filtration systems provided particulate material for various chemical analyses. Midwater and benthic cameras were used to assess the distribution and sedimentation of large particles. Various nets were used to collect faecal pellets and material for biochemical and physiological (including bioluminescence and vision) studies.

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PROJECT

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ITINERARY

Depart Barry 18 June - Arrive Lisbon 15 July 1988

OBJECTIVES

1. To recover sediment trap and Bathysnap moorings previously laid in the Porcupine Seabight (ca. 51°05'N, 12°35'W).

2. To attempt to recover an amphipod trap at the EEC Site (ca. 48°56'N, 12°35'W).

3. To carry out biological, chemical and physical investigations at the BIOTRANS Site (ca. 47°N, 20°W) to study the flux of particles throughout the water column. These investigations to include:-

a) Sediment trap moorings to assess the sedimentation rate of particles, and to provide material for biological and chemical analyses.

b) In situ particle counting (FIDO) to profile particle size (8-256 μm) distribution throughout the water column. This should enable the assessment of mass particle concentration.

c) Large volume filtration systems (SAP and FIDO) to provide material for chemical analyses.

d) Net collection of plankton and micronekton to assess their vertical distribution, diel migrations, and role in trophic transformations and vertical transport of particulate carbon.

e) Collection of surface sediments for biological and chemical analyses.

f) Assessment of phytoplankton and bacterial biomass in the euphotic zone, with measurements of flagellate grazing potential.

NARRATIVE (Fig. 1)

Discovery sailed from Barry at 1000 BST on 18th June. The sailing was delayed overnight to allow the large amount of gear on board to be stowed securely. A short meeting was held that day to outline the objectives of the cruise, together with the general principles of liaison with the Officers and Crew and the necessary safety procedures.

Course was set for the Porcupine Seabight and, overnight, an attempt was made to calibrate the ship's DF off Ballycotton Lighthouse, near Cork, Eire. This had to be abandoned owing to insufficient signal strength from the lighthouse. The PES fish was deployed at 0900 GMT on 19th June and the 2000m station, in the Porcupine Seabight, reached at 1500 - much time having been made up by steaming at full speed with three engines. Recovery of a sediment trap array, deployed by Discovery in September 1987, commenced and swiftly was accomplished. The complete array of three traps was inboard at 1708, but on deck a weld at the base of one of the funnels was broken, rendering the trap useless. A nearby Bathysnap camera was then recovered, also with alacrity, but later it was found that the camera electronics had flooded shortly after deployment.

A brief neuston net trial was carried out, using a modified 'Oxfam' net as unfortunately the proper nets had not been loaded aboard. As the required material was not caught, passage then was resumed towards the EEC site (ca. 48°56'N, 16°37'W).

Expendable bathythermograph (XBT) launches were commenced at 1900 on 19th June and were continued, at 2h intervals, during passage. The data were telexed to the Hydrographic Office in London. The EEC site was reached at 1200 on 20th June and attempts were made to pop-up an amphipod trap, deployed during a 'Meteor' cruise in May. Although, as before, the trap showed all signs of having released it refused to budge from the bottom and further attempts at recovery were abandoned. Meanwhile a trial of the CTD system, using the forw'd electric winch, was carried out successfully. Concern as to whether the double-barrelled capstan would be able to lift the full array of the large sediment traps was put to the test when four of the traps, and anchor weight, were deployed. Although at its limits, the capstan did manage the task and so it was deemed unnecessary to move the whole exercise aft.

Passage to the BIOTRANS site, the main working area at ca. 47°N, 20°W, was resumed at 1700, and two hourly launches of XBTs continued overnight. The BIOTRANS site was reached at 0800 on 21st June and the ship heaved to in the vicinity of an IOS/Kiel Sediment Trap mooring deployed during the earlier 'Meteor' cruise. Stretching of the kevlar rope required for deployment of the large sediment trap array commenced, but a shortage of take-up drums meant that only about half the necessary rope could be stretched at this time. On completion of this exercise, interrogation of the IOS/Kiel sediment traps was commenced and the array successfully released. However, when the rig surfaced it was found to be a Bathysnap mooring; details of the command releases having been transposed. Nonetheless, the Bathysnap was scheduled for recovery and it duly was. The sediment trap array was then released and recovered, only to find that neither of the traps had worked properly.

A deep CTD cast (0-2000m, St. 11792#1) was then carried out. As the large multisampler frame, with 10 litre water bottles, was not available to us, the CTD was followed later by a series of 30 litre water bottle casts. Completion of the rigging of the RMT 1+8M multiple net system was followed by a test deployment. This revealed a problem with one of the opening/closing frequencies and so the nets were recovered. Overnight a 30 x 30 x 30 nm triangular XBT survey was carried out, to assess the variability in the temperature structure of the upper 700-900m of the water column. This revealed considerable vertical displacements in 11 and 12°C isotherms which, in the SW corner, were at ca. 350 and 150m respectively, whereas in the northern sector they shoaled to 160 and 50m respectively. Meanwhile the 8 and 9°C isotherms were deeper in the northern sector. Shortly after the start of the survey the PES fish broke down, later revealed to be a cable break, and so an echo-sounding survey was prevented. The PES fish was recovered the following (22nd June) morning and the spare fish deployed. It is probable that the cable break caused the problems with the net monitor reported above.

Because of the failure of the IOS/Kiel Sediment traps, it was deemed necessary to carry out a further test on the large sediment traps to investigate whether friction in the carousel mechanism increased with depths, as the earlier failure of the IOS trap had been caused by sticking of the base wheel resulting in stripping of the gear box. The traps were lowered to a maximum depth of ca. 2700m and, on recovery, were found to have rotated properly through their sequence although a damaged switch meant that one did not stop at the required

position. Trials of the Stand Alone Pumps (SAP) were carried out during this time, and later the FIDO system and the RMT 1+8M nets were tested successfully.

The PML Double Longhurst Hardy Plankton Recorder was launched during the night (23rd June), with a day deployment being carried out on the following day; and the day/night series of RMT 1+8M net deployments was commenced. The wrong monitor calibration "sticks" were used on the first haul, but fortuntely the error was almost exactly 100m of depth and so the catches were still of use. Problems arose with hang-up in the mouth of the RMT1M-2 net, which required the catch to be washed down into the cod-end on retrieval. What exactly was causing the problem was never resolved, but it eventually disappeared when the positions of the nets were switched. Sampling of the top 1500m of the water column, using the RMT1+8M net system, continued over the next five days. The shortness of the nights prevented more than one deployment per night, except for the two shallowest deployments, which, with some abbreviation of the haul times, were fished on one night. One of the most striking features of the catches was the large numbers of the amphipod, Parathemisto, which totally dominated the RMT8 catches in the top 200-300m of the water column. When not fishing available time periods were filled by shallow CTDs, further rope stretching and stand alone pump sampling.

It was hoped to deploy the main sediment trap array on the 24th June, but preparations were not completed in time to meet a critical time slot when the traps were in the "open" position. However, all was ready on the 25th June and, amidst the entertainment of an amateur film crew dashing about and around the ship, the deployment took place smoothly, although a misunderstanding resulted in the two middle traps being deployed in the wrong order.

With the virtual completion of the day series of RMT 1+8M nets, time was now available for the planned series of FIDO and SAP dips, to various depths throughout the water column; and shallow CTD casts, often in association with 7.5 or 30 l water bottle casts. This continued during the day, throughout the remainder of the time on station. At irregular intervals during this time test runs of a midwater camera system also were carried out. All these deployments were centred on a position, ca. 47°19'N, 19°17'W, which was roughly in the middle of the 30 nm triangle studied during the XBT survey. However, since the XBT survey was slightly more extensive than planned, the position chosen was the centre of the theoretical 30 nm triangle rather than the actual one.

Once the nighttime series (0-1500m) of RMT1+8M hauls had been completed (28th June), deeper depth horizons were fished during the night using the same system. Sampling was carried out to a depth of 4450m, but the planned series of near-bottom hauls had to be cancelled because it was discovered that there were many slack lays of wire on the main winch drum, beyond ca. 8000 mwo, that were causing dangerous slippage through the warping system. Although time might have allowed for the wire to be stretched and relaid on to the drum, for the sake of one or two hauls, and the fact that the trawling warp was due to be taken off in Lisbon, such use of the available time was deemed unacceptable. It also transpired that two nights of fishing were lost later on in the cruise to bad weather. The RMT 1+8M net system then was broken down and replaced by the basic combination (RMT 1+8) net system, to which, on occasions, was added the closing cod-end. Nets were then fished, at night, in order to obtain material for physiological, biochemical and other studies.

On 28th June a free-floating array of sediment-traps was deployed, with traps at depths of 20, 50 and 230m. The drift of this array was tracked from time to time using radar or radio transmission. On 29th June, as the weather conditions were deteriorating, the dahn buoy and floats attached to the traps were examined closely in case a "cocked" shackle might be putting the integrity of the array in danger. This was found not to be the case, and recovery was delayed to the following morning (30th June). Then, although the wind was was blowing Force 6, the sea state was reasonable enough for recovery. The samples were found to be full of the amphipod, Parathemisto, which, since no preservative had been used, would most likely have eaten any sedimenting material. The presence of these animals should not have been unexpected in the light of the earlier RMT 1+8M catches.

A further deployment of the free-floating trap was planned for 1st July, but the weather was too inclement for most work except SAP deployments. A problem with the midships winch, in that it would not haul in, put it out of action for a day and meant that SAP had to be launched from the forw'd electric winch. However, it was found that the latter's conducting cable was spooling badly and time had to be taken to pay out and relay the wire. That night some 2m diameter ring nets, and high-speed Lowestoft nets were fished, at shallow depths, for the Plymouth Marine Laboratory and a materials haul made using the RMT 1+8 combination net. The weather then deteriorated further, with wind speeds consistently in excess of 30kt, and all work was abandoned until the following

morning (3rd July), when FIDO, SAPs, CTDs and water bottle casts were recommenced. There was a brief hiatus in this sampling programme when a problem appeared in the main engine drive, which resulted in the loss of all means of ship's propulsion. This was speedily rectified. The weather conditions were deemed still to be too dangerous to trawl during the night, but for the remainder of the cruise the basic alternation of FIDOs, CTDs and SAPs during the day, and RMT1+8 materials hauls during the night continued, interspersed occasionally with midwater camera trials and a day and night series of Apstein nets to collect faecal material.

By the 6th July the sea state had become calm enough for further mooring work to be considered. This was begun by the deployment, close to the main sediment trap array in the SW corner of the triangle, of two Bathysnaps. One of these was to be a long term mooring while the other was a test for a 'Camera-Live' camera. Despite assurances of preparedness this proved not to be the case and the deployment of these moorings took far longer than it should have. A series of Apstein nets that was planned to follow these deployments had to be abandoned when it was discovered that the 4mm wire on the forw'd electric winch had parted. It was indeed fortunate that the net had not been lost previously, and it was decided to improve further the poor design of the net in order to allow more weight to be attached to it.

The free-floating sediment traps were then redeployed, at the same depths as previously, but this time a large volume of preservative (formalin) was placed in them. The 7th July brought beautifully calm conditions and discussions were held as to whether the main sediment trap array should be retrieved, as the cumbersome nature of the traps required that the weather conditions be well nigh perfect for recovery, and the weather reports for the last few days on station were conflicting. Nevertheless, pressure was applied to let the experiment run its course, which was due to be completed on 9th July, and so recovery was delayed. The position of the free-floating traps was then fixed and, a further series of FIDO, CTD and water bottles carried out. During the FIDO dip the particle cell failed. The SMBA Multicorer then was launched for the first time and good set of cores were collected, although, unfortunately, no "fluff" was present. A second Multicorer cast was carried out the following morning (8th July). As FIDO was still suffering from 'kennel cough' the free-floating sediment traps were retrieved but again were full of, now preserved, amphipods. Any further deployments were, therefore, abandoned.

At 0600h on the 9th July the weather looked reasonable enough for the recovery of the main sediment trap array to be considered but, because of a critical time window, this recovery could not be commenced until 1200. However, by 0900h the wind speed had increases to 30kt and the sea state was worsening and so thoughts of recovery were abandoned. On the following day (10th July), the wind speed had dropped, but the sea was very confused. As a test run the Camera-Alive Bathysnap was recovered, and from this it was concluded that conditions were not good enough for recovery of the main mooring. The following day brought a slight improvement in conditions and, as we were now running out of time, it was decided to attempt the recovery. However, when the critical moment for firing the release was reached, and the release mechanism apparently had fired, nothing happened. It was apparent that the mooring had parted and that some of it, including the release, was lying on the bottom, unable to rise because of the absence of the buoyancy. All hopes of recovery were abandoned and it was unlikely that we will ever know if the traps had operated successfully. A few more nets, FIDO, SAPs, CTDs and water bottles, culminating in a series of Apstein nets, brought the sampling programme at the BIOTRANS site to a close, and passage to Lisbon began at 1500 on the 12th July. Further XBT launches were carried out over the next 48h and Discovery docked in Lisbon at 0900h on the 15th July.

The success of a research cruise, particularly a multidisciplinary one, depends on collaboration and co-operation not only between the participating scientists, but also with the ship's personnel. The latter were outstanding and I have never participated in a cruise where so much help was so willingly offered and given. Therefore, it is a great pleasure to express my thanks to all the Officers, P.O.'s and crew of Discovery for their considerable contribution to the success of the cruise. I should also like to thank Arthur Fisher for his help, and useful advice, during the organization of this cruise, particularly as it was the last Discovery cruise for which he acted in the capacity of Ship's Liaison Officer. I also thank Ace and Helen Wallace, in Barry, and Rob Bonner, in Lisbon, for their great assistance and cooperation during the hectic times of loading and unloading. Finally, I thank the staff of RVS for their help in smoothing out the last minute hiccoughs that always occur before sailing.

P.R.P.

SAMPLING EQUIPMENT AND INSTRUMENTATION

Midwater nets

RMT Nets

Two basic RMT rigs were used during the cruise, the multinet (RMT 1+8M) and the combintation net (RMT 1+8). The combination net was used either with the closing cod-end (CCE) on the RMT 8 or with a standard bucket and liner. The CCE was left off either during bad weather or when the net was fished deeper than the CCE's operating limit (ca. 1000m). A live cod-end (consisting of a cylindrical plastic bucket with small mesh covered window) was tried on the combination net RMT 1. It proved difficult to handle on deck, particularly in bad weather, as it tended to swing about at head height. Also the window was probably too small to filter effectively the volume of water passing into the bucket. It was considered to have no advantage over the conical bucket and possibly, as it had less drag, adversely affected the shape of the net.

