Institute of
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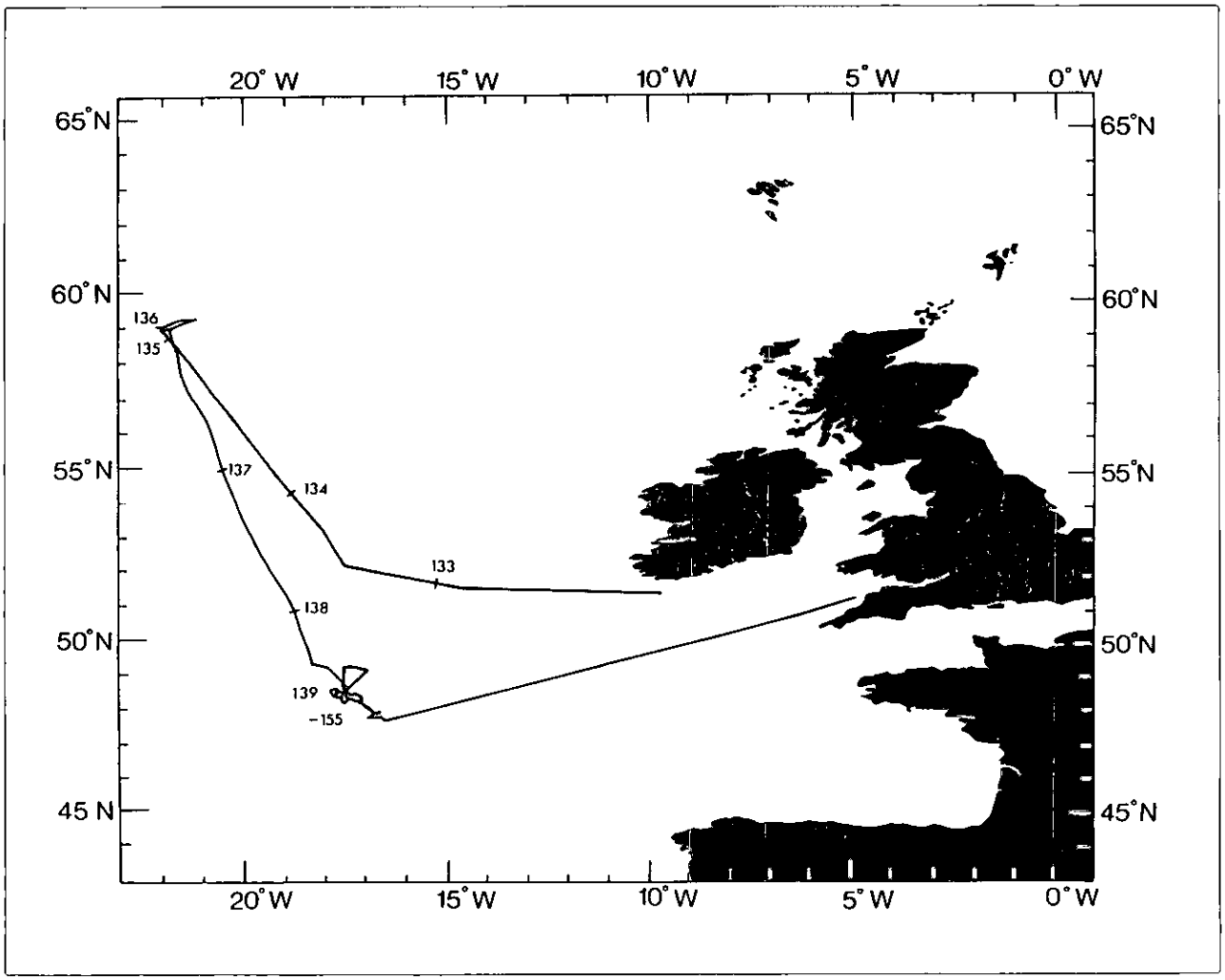
RRS Discovery Cruise 191

11 May - 05 Jun 1990

Biogeochemical Ocean Flux Studies
(BOFS Cruise A2)

Cruise Report No 222 1991



Natural Environment Research Council

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CRUISE REPORT NO. 222

RRS DISCOVERY CRUISE 191
11 MAY-05 JUN 1990

Biogeochemical Ocean Flux Studies
(BOFS Cruise A2)

Principal Scientist
M V Angel

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ABSTRACT

This report describes the scientific activities carried out on *Discovery* Cruise 191, the second in a series of three cruises on *Discovery* run under the aegis of the Biogeochemical Ocean Flux Study (BOFS). The aim of these three cruises and two simultaneous cruises on *Charles Darwin* was to conduct the Lagrangian experiment during the 1990 spring bloom, and to follow the fate of carbon fixed by photosynthesis. During the course of our observations the central buoy drifted in a south-easterly direction from the vicinity of 48°30'N 17°45'W. Key measurements made on the cruise included level 1 JGOFS observations which gave observational continuity between the two *Darwin* cruises. Large aggregates (marine snow) were sampled quantitatively both by water bottles, *in situ* cameras and freely drifting sediment traps, and qualitatively characterised. Microbiological observations were made both of the aggregates and of the water. The role of macroplankton and micronekton in exporting fixed carbon from the euphotic zone into deeper water was studied, and observations made of the impact of sedimenting material on the microbiology and organic chemistry of the abyssal surficial sediments.

KEYWORDS

ALGAL BLOOM
BIOLOGICAL PUMP
BIOLOGICAL SAMPLERS
BOFS
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LIPID GEOCHEMISTRY
MARINE SNOW
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SPRING BLOOM

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BOORMAN, Ben	IOSDL
CONTE, Maureen	Bristol Univ.
GOY, Keith	IOSDL
GRIFFIN, Nigel	IOSDL
HERNDL, Gerhardt	Univ. of Vienna
HILL, Andrew	RVS
HUGHES, Diane	PML
LAMPITT, Richard S.	IOSDL
LEWIS, Derek	RVS
MADUEIRA, Luis	Bristol Univ.
McNEILL, Gavin	Edinburgh Univ.
MILLER, Ian	UCNW
PAULSON, Christopher	RVS
TURLEY, Carol M.	PML
UPSTILL-GODDARD, Rob	PML
WHITE, David	IOSDL
WHITE, Gary	RVS
WISHNER, Karen A.	Univ. Rhode Island

2. SHIPS PERSONNEL

COVERDALE, D.	Master
EVANS,P.	Chief Officer
OLDFIELD, P.	Second Officer
BURRIDGE, P.	Third Officer
MOSS, S.	Chief Engineer
ANDERSON, J.	Second Engineer
GREENHORN, A.	Third Engineer
PHILIPS, C.	Third Engineer
DECKER, J.	Electrical Officer
POOK, G.	CPO
DONALDSON, M.	PO Deck
CORNELIUS, T.	Cook Steward

3. ITINERARY

Depart Barry 11 May - Arrive Barry 6 June 1990

4. OBJECTIVES

a) To recover moorings deployed at 59°N 22°W in 1989.

b) To participate in the BOFS Lagrangian experiment by:

1) Coordinating JGOFS level 1 observations every two days between the two *Darwin* cruises.

2) Investigating quantitatively and qualitatively the particulate material throughout the water column, sampling it using stand-along pumps, sediment traps, large volume water bottles and coherent light photography.

3) Sampling the pelagic communities in the top 1000m of the water column to assess their contribution to the biological pump.

4) Collecting core samples of the surficial sediment to evaluate the microbial response to increases in organic input associated with the onset of the spring bloom.

5) To maintain contact with, and service the drifting moorings deployed for the experiment..

5. NARRATIVE

The planned morning sailing was postponed until the afternoon tide so that repairs could be affected to the CTD system. This proved to be fortuitous because during testing the rosette sampler also developed a fault. Meanwhile the BBC camera team for "Tomorrow's World" were filming some of the cruise activities. We finally cast off at 1700h-11/5. By 1906h, after completing some filming outside the lock and the film crew had gone ashore on the pilot boat, the vessel set course down the Bristol Channel.

Just prior to sailing, the cruise plan had to be altered, because during Cruise 190 the Argos satellite transmitter on the floating sediment trap rig had failed, and instead of proceeding on to 59°N to service the mooring *Discovery* had spent two days searching unsuccessfully for the floating rig. Consequently we proceeded directly to the northern position to pick-up and redeploy the moorings there. However, on the way our first task was to pick up some of the Argos floats, which had drifted away from the main cluster deployed during Cruise 190 and were now close to our northwards track. The first float (3909) was retrieved at 51°28.7'N; 14°52.7'W at 0935h-13/5. This float had not been one of the BOFS cluster but had been deployed 390 days previously by Dr Pingree. It had spend most of that time in the vicinity of 51°30'N 21°W. On recovery the float was found to have lost its drogue and was patchily encrusted with goose barnacles *(Lepas anatifera)*. These were sampled for growth and lipid analysis.