The RMT 1+8M was fished 15 times, to take a day and night vertical series. The electronics functioned well on all occasions. One haul was lost due to the liners being fitted incorrectly and one RMT 1 catch was suspect as a side-wire roller became detached from the end of a net bar during the haul.

A more puzzling problem with the multinet eventually was cured, but still remains a mystery. The catches in some RMT1M-2 nets were hanging up around the mouth of the net. It was noticed that net 1 was considerably longer than nets 2 and 3 and, although clutching at straws, it was thought that this longer net somehow might be having an effect on the net above. Consequently it was changed for a shorter one. This, however, proved not to be the case and the problem still remained. To find out if the catch hang up was due to the net rather than its position in the rig it was decided to change the relative locations of nets 2 and 3. This change cured the catch hang up, which did not recur on any of the subsequent hauls, but the reason for the basic problem was not resolved.

The top panel of the RMT8M-3 net was chafed badly by the end of the vertical series. This was caused by the lacing holding the bucket ring in RMT 1M-1. This could be prevented in future by lacing the ring in such a way that the rope does not lie outside the Nytarp sleeve where it can abrade the net below.

The RMT 1+8 was used successfully with the CCE on 8 occasions, and with a standard RMT 8 bucket on 11 occasions. In the latter form there was one failure due to the drive cam falling off the release gear.

R.G.A.

Apstein Net

This is a 40 cm diameter plankton net with 20 μm mesh. A cone shaped cowl, with a 17 cm aperture and a messenger operated closing mechanism, is fitted to the mouth of the net. The net was purchased as a complete package from Hydro-Bios via their U.K. agents, Duncan Associates, and was delivered to the ship the day before we sailed.

In its original form the net proved to be totally unsuitable for taking vertical samples in the deep-sea. It was so lightly constructed that it would not sink as fast as the pitch rate of the ship, even in fairly calm conditions. Modifications were necessary before the planned series of hauls could be undertaken. A steel ring was manufactured, which fitted round the mouth of the cone and attached to the towing yoke. Three Kevlar ropes were spliced onto the ring, passed under the jubilee clip securing the net to the cone and joined together below the catch bucket, at which point a 50kg weight was attached. The catch bucket was tied, with a thin piece of line, to the junction of the Kevlar ropes to stop the net washing inside out during the descent. In this form the net functioned well and 10 successful samples were taken.

R.G.A.

Electronics and Acoustics

An operational test of the RMT1+8 multinet system was carried out on the fourth day of the cruise. The acoustics provided an erratic operation of the net release, and so the system was recovered and inspected. No fault could be found then, but the location of the problem became apparent that night, during the XBT survey, when the PES fish failed. On recovery of the fish the fault was found to be a ruptured towing cable on the No.2 PES system. This had the effect of shorting the transducers, hence attenuating the acoustic command signals. The fish was replaced with No.5 and this operated successfully for the remainder of the cruise.

On several occasions a closing cod-end device was attached to the RMT8 net to provide, on recovery, a dark environment for the samples preventing the

degeneration of sensitive bioluminescent organs. The cod-end device utilised the IOS solenoid auto-retractor for its operation, and worked without problems.

An IOS telemetry unit was attached to the PML Longhurst-Hardy Plankton Recorder to provide a continuous monitoring of pressure/depth.

Additional work included the conversion/upgrading of a bioluminescence spectrum analyser from a Commodore PET microcomputer to a BBC Master microcomputer. The majority of the time was spent on data translation.

D.E.

Conductivity-Temperature-Depth Probe (CTD)

A total of 17 casts were made successfully with the CTD, including the test deployment at the EEC Site. Three deep casts were made, but these were limited to a maximum depth of 2000m, because of misgivings about the pressure casing and the capabilities of the forward electric winch to haul in the instrumentatiom from deeper depths. However, despite some spooling problems the electric winch functioned well, although the platform requires urgent structural repairs.

Most of the casts were to a depth of 300m and, in addition to the CTD, transmissometer and multisampler, an underwater fluorometer (Chelsea Instruments) and irradiance meter were added. Water bottle samples were taken at various depths in order to obtain chlorophyll a and nutrient profiles, and to obtain salinity samples to calibrate the CTD.

The data were logged by Digidata and the ship-borne computer, via the CTD Level A interface. A BBC microcomputer system provided on-line plots of the various parameters throughout the casts.

T.J.P.G.

FIDO and Stand Alone Pumps

The deep water pumping system (FIDO) was deployed on 17 occasions from the midships winch. Few major problems were encountered, although the particle sensor cell died on one occasion (St. 11794#125), and the pump motor burnt out on another. When sampling close to the sea-bed it was found that not only was there cross-talk between the two near-bottom echo-sounders, but that these caused interference in the particle cell. Nevertheless, an excellent suite of particle count data was obtained for the entire water column, down to a depth of

4577m (5m off the sea bed). In addition, 59 filter samples were collected, using a variety of filter types and manganese scavengers. A total of more than 57,000l of water was pumped through the filters, using the new magnetic coupled pumps.

The Stand Alone Pump (SAP) is a device designed to pump water through filters in order to collect suspended particulate material from the water column. The operation of the unit is controlled by an electronic timer which is set to give a delay time, to allow for deployment, followed by a period of running time during which the pumping takes place. The volume pumped is recorded on a mechanical flow counter.

Although SAP samples were taken during this cruise, the main intention was to evaluate its performance and establish the methodology in order to satisfy the requirements of the BOFS programme. The performance areas of particular importance were the flow rates through the various filter types, and the clogging rates at various depths. The target flow of 1000 l/h was achieved through 293mm diameter GF/F, GF/C and Nuclepore filters. During the cruise it was decided that the most efficient way to sample the top 20m of the water column was to suspend SAP from a rope and power it directly from the ship. This proved to be successful and its capabilities should be developed further, possibly extending the depth limit to 50m. SAPs were also used to collect material on 4.7cm filters and it was found possible to filter 10 l in approximately 10 min before the filter became clogged. In total 24 SAP deployments were carried out, and more then 16,000l of water were filtered.

T.J.P.G., L.H.W.

Moorings

Sediment trap at 51°04.3'N 12°33.7'W.

CR 2432 260 Hz 1.14s.

Radio beacon 156.425 MHz (Ch. 68) + flashing light.

1960m depth.

Released 1548Z on 19 June

Surface 1640Z

Ascent rate 1.4m/s.

3 x IOS one-shot closing sediment traps, set to close 29 July.

Deployed from Discovery September 1987.

Bathysnap at 51°06.3'N 12°37.3'W

CR 2553 460 Hz 1.02s.

Radio beacon 156.375 MHz (Ch. 67) + flashing light.

1970m depth.

Released 1738Z on 19 June.

Surface 1807Z.

Ascent rate 1.1 m/s.

IOS bathysnap, camera leaked and was damaged. All S.S. brackets showing crevice corrosion, the release bracket particularly so.

Bathysnap at 47°11.8'N 19°40.8'W

CR 2431 280 Hz 1.08s.

4565m depth.

Released 1206Z 21 June.

Surface 1300Z.

Ascent rate 1.4m/s.

IOS bathysnap deployed from F.S. Meteor 9 May 1988. Camera on f5.6, frame interval 256 minutes (4.27 hours, 240 frames).

Sediment traps at 47°10.1'N 19°39.8'W

CR 2429 400 Hz 0.94s.

4565m depth.

Released 1421Z 21 June.

Surface 1520Z.

Ascent rate 1.5m/s.

IOS time-series sediment trap + Kiel sediment trap. Both traps failed to operate; deployed from F.S. Meteor on 9 May 1988. Only 1 pyro fired.

Bathysnap at 47°11.5'N 19°38.7'W

CR 2553 460 Hz 1.02s.

4565m depth.

Deployed 6 June: Cut away 1015Z, on the bottom, 1147Z, Descent rate 0.9m/s, release timed out 1240Z.

Recovered 10 June: Released 0845Z, Surface 0942Z, Ascent rate 1.3m/s.

Radio beacon 156.425 MHz + flashing light.

Short term test of Camera Alive Equipment Ltd.'s camera.

Bathysnap at 47°10.7'N 19°39.2'W

CR 2431 280 Hz 1.08s.
4565m depth.
Radio beacon 156.375 MHz (Ch. 67) + flashing light.
Aanderaa current meter started 1231Z.
Cut away 1245Z 6 June.
On the bottom 1421Z.
Descent rate 0.7m/s.
Long term deployment, camera at f11, frame interval 512 minutes (8.5 Hours, 569 days capacity).

Sediment traps at 47°09.9'N 19°38.7'W

CR 2429 400 Hz 0.94s.
4560m depth.
Cut away 1259Z 25 June.
On the bottom 1303.
Descent rate 1m/s.
Interrogated 10 June but failed to pop up.
Short term deployment of 4 IOS time-series traps. Acoustic signal suggests release is lying on its side, i.e. buoyancy failure.

Time-series Sediment Traps

An IOS sediment trap and a Kiel sediment trap which had been deployed at 4600m in May from "Meteor" were recovered with the intention of re-laying. Neither trap had operated at all. The Kiel trap had reduced battery voltages, but it was not possible to carry out any detailed checks. The IOS trap had stripped a gear and subsequently flattened its motor battery in attempting to operate.

Two new traps were lowered to 2700m to test the operation of the carousel at that depth. Both traps worked mechanically, moving the carousel, although there was a fault on one timer (broken switch) which resulted in more operations than were programmed. The baseplates had been cleaned of excess vaseline, which was originally recommended as a lubricant, and four traps were deployed for a trial period, three on repetitive diurnal sampling, the fourth operating for 4 two day periods and 6 one day periods, then stopping. It was not possible to recover them on the 9th as planned, due to gale force winds and a large swell. On the day we attempted to recover them, the 11th, the release indicated that the pyros

had fired, but the mooring failed to lift off. Steaming around the mooring indicated a much stronger signal to the North and West of the release than to the South and East. This implies that the release is on its side, i.e. the buoyancy, and possibly one or all of the traps has parted from the mooring.

D.W.

Midwater Camera Systems

A total of nine deployments were carried out using the lightweight (aluminium) version attached to its (galvanised) swivel bar. The intended long-term mooring did not take place due to the loss of the sediment traps.

Film #1 29 June 1000m

Camera at f11, 2m. Test developed three strips of film at 100 ISO (normal), - 1 stop and + 3 stops. Particles of varying size could be seen.

Strip 1 #3 to #10. 14 frames 700m to surface.

Strip 2 #35A to #2. 9 frames 600m to 1000m to 700m.

Strip 3 #29A to #35. 11 frames surface to 600m.

Film #2 30 June 800m

Camera at f3.5, 2m. The flash beam could be seen, strongly diverging, showing a bright inner beam, with a secondary outer.

Film #3 3 July 800m

Camera at f3.5, 2m. The flash had been moved away from the lens by 2mm. The beam was still strongly diverging.

Film #4 4 July 700m

Camera at f3.5, 2m. The flash had been moved by 18mm. The beam was still strongly diverging.

Film #5 4 July 720m.

Camera at f3.5, 2m. The flash had been moved by 30mm. The beam was markedly less divergent than previously.

Film #6 4 July 800m

Camera at f3.5, 2m. The flash had been moved by 31mm. The beam was virtually parallel.

Film #7 8 July 5 x 75m

Camera at varying f-stops from f4 to f16, 2m. The best aperture to use seems to be f8.

Film #8 10 July 1500m

Camera at f8, 2m.

Film #9 12 July

Camera at f8, 2m. Film not developed on board.

The film used was Kodak TMax 100, developed with TMax developer. The distances of the flash gun, camera and fresnel lens in relation to eath other were:

flash (centre) to lens face 333mm

camera to flash 2025mm

Camera angle approximately 27 degrees, parallel to the lens face and with the ends of the lens support poles in the frame.

Camera Alive Equipment Ltd. Camera

This was deployed for a 4 day period on an aluminium bathysnap frame, with specially manufactured brackets to hold the three pressure cases. The frame interval was 32 minutes (timed ondeck), although no compass or frame data inprint was available. The film was Kodak TMax, ISO 100, which should be developed in TMax developer at standard processing times.

Flash 014 with 2 flash heads fixed to the back of the battery pack frame.
Camera 063D with a field from 1.2m to approx 2m f11, infinity.
Battery pack (no serial no.).
2 Pyros MC15.30 & 31.
Command Release CR 2553.
50m Kevlar to 4 glass spheres nos. 24560, 33083, 384, 337.
8m polypropylene to 2 spheres in a dhan buoy, flashlight + radio beacon.
VHF Ch. 67. Sphere nos.33071, 33081. 10" sphere no. 22047 stray line.

First picture on deck 0919Z, 6 July. Inboard and power pack switched off 1020Z on 10 July.

D W.

Computing

Introduction:

Biology/chemistry research cruise centred on the BIOTRANS site (47°N, 20°W). Sailed Barry 18th June 1988 (JD170) arrived Lisbon 15th July 1988 (JD197).

Computing support provided by Level ABC Computer System for Navigation, CTD and FIDO data reduction.

Hardware:

1. Level A's - all functioned well.
   - EM Log
   - Gyro
   - GPS
   - MX1107
   - CTD
   - FIDO (In situ particle counting)
   - Metpac (Temperature/solar radiation)
   - Anemom (Wind direction/ speed)
   - TSG103 (Thermosalinograph)
   - Sirrad (Surface Irradiance)
   - T_Fluor (Turner Designs Fluorometer)

a. CTD/FIDO: both instrument packages were interfaced via the CTD level A.

b. Metpac: during the latter part of cruise 174 the wiring from the Met. Electronics in the plot was remade but it was not until 175 that logging of the data was attempted. The default calibrations which were carried over from DTS days had been incorrectly transferred, once these calibrations had been corrected all the temperature readings made sense. However, the Barometer is still to be interfaced (or at least calibrated). The electronics appears to be working, the barometer provides a current which has been converted into a voltage by the insertion of a 100 ohm resistor to allow the voltage to be monitored on a Level A analogue board. Various calibration figures were attempted but no meaningful values resulted.

c. T_fluor: all data were logged, but the firmware for this unit requires some attention. The combining of the digital data and the analogue data into a

data value is not correct. If the Auto Ranging Mode of the deck unit is used in conjunction with the Level A tears in the data result when the unit changes range. An attempt was made to rectify this problem but the logging of the data was considered of more immediate value.

2. Level B - functioned well, logged upto 10 level A instrument packages for the duration of the cruise. Input from the Level A's was via Cambridge Ring and V24. Data output to the Level C was via the Cambridge Ring.

During a period of the cruise the Level B did crash repeatedly; a symptom which was prevalent on Cruise 172 but did not occur on 173 or 174. The cause of the problem was the concurrent resetting of the Level A clocks initiated by the drift of the SCG Computer System Clock. The problem did not occur on 173 because the SCG clock was not used and probably did not occur on 174 because only 4 Level A's were in use.

The SCG clock should be calibrated more accurately or exchanged for a unit that has been. The Level B should be able to cope with more concurrent "comment" messages than it apparently can at present, or the number of messages generated by a Level A upon clock reset should be reduced.

3. Level C - no problems.

4. Navigation. GPS/MX/1107 - no problems, prior to the cruise the MX1107 was stripped down and given a thorough clean.

5. Other. The new Advance Flatbed was installed but after two plots failed to put its pens down onto the paper. Various adjustments were tried to adjust the pen height but with no improvement. Eventually the whole pen carriage was disassembled and it was found that the pen height adjustment spring was not located correctly. This problem was rectified and the unit has operated satisfactorily since. The roller ball pens which are being used at present are good on plots with continuous small range data but are not good when data values change rapidly. Possibly the combination of pen type and paper needs to be reassessed.

Software:

"Proctd" was modified to pass all data. This was necessary because the CTD clock drifted slightly against the Level A clock, and at regular intervals a set of about 10 records (in pairs) had identical times. The odd missed CTD record does not cause problems but because of the multiplexed particle data, all records had to be available. Files "fido" and "rascal" (calibrated fido) are both raw to stop the data access routines complaining.

"Distri" the program which assembles the particle data into one record and averages other records for inclusion in the output file was completed and extensively tested. The third program in the suite "fidav" was completed and tested to Dr W. Simpson's satisfaction. The report generating program has yet to be written.

"Biostn" a few wrinkles in the biostation entry programs were noted by Dr. P.R. Pugh, e.g. as the data are entered, one has to press <cntrl> Z, reselect an option and continue data entry. Admittedly this is fast, but is irritating when 40 entries are made at one sitting. Also when modifying a record its format becomes corrupt, happily this is corrected by entering the navigation. The gear code also needs to be held as a number for consistency with other programs. It is also less likely to cause errors. The gear code needs to be translated for the listing, but needs to be as a number in the database. The biostation data are transferred to a shore based Oracle database.

"dplot" does not function if some variables do not have data for the start time. This can be circumvented by copying data to an intermediate file, but this can be long winded if one is asked to present data from 4 sources over 20 days.

Data logging/reduction/archiving

Navigation (1m) 170 1134 - 196 1205. Prime Nav. Aid used was the GPS.

CTD - (plus oxygen, fluorescence and transmittance) 16 stations.

FIDO - 17 stations.

Met. Data. - 174 140830 - 196 120700 (Barometer data invalid).

Surface fluorescence 173 1025 - 196 1159.

Thermosalinograph 171 1255 - 196 1206 (only housing temperature good). The flow from the non toxic supply is not sufficient for a tsg and fluorometer.

Surface Irradiance 171 1420 - 195 1054

Biostation data.

All data were archived to magnetic tape in GF3 format. In addition CTD data from the downcasts, navigation and biostation data were transferred from the Level C to two PC systems (IOSDL and PML), this allowed the integration of such data with other parameters, software packages (LOTUS/HPG) and datasets available on the PC's. The transfer was performed using anylist format files (ascii) and "kermit".

D.A.J., E.B.C.

SCIENTIFIC INVESTIGATIONS

Pelagic sampling and processing

It was intended to carry out a total water column netting programme using the IOS Multiple Rectangular Midwater Trawl system (RMT1+8M). Within the top 1500m of the water column 100m depth bands were to be fished, both by day and by night, while at deeper depths 250m depth bands were to be fished, together with more detailed near-bottom (10-100m off the sea bed) sampling. However, problems with slack wire on the main trawl warp storage drum, and lack of time to rectify the problem, meant that the near-bottom sampling had to be abandoned, but the other aspects of the fishing programme were completed satisfactorily down to a depth of 4450m. The top 100m of the water column was subdivided during the day series of hauls in order to compensate for the wrong monitor calibration having been used on the first net to be fished.

During trawling the RMT1 samples from the top 1500m were subdivided using a cod-end sieving device. Although there was a potential to subdivide the catches into three fractions, namely >4.5, 1-4.5 and 0.32-1mm, it was decided, since the samples primarily would be used for size distribution analysis, only to split off the >4.5mm 'contamination' fraction. Consequently the 1mm liner was omitted from the cod-end device. Immediately after retrieval the RMT1 <4.5mm fraction was divided into two equal halves, using a simple stir and pour technique, and one half was preserved in formalin while the other was frozen for subsequent measurements of dry weight, C:N, etc. The deep (>1500m depth) RMT1 samples were too small to split, and to minimise damage to the catch, the 4.5mm sieve also was omitted. The few large animals caught will be removed during laboratory processing.

The most striking feature of the RMT8 catches was the enormous number of the amphipod, Parathemisto gaudichaudi, caught in the top 200-300m of the water column, to the virtual exclusion of all other animals in the daytime hauls. Between 200 and 500m siphonophores, chaetognaths and euphausiids predominated, while below these depths the more typical combination of chaetognaths, medusae, various crustacean groups and fish were to be found. Pelagic holothurians were at depths as shallow as 1750-2000m (St. 11794#58). The material in the deeper hauls was, as expected, comparatively sparse.

After the completion of the total water column sampling of macroplankton and

micronekton, a series of material hauls, using a variety of nets, was carried out. The types of net used included the single RMT1+8 system, with or without the closing cod-end device on the RMT8; 0.5, 1 and 2m diameter ring nets; a modified Lowestoft High Speed Sampler; and an Apstein net. The RMT nets were used to collect animals for various purposes, including biochemical analyses, studies on fish vision, bioluminescence studies, and for reference material. Animals in good condition were kept alive in incubators and any faecal material produced was collected for subsequent pigment and chemical analyses, or for EM studies. The ring nets and Lowestoft sampler were used to collect bulk material for biochemical analyses, and the Apstein net was fished, over four depth ranges in the top 1000m of the water column, by day and night, in an attempt to assess diel changes in the vertical distribution of faecal pellets.

P.R.P.

Biomass profiles (RMT1+8M) (Figs. 2,3).

The biomass (displacement volume) profiles in the top 1500m of the water column, for the <4.5mm RMT1 and RMT8 catches, have been normalised to volume per $1000m^3$ of water filtered in Figs. 2 and 3. The RMT1 data were derived from the volumes of the preserved half fractions multiplied by two. These profiles show a slight decline in the the average biomass below 500m (Fig.2). There are two low values, which can be related to loss of part of the catch due to its having been caught up in the mouth of the net, that have not been connected into the profiles. Above 500m depth, the daytime biomass is fairly widely spread in the 100-500m depth range, while at night there is a minium between 300 and 400m and a maximum in the top 100m. Presumably this is an indication of diel vertical migration. However, the situation may be complicated by the fact that the daytime hauls in the 200-800m and 1100-1400m depth ranges were fished to the south west of a frontal zone that became apparent during the XBT survey. The temperature changes across the front were most marked in the top 500m as reflected by the changes in the depths of the 11 and 12°C isotherms. These shoaled from ca. 305 and 150m respectively in the SW corner of the work area, to ca. 160 and 50m respectively in the northern sector.

The effects of this frontal zone also may account for the differences in the day and night biomass profiles for the RMT8 catches (Fig. 3). By day, the peak in biomass in the 400-500m depth range was caused by the presence of a large number of siphonophores, particularly Rosacea plicata. They also predominated within this depth range by night, but in much smaller numbers. Since there was

no indication of a diel vertical migration for these animals, it is probable that differences in their horizontal distribution with reference to the frontal zone may account for the observed differences.

As with the RMT1 catches, the displacement volume of the equivalent day and night RMT8 catches below 500m are quite similar. The exception is the 700-800m night haul where a single large medusa, Periphylla periphylla increased the displacement volume considerably. No sorting of the samples took place at sea.

P.R.P.

Longhurst Hardy Plankton Recorder

Two deployments were made with the Double Longhurst Hardy Plankton Recorder (DLHPR) fitted with 20 and 200 µm mesh nets and cod-end filtering gauzes; one at midnight (St. 11793#4) and the other at midday (11794#5). The hauls were taken from the surface to 1000m and gave 107 fine mesh and 106 coarse mesh samples. On recovery the 20 µm samples were each divided into two aliquots; one was frozen (-20°C) for analysis of pigments, carbon, nitrogen and particulate organic carbon, and the other preserved in formalin for phytoplankton and microzooplankton species analysis. The coarse mesh samples were preserved in formalin. The larger organisms, fish, coelenterates, euphausiids and chaetognaths, were removed from the coarse mesh samples and counted. A full analysis of the samples will be carried out in the coming year for species, dry weight, carbon and radionuclides.

A CTD profile and a series of water bottle casts were taken before and after the deployment of the DLHPR to determine the quantity and quality of the particulates in the 1-200 µm size fraction. Water samples from 14 depths, down to 4200m, were preserved in Lugol's for species analysis, while others were frozen for pigment analysis and determination of C, N and POC. Samples also were processed for measurements of radionuclides.

R.G.W.

Bioluminescence and vision

Measurements were made of the spectral distribution of the bioluminescence and fluorescence of the luminous tissues of a number of crustaceans, fish and squid. The fluorescence emission was frequently a very close match to that of the bioluminescence, indicating that the fluor present was probably the emitter and that energy transfer from the luciferin reaction was occurring. The

reflectance of a number of photophores, especially of myctophids, is closely tuned to the spectral distribution of the ambient daylight in the sea. However, many reflector systems are not spectrally selective and appear to have little effect on the spectral distribution of emitted bioluminescence.

Further study of the luminous glands of certain copepods was undertaken, with particular emphasis on the cyclopoid Oncaea. In addition some photophore material was frozen for chemical study and the bacteria in the esca of four species of anglerfish were prepared for immunological and DNA analysis.

Specimens of the decapods Acanthephyra, Systellaspis and Sergestes were maintained alive under different light intensities in order to test whether these midwater shrimps have pigment movements in the eye that would allow a degree of dark- and light-adaptation in their normal environment. The eyeshine characteristic of such animals, and of dark-adapted shallower species, is not readily lost, even under 2-3 days of illumination.

P.J.H.

CTD profiles, chlorophyll and nutrient samples.

The IOS New Deep CTD was used for all the CTD profiles. It had been fitted with a new end-cap so that the Plessey Irradiometer, Chelsea in situ fluorometer and Seatek transmisometer could be sampled. Altogether 16 CTD profiles were made of which one was to 2000m (11792), one to 1500m (11794#141), one to 1000m (11794#16) and the rest to 300m. Water bottle samples were taken for measurements of chlorophyll a concentration on 7 of the profiles and for nutrient determination on 8 of the profiles (see Table 1 for details).

The 48 chlorophyll samples taken deeper than 10m (to avoid photo-inhibition effects on fluorescence) were used to calibrate the Chelsea fluorometer and the resulting calibration is shown in Fig. 4. This calibration was not as good as has been obtained on previous cruises; the reason for this is not known.

During the first week at the BIOTRANS station the CTD profiles revealed an extremely shallow mixed layer of 10m. The chlorophyll a concentration in the mixed layer was c. 1mg/m^3, with nitrate and silicate concentrations in the range 0.2-0.6 and 0.1-0.4mMol/m^3 respectively. Below the mixed layer there was a chlorophyll maximum at depths between 15 and 30m with magnitude 2-4mg/m^3. The nitrate-cline began at depths of 15-30m, with nitrate concentrations increasing

Table 1. Details of water bottle samples of chlorophyll *a*, nitrate and silicate obtained on the cruise.

Depth (m)	Temperature (°C)	Chlorophyll *a* (mg/m^3)	Nitrate ($mMol/m^3$)	Silicate ($mMol/m^3$)
Station 11794#7 (23.vi.88)				
1	15.70	1.08	0.3	0.1
5	15.70	1.27	0.2	0.1
11	15.02	1.83	0.3	0.1
15	13.83	1.47	3.1	0.1
50	13.05	1.14	3.1	0.2
95	12.03	1.26	0.9	0.2
117	11.60	-	9.8	2.8
150	11.22	-	9.4	3.6
200	10.96	-	9.8	3.9
250	10.80	-	8.2	3.3
300	10.73	-	10.3	4.1
Station 11794#43 (27.vi.88)				
1	16.26	1.29	0.6	0.1
2	16.17	1.12	0.3	0.1
4	16.18	0.83	0.2	0.1
6	16.31	1.26	0.2	0.1
13	15.63	1.53	0.5	0.2
17	14.54	1.93	0.2	0.2
22	13.95	2.46	1.0	0.3
30	13.52	1.44	2.0	0.5
39	12.96	-	4.0	1.3
50	12.72	0.64	5.0	1.9
300	11.07	-	10.7	4.8

Depth (m)	Temperature (°C)	Chlorophyll *a* (mg/m^3)	Nitrate ($mMol/m^3$)	Silicate ($mMol/m^3$)
Station 11794#69 (30.vi.88)				
5	16.31	1.06	0.2	0.4
10	16.00	1.22	0.2	0.3
15	16.10	1.05	0.2	0.4
20	16.09	1.85	0.4	0.3
30	13.89	1.97	1.6	0.5
40	13.30	0.90	2.7	0.6
50	12.92	0.49	5.4	1.7
100	12.58	-	8.3	3.3
150	12.14	-	8.5	3.4
200	11.83	-	9.5	3.9
250	11.56	-	10.0	3.9
300	11.33	-	9.9	3.2
Station 11794#106 (5.vii.88)				
1	14.90	0.99	0.5	0.3
10	14.90	0.99	0.9	0.3
20	14.88	1.17	1.0	0.3
30	14.76	1.05	1.1	0.5
33	13.45	0.28	5.6	1.7
40	13.29	-	5.8	1.9
50	13.09	0.18	6.0	1.9
100	12.20	-	7.6	2.7
150	12.00	-	9.5	3.9
200	11.70	-	10.0	4.1
250	11.46	-	10.3	4.4
300	11.12	-	10.4	4.4