We arrived at the last known position of the next float at 1830h-13/5; no signal could be detected. Dr Pingree telephoned through a more recent undated position and this enabled us to locate the float just before darkness. Even so, finding the float was far from easy, because it presented a very small and insignificant visual target. The float was grappled at 2055h and safely retrieved. Half an hour was spent successfully testing the marine snow catcher before the vessel got underway again for the position of the mooring.

We reached the position at 1400h-15/5. Before searching for the mooring, a deep CTD cast with twelve 10 l water-bottles was completed in order to provide deep water for use in the planned re-deployment of sediment traps. The water samples were also used for dissolved gas and nutrient analysis. Once this cast was completed at 1620h, the search was begun for the mooring. Conditions were quite reasonable and acoustic ranges were expected to be over a mile. Even so, there was no sign of the mooring at the deployment position. A box search was conducted for the next five hours but failed to locate the mooring. The search was abandoned temporarily at 2200h and two Stand-Alone-Pumps (SAPS) were deployed at a depth of 75m for 45 minutes. Then after just over two hours steaming we reached the position at which a bathysnap had been deployed on 26/5/89 during one of the previous year's BOFS cruises. As we approached the deployment position, it responded acoustically at a range of about a mile and a half. This confirmed that our failure to locate the sediment trap mooring had not been the result of failure of the acoustic transmission from the ship. At 0302h-16/5, the bathysnap released immediately on command. Its ascent rate of just over a metre per second brought it to the surface at 0347h. In the pre-dawn light its flashing light was sighted at once, but even if the light had failed, the strong RDF signal would have enabled us to locate it quickly. Once it was all onboard, the vessel once again returned to the sediment trap mooring position and continued to search unsuccessfully for the missing mooring. When the current meter on the bathysnap was interrogated it showed that at times it had recorded currents of in excess of half a knot just one metre above the sea-bed; so the probability is that the sediment trap mooring had been dragged by these strong currents. Two shallow CTD casts were made followed by a multicorer deployment. The latter was only partially successful because the tubes supplied just prior to the cruise by the suppliers proved to be slightly different in both diameter and length than the design specification. However, five of the twelve tubes contained good sediment samples. This completed the work at the northern position and the ship headed for the main experimental area.

We made good progress southwards thanks to the calm weather. Contact was made with *Darwin* to make arrangements for a parallel set of level 1 measurements to be made, prior to her leaving the area of the central buoy. But first we needed to recover the Bertha and Aries rig. A series of two-hourly XBT observations combined with surface nutrient determinations were carried out starting at 1200h-17/5, to establish the character of the front in the vicinity of 52^{o}N (in which the first Argos float we had picked up, had sat for most of the previous 390 days), and the southern boundary to the region of high surface nutrients. The section located the front and showed considerable eddy activity associated with it. The section was completed as we completed the approach towards the Aries rig. Towards dusk on 18/5, as we approached the last reported position of Aries, a thick mist developed (caused by the front?) reducing visibility to around 100m or less. The

RDF signal from the rig was picked up at a range of about three miles, but the precise direction remained uncertain. Good signals began to picked up on the Argos tracker and the ship manoeuvred to enable the best approach to be made. Fortunately we made acoustic contact with the release on the bottom of the rig and this enabled us to navigate accurately towards it. It was eventually spotted in the gathering gloom of late dusk at the edge of visibility; *it was an example of technical skill and seamanship of the highest order to find the rig in such conditions.* Recovery was further hampered by the array being very tangled and quite heavily oiled, but was completed at 2200h well after dark. A CTD dip planned for the position had to be abandoned so that we could rendezvous with *Darwin* in time to make parallel level 1 productivity measurements.

The vessel hove to at 0416h-18/5 about a mile off the *Darwin*, and immediately carried out a shallow CTD deployment for productivity measurements. The standard level 1 measurements were begun with a deep CTD dip, but it was soon clear that the salinity measurements were well in error. A call to the *Darwin* resulted in Phil Taylor coming across to replace the leaking salinity sensor with a spare from the *Darwin*'s back-up. This took him until 2010h, meanwhile a long-term drifting sediment trap array was deployed, but the planned deployment of a short-term array was postponed until Phil Taylor had been transferred back to the *Darwin*. The postponed shallow CTD dip for the Level 1 measurements was completed. Stand-alone-pumps (SAPS) were then deployed, and simultaneously a marine snow catcher sample was collected at 35m. There was another short deployment of SAPS followed by water sampling for productivity measures.