Depth (m)	Temperature (°C)	Chlorophyll *a* (mg/m³)	Nitrate (mMol/m³)	Silicate (mMol/m³)
Station 11794#126 (7.vii.88)				
1	15.44	0.70	0.1	0.3
10	15.37	0.72	0.4	0.3
15	15.04	1.11	0.6	0.3
20	14.84	0.99	0.9	0.3
25	14.78	0.58	0.8	0.4
30	14.50	0.65	0.9	0.4
36	13.36	-	2.8	0.4
50	13.31	0.56	6.3	2.0
70	13.03	0.09	7.2	2.4
100	12.66	-	7.8	3.0
200	11.86	-	9.9	4.0
300	11.29	-	10.9	4.7
Station 11794#129 (7.vii.88)				
1	15.30	1.39	0.3	0.2
5	15.30	1.05	0.4	0.2
10	15.28	-	-	-
20	14.81	1.01	0.8	0.3
25	14.79	0.77	0.9	0.4
35	14.68	0.68	0.9	0.4
39	14.03	0.57	1.5	0.5
50	13.44	0.24	5.4	1.7
70	12.86	0.08	7.2	2.5
100	12.54	0.04	8.3	3.1
200	11.81	-	10.3	4.2
300	11.23	-	11.3	4.8

Depth (m)	Temperature (°C)	Chlorophyll *a* (mg/m^3)	Nitrate ($mMol/m^3$)	Silicate ($mMol/m^3$)
1	16.23	0.43	0.2	0.4
5	16.23	0.56	0.2	0.4
10	16.22	0.47	0.2	0.4
15	16.21	-	-	-
20	15.95	-	0.2	0.6
25	15.81	0.65	0.2	0.6
30	15.78	-	-	-
35	15.66	0.48	0.4	0.6
42	15.07	-	-	-
50	13.23	-	-	-
55	13.00	0.22	6.1	1.3
60	12.93	-	6.4	1.4
65	12.87	-	6.4	1.7
100	12.45	0.05	8.5	2.6
295	11.34	-	10.8	4.6

Table 2. RRS Discovery XBT surveys

XBT Number	Date 1988	Time (GMT)	Latitude °N	Longitude °W	Remarks
1	19/6	1922	51 04.0	12 41.5	
2		2009	50 57.7	12 53.2	
3		2200	50 43.0	13 19.0	
4	20/6	0002	50 26.6	13 47.8	
5		0202	50 10.2	14 16.0	
6		0359	49 55.7	14 41.4	
7		0602	49 41.7	15 10.8	
8		0759	49 28.5	15 37.0	
9		1006	49 13.2	16 03.5	
10		1209	48 58.4	16 29.5	
11		1848	48 51.0	16 46.9	
12		2004	48 36.1	17 14.0	
13		2159	48 21.6	17 37.0	
14	21/6	0003	48 06.2	18 02.1	
15		0158	47 53.6	18 23.6	
16		0403	47 37.8	18 51.7	
17		0604	47 22.5	19 17.6	
18		0743	47 12.1	19 36.5	
19	22/6	0235	47 13.5	19 34.3	
20		0353	47 26.9	19 22.9	
21		0516	47 39.1	19 12.0	
22		0646	47 27.0	19 00.0	
23		0801	47 13.5	18 50.0	
24		0957	47 11.1	19 12.1	Failed
25		1005	47 11.8	19 12.3	
26		1113	47 12.3	19 34.6	
27	12/7	1514	47 09.5	19 26.6	
28		1659	46 54.3	19 07.6	
29		1901	46 36.7	18 46.9	
30		2100	46 18.8	18 26.1	
31		2302	46 00.2	18 04.7	Failed
32		2315	46 00.2	18 04.7	

XBT Number	Date 1988	Time (GMT)	Latitude °N	Longitude °W	Remarks
33	13/7	0103	45 43.8	17 41.8	
34		0358	45 17.7	17 08.8	
35		0612	44 56.3	16 45.9	
36		0757	44 38.9	16 27.3	
37		1003	44 22.1	16 09.5	
38		1210	44 00.7	15 38.5	
39		1357	43 42.9	15 03.7	
40		1615	43 23.1	15 08.4	
41		1813	43 05.7	14 47.8	
42		2102	42 40.4	14 18.3	
43		2326	42 13.9	13 49.1	
44	14/7	0302	41 46.6	13 20.3	Failed
45		0317	41 46.6	13 20.3	
46		0635	41 13.7	12.44.1	
47		1025	40 39.3	12 06.6	Failed
48		1031	40 39.3	12 06.6	

to 10mMol/m^3 at 300m (Table 1). The silicate-cline was deeper, presumably reflecting the depth of the mixed layer during the spring diatom bloom.

Between the 29th of June and the 5th of July there were gale force winds that deepened the mixed layer to around 40m. This mixing eroded the subsurface chlorophyll maximum, although by the 7th of June surface heating had produced a shallow thermocline at a depth of 10m. A chlorophyll maximum (1.5-3mg/m^3 chlorophyll a) developed below this thermocline.

Mention has been made of the subsurface chlorophyll maxima. These were very clearly delineated by the in situ fluorometer profiles, but were also apparent in the water bottle samples of chlorophyll a concentrations (Table 1). However the profiles of attenuation obtained by the transmissometer tended to show either a much reduced maximum or no subsurface maximum at all. This would suggest that the mixed layer contained a population of small particles that did not fluoresce, presumably either detritus or bacteria.

At three of the stations (11794#43, 11794#106 and 11794#160) the water bottle samples were passed through a fractionating filter stack to determine the chlorophyll concentrations in the size fractions 0.2-1, 1-5 and >5 μm. The average percentage contribution of each of the size fractions at the three stations was as follows:

Station	>5μm	1-5μm	0.2-1μm
11794# 43	43.2	46.5	10.3
11794#106	39.3	47.7	13.0
11794#160	54.7	36.8	8.5

M.J.R.F.

XBT surveys

Three boxes of T7 XBTs were kindly donated by the Navy and the results of all the XBT dips were transmitted to the Meteorological Office at Bracknell. The time and position of the XBT launches is given in Table 2.

The first XBT survey was carried out on the outward leg to the BIOTRANS station (Fig. 5a). Note the sharp change in the depth of the 11° and 9°C isotherms that occurs between stations 11 and 13. During the 21st-22nd of June a triangular XBT survey was made to investigate mesoscale variability. The

results (Fig. 5b) showed that there was little variability in the surface 50m, but below this there were significant changes in the depths of the 11° and 12°C isotherms. There was no indication of any mesoscale variability in the 10°C isotherm, and therefore there was no evidence of deep cold-core eddy of the sort observed by the German cruise in 1985. The final survey was made on the return leg from BIOTRANS to Lisbon (Fig. 5c). There was a gradual warming of the surface from 17° at BIOTRANS to 19°C south of 42°N. There was also a marked deepening of the 10°C isotherm south of 46°18'N.

M.J.R.F.

Suspended particulate matter

Filter samples were collected at various depths throughout the water column using the deep water particle samples (FIDO) and stand along pumps (SAP). A variety of filter types were used (Table 3), dependent on the chemical moieties to be analyzed. These moieties included:-

a) Isotopes of Thorium (Thomson, IOSDL). After the 293mm Nuclepore filter, two manganese scavengers were placed in line in order to remove dissolved thorium. Using both the dissolved and particulate thorium data it is hoped to estimate the adsorption-desorption rate constants as well as estimates of particle settling-removal rates. These data will help to constrain the uptake-removed models for other elements.

b) Major elements (Jickells, UEA). Analyses will be carried out for calcium, silicon and aluminium. The first two are the major bioinorganic elements and the third a marker for lithogenic material. Carbon, nitrogen and phosphorus also will be measured.

c) Trace elements (Ridout, IOSDL). Samples were taken for trace metal analyses using the ICP-MS. Authigenic enrichments with respect to aluminium will provide information on element cycles.

d) Samples taken throughout the water column will be used to provide information on carbon and nitrogen compounds through variations in their ^{13}C and ^{15}N content (Blackburn, UCNW). Additional samples from the upper water column (0-400m) were collected for analyses of ^{15}N particulate organic nitrogen (Kennedy, UCNW) amd ^{210}Po, ^{210}Pb (Shimmield, Edinburgh). These data should provide information on the rate and nature of the recycling of particulate

Table 3. Station log for FIDO and SAP samples

Station	Date 1988	Gear	Filter/ Diameter	Volume Filtered (l)	Depth (m)	Person	Comment
11793# 1	22/6	SAP	GFC/293	283	20	DM/GE	
2	22/6	SAP	GFF/47	4	20	RW	
3	22/6	FIDO	NUC/MOL	148	20	EH	+ trials
11794# 8	23/6	SAP	NUC/293	12	20	WS/PR	
20	23/6	SAP	No sample				Broken brush
28	23/6	SAP	GFF/293	157	20	HK	
			NUC/293	41	20	GS	
32	26/6	FIDO	NUC/293	1037	260	GS	
			GFF/293	1338	260	HK	
			GFC/293	1431	260	DM/GE	
			GFC/293	1461	150	DM/GE	
42	27/6	FIDO	NUC/293	1466	1000	JT	
			GFF/293	1472	1000	HK	
			NUC/293	1206	1000	TJ	
			NUC/293	1185	1000	WS/PR	
45	27/6	FIDO	NUC/293	1235	260	JT	
			MIL/47	12	260	RW	
			NUC/293	975	260	WS/PR	
			NUC/293	1053	260	TJ	
52	28/6	SAP	GFC/293	2675	2500	DM/GE	
53	28/6	FIDO	NUC/293	1198	600	JT	
			MIL/47	3.5	600	RW	
			NUC/293	1170	600	TJ	
			NUC/293	1117	600	WS/PR	
61	29/6	SAP	NUC/293	1715	3500	WS/PR	
62	29/6	FIDO	MIL/47	7	1000	RW	
			GFC/293	1424	1000	DM/GE	
			GFC/293	1623	600	DM/GE	
			GFF/293	1286	600	HK	
68	30/6	SAP	GFF/293	971	80	HK	
			NUC/293	624	80	GS	

Station 11794	Date 1988	Gear	Filter/ Diameter	Volume Filtered (l)	Depth (m)	Person	Comment
70	30/6	FIDO	NUC/293	953	400	JT	
			GFF/293	1396	400	HK	
			NUC/293	1136	400	GS	
			NUC/293	959	400	TJ	
74	1/7	SAP	NUC/293	1035	400	MS	
75	1/7	SAP	NUC/293	67	20	JT	
76	1/7	SAP	NUC/293	1065	400	WS/PR	
84	3/7	FIDO	NUC/293	741	150	JT	
			GFF/293	1279	150	HK	
			NUC/293	765	150	TJ	
			NUC/293	1038	150	WS/PR	
87	3/7	SAP	NUC/293	688	150	GS	
88	3/7	FIDO	NUC/293	397	50	JT	
			GFF/293	633	50	HK	
			NUC/293	382	50	TJ	
			NUC/293	400	50	WS/PR	
90	3/7	FIDO	NUC/293	340	50	GS	
			GFC/293	1447	50	DM/GE	
			GFF/47	14	50	RW	
			MIL/47	4	50	RW	
			GFC/293	1028	50	FM	
92	4/7	SAP	NUC/293	823	200	GS	
93	4/7	SAP	GFF/293	1088	200	HK	
97	4/7	SAP	NUC/293	1072	50	?	
98	4/7	FIDO	NUC/293	1135	1500	JT	
			GFF/293	1391	1500	HK	
			NUC/293	1255	1500	WS/PR	
			NUC/293	1210	1500	TJ	
103	5/7	SAP	NUC/293	992	400	CT	
104	5/7	FIDO	NUC/293	1033	4487	JT	100m above sea level
			GFF/293	1369	4487	HK	" " " "
			NUC/293	1083	4487	WS/PR	" " " "
			NUC/293	1075	4487	TJ	" " " "
118	6/7	SAP	NUC/293	64	20	WS/PR	

Station	Date 1988	Gear	Filter/ Diameter	Volume Filtered (l)	Depth (m)	Person	Comment
11794							
119	6/7	SAP	GFF/293	172	20	HK	
120	6/7	SAP	MIL/47	3	20	RW	
			GFF/47	3.5	20	RW	
125	7/7	FIDO	NUC/293	1389	4577	JT	10m above sea bed
			GFF/293	1241	4577	HK	" " " "
			NUC/293	1335	4577	WS/PR	" " " "
			NUC/293	No sample			Filter broken
134	8/7	SAP	NUC/293	1714	2500	WS/PR	
135	8/7	SAP	NUC/293	62	20	TJ	
139	9/7	FIDO	NUC/293	No sample			Loose filter holder
			GFF/293	1338	3500	HK	
			NUC/293	1528	3500	WS/PR	
			NUC/293	1310	3500	TJ	
147	10/7	FIDO		No samples			Pump motor burnt out
148	10/7	FIDO	NUC/293	963	2500	JT	
			GFF/293	958	2500	HK	
154	11/7	FIDO	NUC/293	1029	3500	JT	
			NUC/MOL	1045	2500	EH	
			MIL/47	30	2500	RW	
			NUC/293	1135	2500	TJ	
			MIL/47	5.5	150	RW	
159	12/7	SAP	GFC/293	1120	4567	DM/GE	10m above sea bed
			MIL/47	< 1	4567	RW	No flow

Person (abbreviations). EH: Eric Hamilton (PML); TJ: Tim Jickells (UEA); HK: Hilary Kennedy (UCNW); FM: Faouzi Mantoura (PML); DM/GE: Dave Morritt/ Geoffrey Eglinton (Univ. Bristol); GS: Graham Shimmield (Univ. Edinburgh); WS/PR: William Simpson/Paul Ridout (IOSDL); JT: John Thomson (IOSDL); CT: Carol Turley (PML); RW: Bob Williams (PML).

material in the upper water column.

Additional filtered samples were obtained from water bottle casts in the top 80m of the water column. These will be analysed for ^{15}N and ^{13}C in order to investigate the diel and depth changes in the isotopic content of the organic matter in the euphotic zone.

e) Alpha-emitters (Hamilton).

f) Pigments and radionuclides (Williams, PML). Samples were frozen for pigment analyses, using HPLC, and other samples will be analysed for C, N, POC and radionuclides. Three sediment cores also were collected for radionuclide determinations. In addition a selection of animals, representing the most abundant species in the water column, were collected from the RMT combination nets and frozen for subsequent analysis of radionuclides and chlorophyll breakdown products.

Live animals were collected from a variety of depths, and incubated for 12 h in the hope of collecting faecal pellets for pigment and E.M. analyses.