At 0600h-20/5 the short-term floating sediment trap, was deployed. Much of the day on the 20th was spent abortively trying to fish the Multiple Rectangular Midwater Trawl (RMT's). A trial dip worked perfectly; but when the nets were deployed in earnest the net trace was lost and the second net opened prematurely. The net monitor was changed, but the release continued to operate continuously and was found to have leaked. The vessel returned to the central buoy for a multicorer deployment, which gave eight good cores. The RMT was then tried again, and this time a successful sequence of tows was collected over the dusk period at a depth of 200m.

Once again the vessel returned to close to the central buoy and another set of level 1 observations was completed. The RVS CTD functioned well thanks to the repairs affected by Phil Taylor, but it was considered unwise to risk making the deep observations with this instrument in case it leaked again. So the deep CTD observations were carried out using the instrument loaned by IOS. This proved to have an offset in its calibration when its data were compared with both the salinometer values of water samples and the historical deep water T/S relationships. Once the level 1 measurements were completed, there was a successful tow with the RMT at 500-200m. The vessel returned to the central buoy where SAPS were deployed (2024h-21/5). Throughout the night there were deployments of SAP, the Marine Snow catcher and water samples were collected for productivity measurements. From dusk until 1700h on the 22/5, there were three successful tows with the RMT. More SAP work preceded the next set of level 1 measurements. Once these were completed the vessel then went in search of the short-term sediment trap rig. It was located and grapnelled at 1400h-23/5, and recovery completed at 1438h. The traps contained considerable quantities of

material and it was decided to shorten further deployments from three to two days. The vessel returned to the central buoy for more SAP work. During the night (23-24/5) there were marine snow catcher deployments, but a shallow CTD drop for productivity was abandoned. The short-term sediment trap rig was redeployed at first light, and the following day was spent conducting deep RMT tows. Throughout the day the winds were freshening and on recovery of the second series of nets two of the RMT1 cod-end bags were lost while the nets were surging at the surface. Further netting was abandoned, partly because of the weather and partly because the engineers wanted to pump out the ship's sewage system. This was done well away from the central buoy position.

At midnight (24-25/5) a further set of level 1 observations were made but the deep CTD cast was abandoned because the cross wind and swell conditions were making station keeping problematic. By the time the level 1's had been completed the weather conditions had ameliorated and at 1500h-25/5 there was a deep SAP observation.

The next night (25-26/5) was spent midwater trawling but with only limited success. Although the weather had again deteriorated and there were heavy swells, it was not the source of the problems. During the first tow the third net prematurely opened because of a fault on the monitor, and the second tow failed because a newly-charged battery pack failed to hold its charge. The ship returned to pick up and redeploy the short-term sediment trap rig. This was followed by a near sea-bed SAP collection. By this time the weather had reverted to light winds and the seas were subsiding.

The night of the 26-27/5 was spent carrying out another set of level 1 observations. The results were quite startling. The thermocline had deepened, and there was chlorophyll fluorescence down to 50-60m. The phytoplankton populations had become dominated by diatoms and concentrations of bacteria had fallen by an order of magnitude. The quantity of marine snow also had decreased substantially. The conclusion was that there had been a major advective change in the water. A short CTD transect was conducted northwards, but no front was detected. An XBT survey was run westwards to the buoy's previous position, and *Darwin* which by then was only some 20 miles away, was asked to XBT up to the central buoy's position. Neither short XBT survey located any frontal feature. The final midday vertical plankton net haul to round off the level 1's. There was a boat exchange of personnel and mail via the *Darwin*'s work-boat, Ms Doriel Jones came over to *Discovery* in order to sort out the *Darwin*'s CTD computer interface. At 1630h-27/5 there was another SAP deployment, and the night hours were spent fishing the near surface layers with the RMT's. Very large catches were taken; the communities in the wind-mixed layer were quite different from those within the thermocline. At dawn (28/5) we returned to the central buoy and picked-up the short-term sediment trap rig. At 0835 Doriel Jones returned to the Darwin with the interface fixed.