Water bottle samples also were collected in near-surface waters for counts of particulates and size spectra analysis, using a Coulter Counter. Throughout the cruise, the particle concentration in the euphotic zone ranged from 47 to 59,000 per ml, with total particulate volumes from 1 to 2 ppm, over the size range 1.6 to 128 µm. Differences were observed in the relative importance and contribution to the total particulate volume of different sizes (>50, >20, >5, <5µm) throughout the period of sampling.

g) Organic chemistry (Eglinton, Bristol).

Lipid biomarkers represent a sensitive method for tracing the flux of organic carbon down through the water column. A wide variety of biomarkers have been identified as specific in origin, including dinosterol, which occurs in dinoflagellates, and long chain waxes present in higher plants. More complex biomarkers such as lignin can be used to quantify the contribution and flux of terrestrially derived polymeric organic material to the underlying sediments. The molecular abundance data will be examined in relation to food web modificiations and mineralisation processes involved in the descent of organic

material to the sea floor.

In addition to the eight filter samples obtained throughout the water column, using FIDO or SAP, lipid biomarker investigations also will be carried out on other samples collected during the cruise, namely:-

i) Two multicorer cores.

ii) Thirty phytoplankton/particulate samples collected near surface, filtered onto 4.7cm GF/C filters and stored in 50:50 dichloromethane/methanol.

iii) Forty-five faecal pellet and animal samples obtained from a range of organisms, e.g. copepods, amphipods and decapods.

The newly developed pumping system allowed us to increase our pumping capability, and proved to be highly efficient in terms of power requirments, due to the magnetically coupled pump motor arrangement. Only one sample was missed out of the 80 requested. The data logogng ran perfectly and all the secondary (volume, mass and flux estimates) and averaging programs were operational. These data will be combined with the chemical data in order to estimate element cycles and fluxes.

W.R.S., H.K., D.M., R.G.W.

Particle Flux

One of the main objectives of the cruise was to measure the flux of material through the water column using sediment traps and FIDO, to compare these two quite different approaches and to relate the flux measurements to the biota and their particulate products. Sediment traps were deployed both on drifting and fixed moorings, the former to measure fluxes in the upper 250m and the latter to cover the 250-1000m depth range. In both cases considerable difficulties were encountered but for different reasons.

Two deployments of the drifting traps were carried out using single sample IOS traps ($0.13m^2$) at 20, 50 and 230m depths. During the first deployment no poison or preservative was used, whereas in the second 10l of 2% buffered formalin was added just before deployment. In both cases, after two days of sampling, the cups were full, or nearly so, of the amphipod Parathemisto gaudichaudii. Because of the perfect condition of the preserved specimens, and the very large numbers collected, it is thought that these had swum into the sediment traps. No other material was obvious in the trap cups and it must be

concluded that it may not be possible to measure material flux in the upper water column at certain times of the year when this species is abundant. "Swimmers" are a recognised problem in the sediment trapping fraternity, but the scale of the problem encountered here is probably without precedent.

Only one fixed mooring was deployed, but unfortunately the mooring collapsed as soon as it reached the seabed, and naturally did not rise to the surface when the release was fired. As the buoyancy was not seen at the surface and no implosion was heard it has been concluded that the steel buoyancy sphere leaked. The mooring comprised 4 IOS time series traps ($0.5m^2$) at depths of 250, 270, 600 and 1000m, 2 Aanderas current meters at 570 and 630m, a 1.3m steel sphere at 220m and an IOS command release 25m above the seabed. The traps were set in one of two timing modes, one of which was expected to perform one complete rotation during the deployment and then stop, and the other was to move to the next position at much shorter intervals so that one rotation of the carousel was completed every day.

It has been suggested that the faecal pellet is the principle agent mediating particle flux. As an adjunct to the zooplankton and sediment trapping studies, particles greater than 20µm were collected using an Apstein closing net (17cm diameter). Samples were collected in the depth horizons 0-50, 50-250, 250-600, and 600-1000m at about midnight and midday, and subsequently were preserved in 4% formalin.

R.S.L.

In situ Photography

Midwater Aggregates

Particles may be examined in a variety of ways, both in situ and after collection. Commonly used techniques (e.g. transmissometer, FIDO, water bottles) do not collect the large fragile particles in their in situ condition, nor do they measure their abundance and size. A photographic apparatus was developed so that the in situ abundance and size distribution of these large particles can be estimated. The principle is that a 100l block of water is photographed using orthogonal illumination from a collimated flash light. Particles greater than 3mm subsequently can be analysed using existing image analysis techniques. Several trials were successfully carried out and data obtained down to 200m. The equipment was, however, too large to be accommodated

on the CTD rig, as was hoped, and in future will be reduced in size leading to a 50% reduction in the photographed volume.

Bathysnap

A "Bathysnap" module was successfully recovered from the Porcupine Seabight but unfortunately the camera had not worked, probably due to a small leak. Another Bathysnap, previously deployed at BIOTRANS was recovered and useful film obtained. This was then redeployed for recovery next year. A third Bathysnap was deployed and recovered during the cruise to test a new type of camera (Camera Alive Marine Equipment Ltd; Camera CI800 with flash CI20/20). This camera has a maximum frame capacity of 800 frames using standard base film and in this case two flash heads were used. The results are promising although the test demonstrated some problems.

R.S.L.

Microbial Loop Studies

The potential role of pico- and nanoplankton in the food chain of the upper ocean was studied by observing their vertical distribution in the top 300m and by experimental estimation of their growth rate and the grazing pressure experienced by them.

Vertical distribution.

Water samples for the depth profiles were taken from the CTD rosette sampler. Three of the profiles had fine resolution sampling within the mixed layer. The depths at which the water bottles were fired being chosen on the basis of the biological and physical features, identified from the real time plots, rather than at fixed depths. Changes in the vertical distribution of pico- and nanoplankton were noted during the cruise, and weather induced changes were followed in the mixed layer, before and after high winds.

Initial counts from high resolution CTD profiles carried out early in the cruise indicate an inner stratification within the mixed layer, which was not identifiable from the physical data. This structure disappeared after a spell of bad weather and was not observed in later profiles.

Chlorophyll profiles taken simultaneously with the pico- and nanoplankton counts allowed us to correlate phytoplankton abundance with primary and

secondary consumers. For the three fine resolution profiles, samples were fractionated to give chlorophyll concentrations in three size classes, namely diameters of >5, 1-5 and 0.2-1 μm. From this we can distinguish potential primary production directly available to the microbial loop, some of which may be immediately respired and lost to the atmosphere, from that available to the traditional food chain. Water samples also were preserved in glutaraldehyde for later examination and identification into major groups.

Growth and Grazing Experiments

Four experiments were carried out to study the growth of and grazing on bacteria and nanozooplankton, pico- and nanophytoplankton. Grazing pressure on all groups was determined using a dilution technique in which population changes after incubation are quantified by direct counting using an epifluorescence microscope. Most of the nanozooplankton and pico- and nanophytoplankton count were done onboard. The remainder, and the bacterial samples, were preserved in 2% glutaraldehyde for later analysis. One of the critical assumptions of the dilution technique was tested. Water for the grazing experiments was collected in 30l water bottles. One grazing experiment was carried out at night in order to establish whether the increased number of microzooplankton affected the dynamics of the microbial loop.

For phytoplankton, as well as direct counts, changes in ^{14}C bicarbonate uptake and chlorophyll fluorescence in the three size fractions were measured. We can relate this information to the vertical profiles of fractionated chlorophyll and estimate routes of transfer of primary production to higher trophic levels.

For bacteria, in addition to direct counts, changes in the rate of uptake of ^{3}H Thymidine by bacterial communities were measured. This gives an independent measure of the changes in bacterial population and bacterial growth rate.

Summary of activities at Discovery St. 11794

Pico- and nanoplankton vertical profiles: #7,43,68,85,105,126,129,145.
Fractionated chlorophyll *a* vertical profiles: # 43, 105, 160.
Grazing experiments: # 44, 70, 130(night), 146.
Checks were made for radioactive contamination in the after chemistry laboratory.

M.W.S.

GEAR ABBREVIATIONS IN STATION LIST

APSTEIN	40cm diameter closing plankton net, with 20µm mesh.
B.SNAP2	Bathysnap benthic camera system.
CCE	Acoustically operated closing cod end device (used in conjunction with the RMT).
CM	Current Meter.
CRAPSNAP	Midwater Camera System
CTD	Conductivity-Temperature-Depth Probe
FIDO	In situ particle counter and pump filtration system.
LHS2	PML Double Longhurst Hardy Plankton Recorder, fitted with 20 and 200µm mesh nets.
LMD	Light Meter with Photodiode.
LNHS/30	Modified Lowestoft High speed net, with 30cm nose cone.
MLT.CORER	SMBA design multiple sediment corer.
MS	Multi-Sampler, with 12 x 1.7l water bottles attached to the CTD.
N50	50cm diameter ring net (53 µm mesh).
N113	1m diameter ring net.
N200	2m diameter ring net.
RMT1+8	Rectangular midwater trawl, having a pair of nets with nominal mouth openings of $1m^2$ (RMT1, mesh size 0.33mm) and $8m^2$ (RMT8, mesh size 4.5mm).
RMT1+8M	Multiple net system as above, but with 3 pairs of nets.
SAP	Stand Alone Pump, for in situ particle filtration.
SED.FLOAT	Free-floating sediment traps.
SED.TRAP	Moored sediment traps.
TRANSM	Transmissometer with 1m path length.
UFL	Underwater fluorometer.
WB7.4	7.4l water bottle.
WB30	30l water bottles.

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11792	21/6	47 10.5	19 38.9	CTD	0-2000	1722-1921		3 bottles failed to fire
# 1		47 11.1	19 37.6	TRANSM MS		DAY		
# 2	21/6	47 13.6	19 34.2	WB30	10-80	2149-2213		Bottles at 10, 50 & 80m
		47 13.5	19 34.1			DUSK		
# 3	21/6	47 13.4	19 34.0	WB30	600-2000	2230-0053		Bottles at 600, 1000, 1500 &
	22/6	47 13.2	19 34.2			NIGHT		2000m
# 4	22/6	47 13.2	19 34.3	WB30	140-250	0059-0150		Bottles at 140*, 200, 250* &
		47 13.5	19 34.4			NIGHT		400m. *Failed to close
# 5	22/6	47 13.5	19 34.4	WB30	140-250	0155-0223		Bottles at 140 and 250m
		47 13.7	19 34.4			NIGHT		
11793	22/6	47 12.6	19 39.5	SAP	10-10	1455-1555		GF/C filter
# 1		47 12.9	19 39.7			DAY		
# 2	22/6	47 13.3	19 39.4	SAP	20-20	1814-1842		4.7cm GF/F filter
		47 13.2	19 39.2			DAY		
# 3	22/6	47 15.5	19 31.0	FIDO	0-300	2119-2320		1 sample at 20m
		47 15.2	19 29.9			DUSK		
# 4	23/6	47 15.7	19 28.5	LHS2	0-999	0018-0248		51 coarse, 52 fine samples
		47 20.2	19 19.2			NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 1	23/6	47 18.0	19 23.4	RMT1M/1	800-900	0700-0800	3415	
		47 20.4	19 20.2	RMT8M/1		DAY		
# 2	23/6	47 20.4	19 20.2	RMT1M/2	900-1000	0800-0900	3550	Problems with RMT1M/2 catch
		47 21.7	19 17.3	RMT8M/2		DAY		
# 3	23/6	47 21.7	19 17.3	RMT1M/3	1000-1100	0900-1000	3708	
		47 22.8	19 14.1	RMT8M/3		DAY		
# 4	23/6	47 20.6	19 22.0	RMT1M/1	0-50	1231-1331	3820	Flow approx.
		47 22.7	19 20.3	RMT8M/1		DAY		
# 5	23/6	47 22.7	19 20.3	RMT1M/2	50-100	1331-1431	3865	Problems with RMT1M/2
		47 24.7	19 19.0	RMT8M/2		DAY		
# 6	23/6	47 24.7	19 19.0	RMT1M/3	100-195	1431-1531	4000	
		47 26.8	19 18.2	RMT8M/3		DAY		
# 7	23/6	47 27.6	19 18.1	CTD	0-300	1610-1652		WB at various depths
		47 27.9	19 19.5	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 8	23/6	47 30.3	19 24.1	SAP	20-20	1850-2000		Nuclepore filter
		47 30.5	19 24.5			DAY		
# 9	24/6	47 23.0	19 25.7	RMT1M/1	890-1000	0004-0104	3438	
		47 23.6	19 22.2	RMT8M/1		NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 10	24/6	47 23.6	19 22.2	RMT1M/2	1000-1115	0104-0204	4293	
		47 24.3	19 18.5	RMT8M/2		NIGHT		
# 11	24/6	47 24.3	19 18.5	RMT1M/3	1115-1200	0204-0304	4225	
		47 24.8	19 15.4	RMT8M/3		NIGHT		
# 12	24/6	47 16.1	19 25.6	RMT1M/1	1100-1205	0701-0801	3618	Liners wrongly rigged
		47 16.4	19 24.3	RMT8M/1		DAY		catch discarded
# 13	24/6	47 16.4	19 24.3	RMT1M/2	1200-1300	0801-0901	3730	Liners wrongly rigged
		47 17.6	19 21.3	RMT8M/2		DAY		catch discarded
# 14	24/6	47 17.6	19 21.3	RMT1M/3	1300-1400	0901-1001	3730	Liners wrongly rigged
		47 18.8	19 18.1	RMT8M/3		DAY		catch discarded
# 15	24/6	47 19.7	19 16.8	LHS2	0-982	1138-1436		55 coarse, 56 fine samples
		47 15.4	19 30.4			DAY		
# 16	24/6	47 15.5	19 30.9	CTD	0-1000	1458-1543		WB at 1000 & 14m
		47 16.0	19 31.6	TRANSM				
				MS				
# 17	24/6	47 18.5	19 31.0	RMT1M/1	500-600	1647-1747	4180	
		47 21.1	19 29.9	RMT8M/1		DAY		
# 18	24/6	47 21.1	19 29.9	RMT1M/2	600-700	1747-1847	3798	
		47 23.3	19 29.0	RMT8M/2		DAY		
# 19	24/6	47 23.3	19 29.0	RMT1M/3	700-800	1847-1947	3528	
		47 25.4	19 27.8	RMT8M/3		DAY		
# 20	24/6	47 26.5	19 26.8	SAP	80-80	2025-2106		No sample taken
		47 26.4	19 26.6			DUSK		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 21	24/6	47 26.0	19 20.7	RMT1M/1	1210-1315	2321-0021	3258	
	25/6	47 25.9	19 17.5	RMT8M/1		NIGHT		
# 22	25/6	47 25.9	19 17.5	RMT1M/2	1305-1400	0021-0121	3550	Problems with RMT1M/2
		47 25.5	19 14.2	RMT8M/2		NIGHT		
# 23	25/6	47 25.5	19 14.2	RMT1M/3	1400-1500	0121-0221	3640	
		47 25.3	19 11.1	RMT8M/3		NIGHT		
# 24	25/6	47 09.6	19 39.2	SED.TRAP	250-1000	0845-1259		Released 1259, traps at
		47 09.8	19 38.9	CM		DAY		250, 270, 600 & 1000m
# 25	25/6	47 10.9	19 33.7	RMT1M/M	200-305	1404-1504	3415	
		47 13.1	19 32.6	RMT8M/1		DAY		
# 26	25/6	47 13.1	19 32.6	RMT1M/2	300-400	1504-1604	3730	
		47 15.5	19 31.1	RMT8M/2		DAY		
# 27	25/6	47 15.5	19 31.1	RMT1M/3	400-490	1604-1704	3640	
		47 17.8	19 29.7	RMT8M/3		DAY		
# 28	25/6	47 18.4	19 29.6	SAP	20-20	1800-1850		2 casts (GF/F, Nuc)
		47 18.2	19 29.2			DAY		powered from deck
# 29	25/6	47 20.0	19 25.8	RMT1M/1	2000-2300	2101-2301	5750	
		47 23.7	19 22.0	RMT8M/1		DUSK		
# 30	25/6	47 23.7	19 22.0	RMT1M/2	2275-2505	2301-0101	6673	Problems with RMT1M/2
	26/6	47 27.1	19 18.0	RMT8M/2		NIGHT		
# 31	26/6	47 27.1	19 18.0	RMT1M/3	2500-2750	0101-0301	6785	
		47 30.6	19 14.0	RMT8M/3		NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 32	26/6	47 06.6	19 40.8	FIDO	0-300	0905-1405		Nuc, GF/F, 2 x GF/C samples
		47 07.4	19 40.0			DAY		at 260m
# 33	26/6	47 07.4	19 40.1	CTD	0-300	1419-1443		WB at various depths
		47 07.4	19 40.2	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 34	26/6	47 07.3	19 40.2	WB30	11-11	1455-1514		
		47 07.3	19 40.2			DAY		
# 35	26/6	47 12.7	19 33.4	RMT1M/1	1100-1200	1710-1810	3100	
		47 14.3	19 31.2	RMT8M/1		DAY		
# 36	26/6	47 14.3	19 31.2	RMT1M/2	1200-1300	1810-1910	3415	
		47 15.9	19 28.4	RMT8M/2		DAY		
# 37	26/6	47 15.9	19 28.4	RMT1M/3	1300-1400	1910-2010	3595	
		47 17.3	19 26.1	RMT8M/3		DAY		
# 38	26/6	47 18.4	19 19.4	RMT1M/1	600-700	2248-2348	3595	
		47 17.8	19 15.8	RMT8M/1		NIGHT		
# 39	26/6	47 17.8	19 15.8	RMT1M/2	700-795	2348-0048	3505	
	27/6	47 17.1	19 12.5	RMT8M/2		NIGHT		
# 40	27/6	47 17.1	19 12.5	RMT1M/3	795-900	0048-0148	3618	
		47 16.4	19 09.3	RMT8M/3		NIGHT		
# 41	27/6	47 16.0	19 07.5	WB30	2300-4200	0234-0620		WB at 2300, 3200 & 4200m
		47 15.0	19 07.3			NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 42	27/6	47 18.6	19 17.9	FIDO	0-1000	0755-1331		3 x Nuc, GF/F samples at 1000m
		47 18.4	19 15.5			DAY		
# 43	27/6	47 18.3	19 15.3	CTD	0-300	1354-1425		WB at various depths
		47 18.1	19 15.3	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 44	27/6	47 18.0	19 15.2	WB7.4	0-50	1440-1530		WB at 5, 10, 15, 17.5, 20, 25,
		47 17.7	19 15.2			DAY		30, 40 and 50m.
# 45	27/6	47 18.6	19 17.2	FIDO	0-260	1724-2059		3 x Nuc, 4.7cm Millipore samples
		47 18.9	19 16.3			DAY		at 260m
# 46	27/6	47 20.8	19 14.8	RMT1M/1	300-405	2216-2316	3708	
		47 22.7	19 12.8	RMT8M/1		NIGHT		
# 47	27/6	47 22.7	19 12.8	RMT1M/2	405-505	2316-0016	3685	
	28/6	47 24.5	19 11.1	RMT8M/2		NIGHT		
# 48	28/6	47 24.5	19 11.1	RMT1M/3	500-600	0016-0116	3055	
		47 26.2	19 09.5	RMT8M/3		NIGHT		
# 49	28/6	47 27.0	19 08.9	RMT1M/1	20-110	0154-0227	1908	
		47 27.9	19 08.3	RMT8M/1		NIGHT		
# 50	28/6	47 27.9	19 08.3	RMT1M/2	110-205	0227-0324	3620	
		47 29.9	19 07.4	RMT8M/2		NIGHT		
# 51	28/6	47 29.9	19 07.4	RMT1M/3	200-300	0324-0424	3528	
		47 31.7	19 06.4	RMT8M/3		NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 52	28/6	47 18.3	19 17.8	SAP	2500-2500	0712-1050		GF/C sample at 2500m
		47 18.5	19 17.8			DAY		
# 53	28/6	47 18.4	19 17.7	FIDO	0-600	1106-1505		3 x Nuc, 4.7cm Millipore
		47 18.0	19 17.1			DAY		at 600m
# 54	28/6	47 17.9	19 16.8	CTD	0-300	1528-1544		WB at 300m
		47 17.8	19 16.7	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 55	28/6	47 17.5	19 16.5	SED.FLOAT	10-250	1637-0846		Traps at 20, 50, 230m
	30/6	47 12.6	19 07.1					no preservative
# 56	28/6	47 19.7	19 17.7	RMT1M/1	1400-1500	1900-2000	3078	
		47 21.8	19 16.4	RMT8M/1		DAY		
# 57	28/6	47 21.8	19 16.4	RMT1M/2	1500-1750	2000-2200	7178	
		47 26.3	19 14.3	RMT8M/2		DUSK		
# 58	28/6	47 26.3	19 14.3	RMT1M/3	1730-2000	2000-2400	7505	
		47 30.9	19 12.2	RMT8M/3		NIGHT		
# 59	29/6	47 33.1	19 11.3	CTD	0-300	0132-0147		WB at 300m
		47 33.1	19 11.2	TRANSM		NIGHT		
				UFL				
				LMD				
				MS				

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 60	29/6	47 33.1	19 10.9	CRAPSNAP	0-1000	0216-0257		Camera trials
		47 33.2	19 10.4			NIGHT		
# 61	29/6	47 18.6	19 17.2	SAP	3500-3500	0600-1001		Nuc sample at 3500m
		47 17.7	19 14.3			DAY		
# 62	29/6	47 15.3	19 11.4	FIDO	0-1000	1056-1505		4.7cm Millipore + GF/C at
		47 13.4	19 09.9			DAY		1000m GF/C + GF/F at 600m
# 63	29/6	47 13.3	19 10.0	CTD	0-300	1526-1601		WB at various depths
		47 13.2	19 10.1	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 64	29/6	47 13.2	19 10.1	CRAPSNAP	0-1200	1605-1656		Trials, film jammed after
		47 13.2	19 10.0			DAY		16 frames
# 65	29/6	47 16.3	19 12.5	RMT1M/1	2750-3010	2138-2338	6133	
		47 20.6	19 14.8	RMT8M/1		DUSK		
# 66	29/6	47 20.6	19 14.8	RMT1M/2	3010-3255	2338-0138	7078	
	30/6	47 24.9	19 16.2	RMT8M/2		NIGHT		
# 67	30/6	47 24.9	19 16.2	RMT1M/3	3255-3500	0138-0338	6763	
		47 28.9	19 18.5	RMT8M/3		NIGHT		
# 68	30/6	47 16.0	19 14.6	SAP	80-80	1010-1330		2 casts, GF/F & Nuc samples
		47 15.9	19 16.0			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 69	30/6	47 15.9	19 16.0	CTD	0-300	1333-1410		WB at various depths
		47 16.0	19 16.3	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 70	30/6	47 16.0	19 16.5	FIDO	0-500	1441-1902		3 x Nuc + GF/F samples at 400m
		47 16.8	19 17.2			DAY		- New Cell
# 71	30/6	47 15.2	19 13.6	RMT1M/1	3490-3800	2247-0047	5120	
	1/7	47 18.1	19 17.2	RMT8M/1		NIGHT		
# 72	1/7	47 18.1	19 17.2	RMT1M/2	3800-4085	0047-0247	5840	
		47 21.1	19 20.8	RMT8M/2		NIGHT		
# 73	1/7	47 21.1	19 20.8	RMT1M/3	4085-4450	0247-0447	5953	Problems with slack wire on drum
		47 24.8	19 22.9	RMT8M/3		NIGHT		
# 74	1/7	47 17.1	19 15.9	SAP	400-400	1228-1540		No sample - wire relayed on drum
		47 15.9	19 14.5			DAY		
# 75	1/7	47 15.7	19 14.4	SAP	20-20	1630-1653		Launched by hand Nuc sample
		47 15.6	19 14.3			DAY		
# 76	1/7	47 17.5	19 17.9	SAP	400-400	1832-2026		Nuc sample
		47 17.6	19 17.9			DAY		
# 77	1/7	47 17.7	19 18.3	N200	0-120	2035-2136		
		47 17.0	19 21.2			DUSK		
# 78	1/7	47 16.8	19 21.7	N200	0-145	2145-2248		
		47 15.8	19 25.5			DUSK		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 79	1/7	47 15.6	19 26.1	LNHS/30	0-110	2300-2330		
		47 15.0	19 29.7			NIGHT		
# 80	1/7	47 14.8	19 30.8	LNHS/30	0-100	2340-0012		
	2/7	47 14.1	19 35.1			NIGHT		
# 81	2/7	47 14.3	19 34.0	LNHS/30	0-100	0030-0100		
		47 15.6	19 31.3			NIGHT		
# 82	2/7	47 15.8	19 30.9	LNHS/30	0-100	0108-0142		
		47 17.3	19 27.8			NIGHT		
# 83	2/7	47 17.9	19 21.4	RMT1	1300-1395	0334-0434	3708	New cod-end liner on RMT1
		47 18.0	19 17.8	RMT8		NIGHT		
# 84	3/7	47 18.3	19 16.7	FIDO	0-150	0816-1228		3 Nuc + GF/F samples at 150m
		47 18.1	19 14.0			DAY		
# 85	3/7	47 18.0	19 13.7	CTD	0-300	1300-1334		WB at various depths
		47 17.9	19 13.5	TRANSM		DAY		
				UFL				
				LMD				
				MS				
# 86	3/7	47 17.9	19 13.5	WB30	10-16	1346-1358		WB at 10 and 16m
		47 17.8	19 13.4			DAY		
# 87	3/7	47 16.4	19 12.5	SAP	100-100	1535-1650		Nuc sample
		47 16.1	19 11.7			DAY		
# 88	3/7	47 17.3	19 13.7	FIDO	0-50	1724-1938		3 x Nuc + GF/F samples at 50m
		47 17.1	19 13.6			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
# 89	3/7	47 17.1	19 13.6	N50	0-10	1940-2036		Launched by hand
		47 17.1	19 13.6			DAY		
# 90	3/7	47 17.1	19 13.4	FIDO	0-50	2055-2250		2 x GF/C, Nuc + GF/F/Millipore
		47 17.4	19 13.1			DUSK		samples at 50m
# 91	3/7	47 17.4	19 13.1	CRAPSNAP	0-800	2308-2345		Camera trials
		47 17.6	19 12.9			NIGHT		
# 92	4/7	47 18.2	19 18.0	SAP	200-200	0828-0942		Nuc sample
		47 18.3	19 18.2			DAY		
# 93	4/7	47 18.2	19 18.2	SAP	200-200	1005-1150		GF/F sample
		47 18.2	19 18.3			DAY		
# 94	4/7	47 18.2	19 18.2	CRAPSNAP	0-700	1210-1249		Camera trials
		47 18.1	19 18.0			DAY		
# 95	4/7	47 18.0	19 17.8	CRAPSNAP	0-700	1348-1423		Camera trials
		47 17.9	19 17.6			DAY		
# 96	4/7	47 17.9	19 17.6	N50	0-10	1435-1517		Launched by hand
		47 17.8	19 17.4			DAY		
# 97	4/7	47 17.8	19 17.4	SAP	50-50	1523-1653		Nuc sample
		47 17.6	19 16.7			DAY		
# 98	4/7	47 17.5	19 16.5	FIDO	0-1500	1717-2225		3 x Nuc + GF/F samples
		47 17.2	19 16.2			DUSK		at 1500m
# 99	4/7	47 17.4	19 16.3	CRAPSNAP	0-700	2252-2331		Camera trials
		47 17.3	19 16.0			NIGHT		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#100	5/7	47 17.0	19 15.5	APSTEIN	50-250	0010-0021		Vertical haul
		47 17.0	19 15.5			NIGHT		
#101	5/7	47 18.4	19 14.8	RMT1	165-240	0114-0314	7370	RMT1 live cod end
		47 21.9	19 11.5	RMT8		NIGHT		
#102	5/7	47 24.1	19 09.3	RMT1	830-960	0453-0625	5908	Nets failed to open - RMT1
		47 26.6	19 07.2	RMT8		DAWN		cod-end lost
#103	5/7	47 18.0	19 18.5	SAP	400-400	0830-0950		Nuc sample
		47 18.0	19 18.4			DAY		
#104	5/7	47 18.0	19 18.6	FIDO	0-4577	1055-1808		3 x Nuc + GF/F at 100m off
		47 17.0	19 16.6			DAY		bottom
#105	5/7	47 17.2	19 16.2	WB30	16-16	1631-1641		
		47 17.2	19 16.2			DAY		
#106	5/7	47 17.0	19 16.5	CTD	0-300	1838-1918		WB at various depths
		47 17.1	19 16.2	TRANSM		DAY		
				UFL				
				LMD				
				MS				
#107	5/7	47 17.0	19 16.2	WB7.4		1936-2035		WB at 0, 5, 10, 15, 20, 25, 30,
		47 17.2	19 16.0			DAY		35, 37.5, 40, 45 and 50m
#108	5/7	47 17.2	19 16.0	WB30	16-16	2040-2047		
		47 17.2	19 16.0			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#109	5/7	47 19.2	19 18.5	RMT1	800-950	2200-2400	7820	Material haul
		47 22.5	19 23.7	RMT8		NIGHT		
#110	6/7	47 23.3	19 25.3	APSTEIN	600-1000	0059-0235		Vertical haul
		47 23.4	19 25.7			NIGHT		
#111	6/7	47 23.4	19 25.7	APSTEIN	250-600	0240-0332		Vertical haul
		47 23.4	19 25.7			NIGHT		
#112	6/7	47 23.4	19 25.7	APSTEIN	0-50	0337-0341		Vertical haul
		47 23.4	19 25.7			NIGHT		
#113	6/7	47 25.3	19 26.1	RMT1	460-570	0438-0638	7730	Material haul
		47 29.5	19 26.6	RMT8		DAWN		
#114	6/7	47 11.5	19 38.8	BSNAP2	4587-4587	0958-1016		On bottom 1204 - Camera Alive
		47 11.5	19 39.0			DAY		camera
#115	6/7	47 11.1	19 39.0	BSNAP2	4587-4587	1230-1245		On bottom 1421 - long term
		47 11.0	19 39.0			DAY		deployment
#116	6/7	47 18.2	19 17.9	SED.FLOAT	30-250	1616-1656		Traps at 20, 50 and 230m
		47 18.0	19 16.8			DAY		
#117	6/7	47 18.0	19 16.7	APSTEIN	0-50	1711-1714		Slack wire problems
		47 17.9	19 16.6			DAY		
#118	6/7	47 17.7	19 15.7	SAP	20-20	1814-1839		Launched by hand - Nuc sample
		47 17.5	19 15.3			DAY		
#119	6/7	47 17.5	19 15.3	SAP	20-20	1852-1922		Launched by hand - GF/F sample
		47 17.5	19 15.3			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#120	6/7	47 17.5	19 15.2	SAP	20-20	1939-2019		Launched by hand - 4.7cm
		47 17.1	19 14.7			DAY		Millipore GF/F samples
#121	6/7	47 19.0	19 13.7	RMT1	300-400	2105-2205	3460	Material haul - RMT8 hung up
		47 21.0	19 13.6	RMT8		DUSK		
				CCE				
#122	6/7	47 22.8	19 13.9	RMT1	200-340	2346-0114	5147	Material haul
	7/7	47 25.9	19 14.0	RMT8		NIGHT		
				CCE				
#123	7/7	47 27.2	19 14.0	RMT1	280-350	0244-0414	5235	Material haul
		47 30.2	19 14.2	RMT8		NIGHT		
				CCE				
#124	7/7	47 26.3	19 14.8	RMT1	360-460	0544-0644	3325	Material haul
		47 23.9	19 15.1	RMT8		DAWN		
				CCE				
#125	7/7	47 19.2	19 16.0	FIDO	0-4577	0912-1643		3 x Nuc + GF/F at 10m off
		47 18.6	19 11.1			DAY		bottom
#126	7/7	47 18.3	19 11.0	CTD	0-300	1711-1744		WB at various depths
		47 18.1	19 10.6	TRANSM		DAY		
				UFL				
				LMD				
				MS				
#127	7/7	47 18.1	19 10.4	WB7.4	0-50	1756-1844		WB at 0, 5, 10, 20, 25, 30, 40,
		47 17.8	19 9.7			DAY		45 & 50m.

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#128	7/7	47 17.7	19 9.3	MLT.CORER	4592-4592	1917-2252		
		47 17.4	19 7.5			DUSK		
#129	7/7	47 17.3	19 7.5	CTD	0-300	2301-2342		WB at various depths
		47 17.5	19 7.2	TRANSM		NIGHT		
				UFL				
				LMD				
				MS				
#130	7/7	47 17.5	19 7.1	WB7.4	0-50	2348-0035		WB at 0, 5, 10, 20, 25, 30, 40,
	8/7	47 17.6	19 7.0			NIGHT		45 and 50m
#131	8/7	47 17.8	19 8.9	RMT1	325-400	0118-0248	5798	Material haul
		47 18.5	19 13.4	RMT8		NIGHT		
				CCE				
#132	8/7	47 19.0	19 15.6	RMT1	310-365	0418-0540	5377	Material haul
		47 19.3	19 17.2	RMT8		NIGHT		
				CCE				
#133	8/7	47 16.4	19 11.3	MLT.CORER	4597-4597	0830-1132		
		47 15.3	19 9.6			DAY		
#134	8/7	47 18.7	19 17.2	SAP	2500-2500	1623-1946		Nuc sample
		47 19.1	19 15.8			DAY		
#135	8/7	47 19.2	19 16.2	SAP	20-20	1833-1850		Nuc sample - launched by hand
		47 19.1	19 16.0			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#136	8/7	47 19.1	19 15.8	CRAPSNAP	0-75	2002-2049		Camera trials
		47 18.7	19 15.0			DUSK		
#137	8/7	47 17.4	19 15.8	RMT1	310-400	2135-2300		Material haul
		47 14.9	19 19.0	RMT8		NIGHT		
				CCE				
#138	9/7	47 12.7	19 23.2	RMT1	940-1050	0128-0328		Material haul
		47 10.1	19 28.5	RMT8		NIGHT		
				CCE				
#139	9/7	47 18.9	19 17.6	FIDO	0-3500	1051-1756		3 x Nuc + GF/F samples at 3500m
		47 19.7	19 15.3			DAY		
#140	9/7	47 19.5	19 15.3	CRAPSNAP	0-1500	1810-1906		Camera test run
		47 19.2	19 15.3			DAY		
#141	9/7	47 19.1	19 15.4	CTD	0-1500	1915-2037		WB at various depths
		47 18.5	19 14.9	TRANSM		DAY		
				MS				
#142	9/7	47 15.2	19 20.7	RMT1	1200-1410	2229-0029		Material haul
	10/7	47 12.9	19 27.8	RMT8		NIGHT		
#143	10/7	47 11.2	19 33.9	RMT1	960-1040	0242-0442		Material haul
		47 9.0	19 38.3	RMT8		NIGHT		
#144	10/7	47 7.9	19 40.3	RMT1	660-760	0556-0720		Material haul
		47 7.0	19 43.4	RMT8		DAWN		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#145	10/7	47 11.0	19 38.0	CTD	0-300	0859-0930		WB at various depths
		47 10.8	19 37.8	TRANSM		DAY		
				UFL				
				LMD				
				MS				
#146	10/7	47 10.8	19 37.8	WB30	25-25	0936-0943		
		47 10.7	19 37.8			DAY		
#147	10/7	47 16.2	19 27.2	FIDO	0-4577	1304-1845		Pump motor burnt out - no
		47 19.4	19 31.7			DAY		samples
#148	10/7	47 19.6	19 31.9	FIDO	0-2500	1855-2200		Nuc + GF/F samples at 2500m
		47 20.4	19 31.2			DUSK		
#149	10/7	47 20.0	19 31.8	N113	0-30	2046-2130		Depth range approx.
		47 20.2	19 31.5			DUSK		
#150	10/7	47 21.4	19 33.5	RMT1	1060-1250	2315-0115		Material haul - upper depth
	11/7	47 22.5	19 37.8	RMT8		NIGHT		doubtful
#151	11/7	47 23.1	19 40.8	RMT1	375-430	0236-0336		Material haul
		47 23.5	19 44.2	RMT8		NIGHT		
#152	11/7	47 24.7	19 49.5	RMT1	1150-1250	0511-0615		Material haul
		47 25.9	19 53.3	RMT8		NIGHT		
#153	11/7	47 9.3	19 39.5	APSTEIN	50-250	1342-1352		Not preserved
		47 9.2	19 39.4			DAY		
#154	11/7	47 8.7	19 38.5	FIDO	0-3500	1504-2014		Nuc at 3500m, 2 x Nuc + Millipore
		47 8.4	19 38.1			DAY		at 2500m, Millipore at 1500m.

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#155	11/7	47 8.3	19 38.2	N113	0-30	2029-2115		Depth approx.
		47 8.4	19 36.5			DUSK		
#156	11/7	47 6.6	19 37.8	RMT1	1050-1270	2256-0026		Material haul
	12/7	47 2.7	19 39.8	RMT8		NIGHT		
#157	12/7	47 4.7	19 39.4	CRAPSNAP	0-200	0154-0258		
		47 5.0	19 38.9			NIGHT		
#158	12/7	47 6.6	19 35.4	RMT1	780-1020	0401-0530		Material haul
		47 9.2	19 31.0	RMT8		NIGHT		
#159	12/7	47 10.4	19 29.3	SAP	4557-4557	0635-0951		GF/F sample
		47 10.6	19 27.8			DAY		
#160	12/7	47 10.6	19 27.7	CTD	0-300	1018-1105		WB at various depths
		47 10.6	19 27.7	TRANSM		DAY		
				UFL				
				LMD				
				MS				
#161	12/7	47 10.7	19 27.6	WB7.4	0-60	1135-1237		WB at 0, 5, 15, 25, 30, 35, 40,
		47 10.7	19 27.5			DAY		42.5, 45, 55 & 60m
#162	12/7	47 10.5	19 27.5	APSTEIN	250-600	1320-1335		
		47 10.5	19 27.5			DAY		
#163	12/7	47 10.6	19 27.6	APSTEIN	600-1000	1400-1420		
		47 10.6	19 27.7			DAY		

Station #series	Date 1988	Latitude (Start/finish) N	Longitude W	Gear	Depth (m)	Fishing time (GMT)	Flow Distance (m)	Remarks
11794								
#164	12/7	47 10.6	19 27.8	APSTEIN	50-250	1435-1445		
		47 10.6	19 27.8			DAY		
#165	12/7	47 10.6	19 27.9	APSTEIN	0-50	1457-1500		
		47 10.6	19 27.9			DAY		

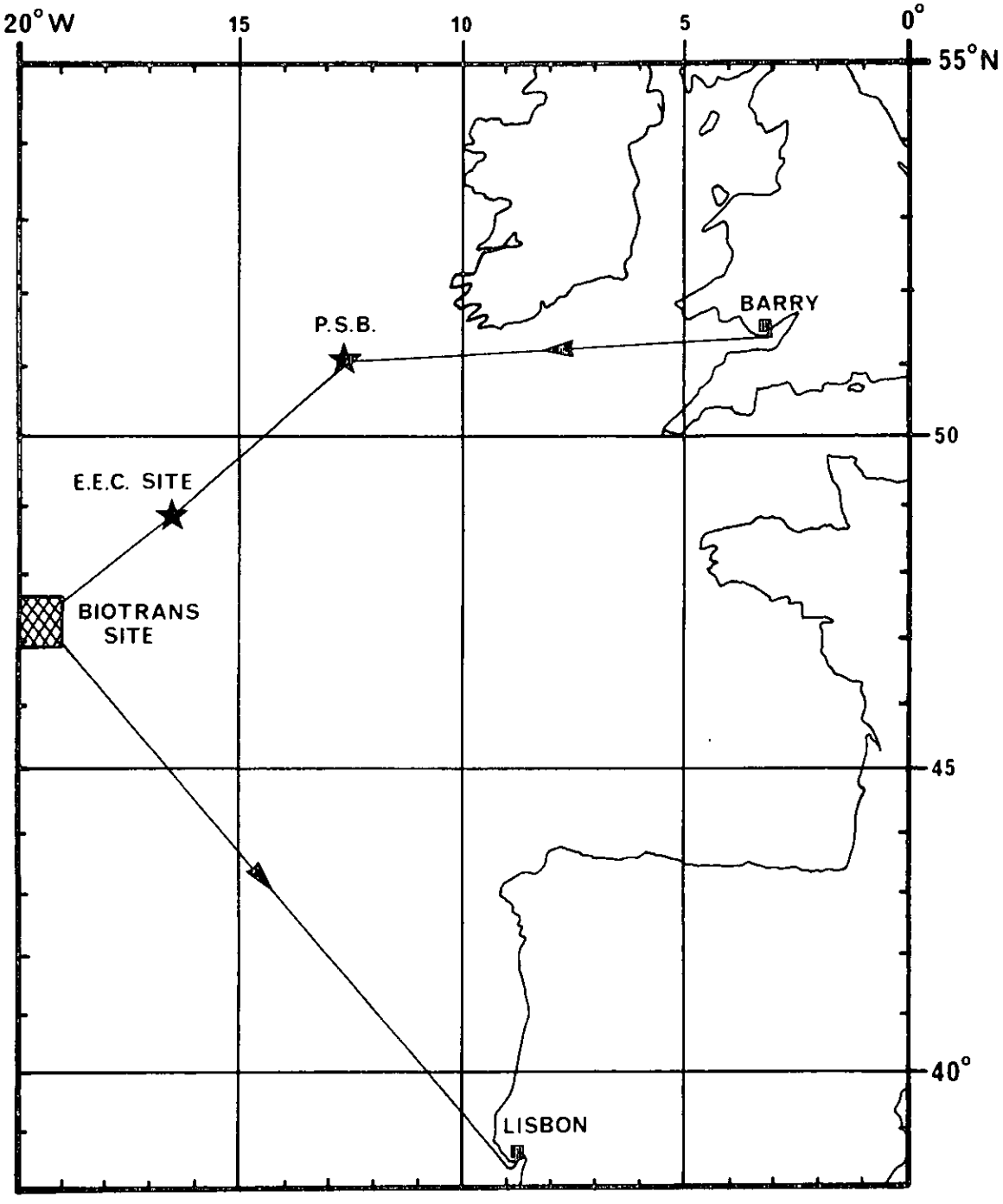

Figure 1. Track chart of RRS "Discovery" Cruise 175, 18 June - 15 July 1988.

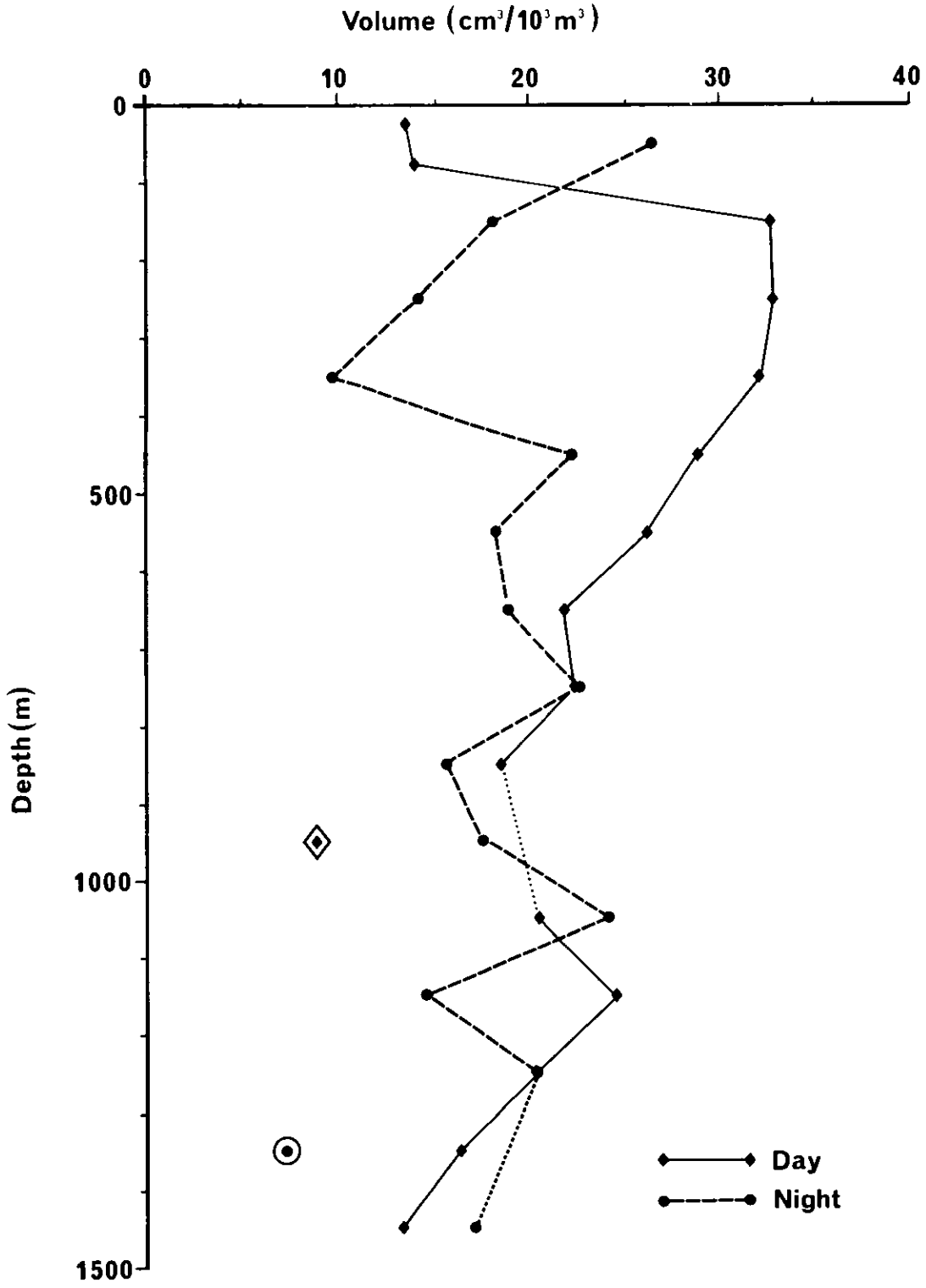

Figure 2. Day and night profiles of displacement volume for RMT1M <4.5mm plankton samples in top 1500m of water column, normalised to $10^3 m^3$ of water filtered.

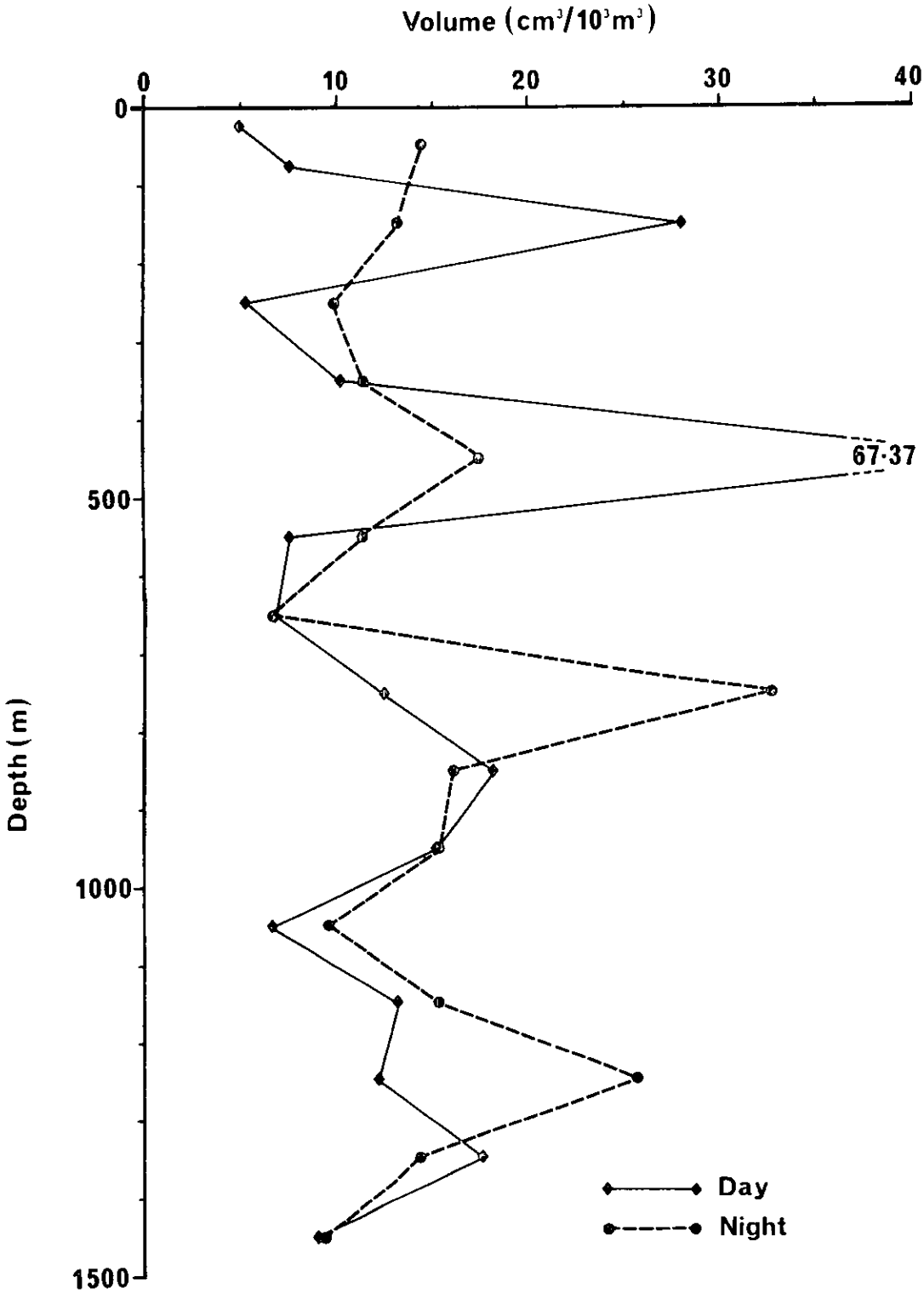

Figure 3. Day and night profiles of displacement volume for RMT8M micronekton samples in top 1500m of water column, normalised to $10^3 m^3$ of water filtered.

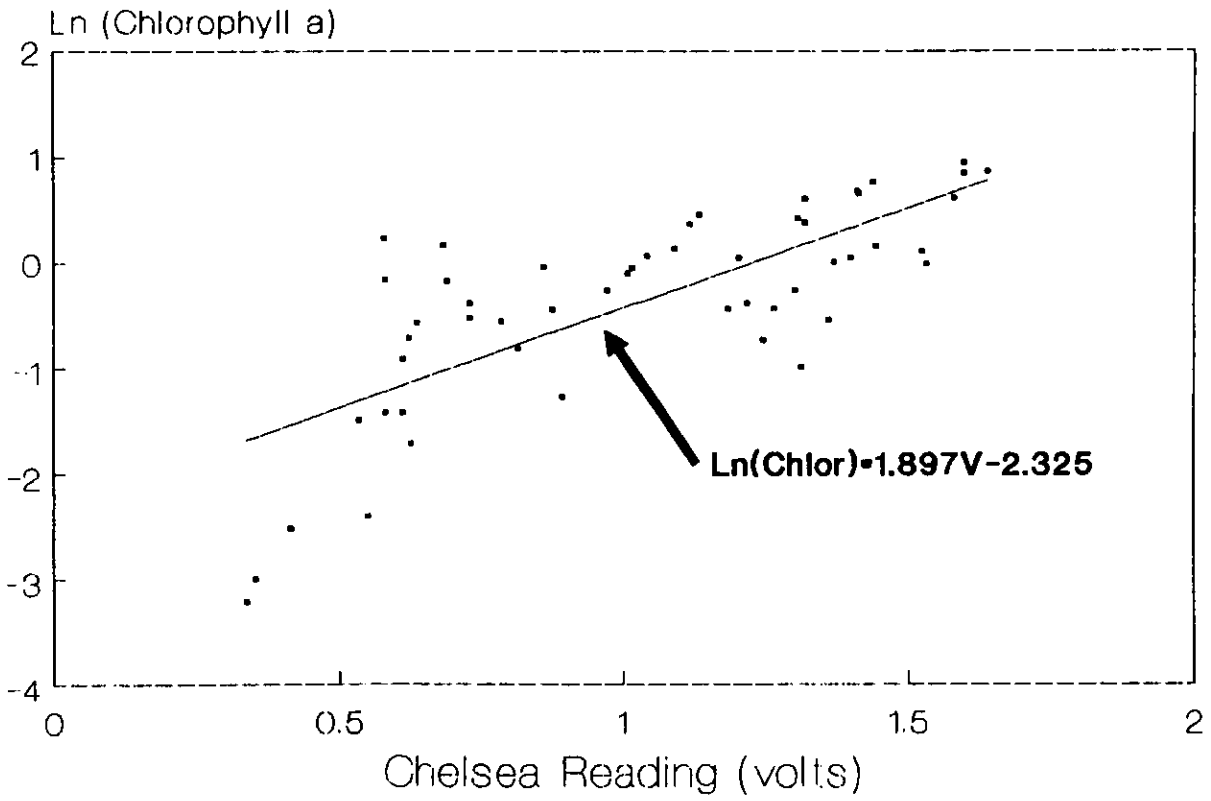

Figure 4. Calibration curve for the Chelsea Subaquatraka fluorometer.

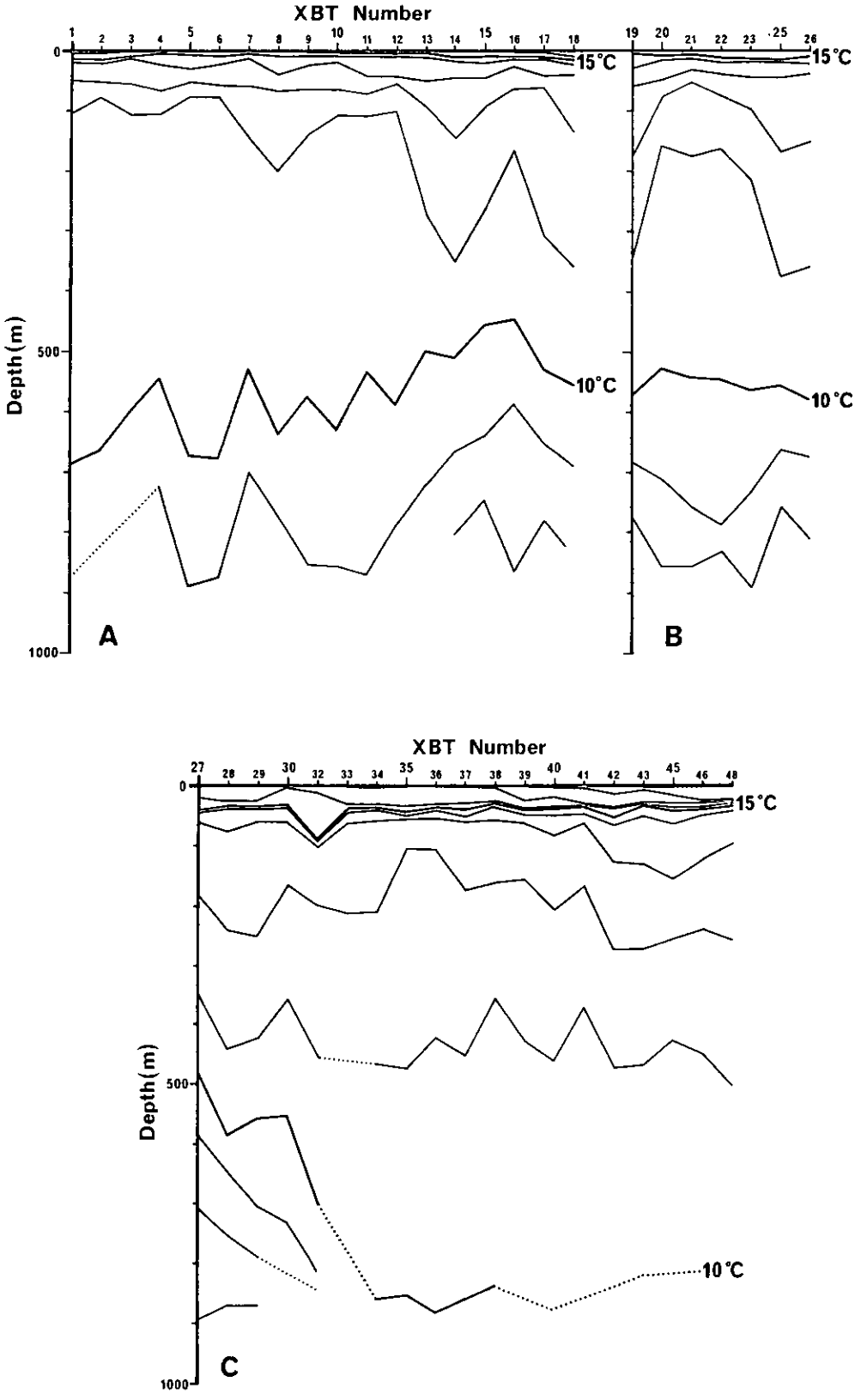

Figure 5. Isotherm depths determined by XBT surveys. a) survey on outward leg between the 19th and 21st of June. b) Triangular survey around the BIOTRANS station on the 22nd June, c) Survey on the return leg between 12th and 14th of July.