The vessel then conducted an XBT survey to the north and north-east, with the aim of locating the water with which the central buoy had previously been associated, but the search proved fruitless. *Darwin* was again contacted in order to make arrangements about a further exchange of water from the level 1 observations made in the early hours of 29th. The water was exchanged at 1000h-29/5 (NB Discovery was

working GMT, whereas Darwin was working BST). Another good set of multicorer samples were obtained before the short-term sediment trap rig was redeployed. The vessel then moved to the west, to where the central buoy had stayed almost motionless over several days prior to the blow. The marine snow catchers hoped that the water which they had been sampling during that period would still be around together with the rather different communities and the very high concentrations of aggregates in the water. A number of observations were made at this position prior to trawling with the midwater nets throughout the night. In the early hours the weather conditions again deteriorated, as another depression moved through the area. During the day (30/5) a triangle of deep CTD casts were made around the central buoy. That evening the winds freshened making it impossible to conducted very much work. A very shallow CTD dip was carried out at 0412h-31/5 for productivity measurements, but otherwise it was too risky to deploy gear.

By 1200h-31/5 conditions had improved sufficiently for trawling to re-start. Even so, on retrieval one of the cod-ends had been torn away. By the time the trawling had been completed the vessel was quite some distance away from the central buoy and it took a couple of hours steaming to regain position. That night (31/5-1/6) was spent collecting aggregates and animals for experimental observations. In the morning the short-term sediment-trap array was recovered and the central buoy was serviced. The RDF unit had dropped off and the head rope was badly chaffed, both were replaced. There was then a deep SAP deployment, and a redeployment of the short-term sediment trap rig. The next night (1-2/6) was spent trawling, trying to established the timings of the migrations by the macroplankton and the micronekton.

Once trawling was completed, the vessel headed for the position of the first multicorer deployment close to the central buoy position (Stn 12060#3), and another good set of cores was collected. The vessel returned to the vicinity of the central buoy, which had moved appreciably southwards during the night. Back at the central buoy there was another successful deployment of the multicorer, and the pattern of alternating trawling, CTD profiling and "snow" catching was continued until 4/6. The final activity was a deep CTD before the vessel final set course for Barry.

In the Bristol Channel we were treated to a splendid display of helicopter flying by the Royal Naval Rescue Service using the ship for training, landing a man on the fore-deck. The ship eventually entered the lock at Barry at 0530h. It had been a most successful and happy cruise.

MVA

6. SUMMARY OF CRUISE STATISTICS

CTD casts deep	11
300m	23
35m (for productivity)	12
assorted depths	4
Marine Snow Profiler	14
RMT(1+8)M trawls	18
Marine Snow Catcher	29
WP2 net; vertical hauls	13
Apstein net; vertical hauls	8
Stand Alone Pumps	13
Multicorer	4
Sediment Trap deployments	
Short term/and recovery	5
Long term	1
Bathysnap recovery	1
ARGOS buoy recoveries	2
ARIES recovery	1
XBT surveys	2
Sets of Level 1 Observations	10

7. ACKNOWLEDGEMENTS

The success of this cruise was greatly assisted by the help of many people to whom, on behalf of the scientific party, I wish to extend our most grateful thanks.

Captain Coverdale and his team of officers and crew provided us with a high level of seamanship, which not only made the science easier to accomplish, but made this one of the happiest cruises it has ever been my pleasure to participate in.

The shoreside support from RVS also was a key element in the efficient and safe operation of the vessel.

Dr Philip Williamson played an essential, and as always, a most efficient role in coordinating and trouble-shooting both before and during the cruise. His contribution to this cruise and all BOFS activities needs a special vote of thanks.

Dr Robin Pingree and Bob Barrett for continually updating the Argos positions also made an essential contribution to our success.

Dr D. Robbins loaned us his experimental incubator.

Dr Peter Burkill, Principal Scientist on the B2 cruise of *Darwin* for picking up the medium-term sediment trap array.

Phil Taylor for temporarily transferring to *Discovery* to repair our CTD at sea.

McLane Research Labs. Inc. for the modified software for one of the medium-term sediment traps.

Dr. Peter Herring for the loan of a temperature controlled laboratory.

Dr. Philip Pugh for his work on the biological database and production of the station list.

8. GEAR REPORTS

8.1 Neil Brown CTD - RVS system

The oxygen sensor failed on the first deployment and a steadily increasing positive drift in salinity (Table 1) indicated there was probably a leak of water through the sensor head. A test cast to 1000m to investigate the integrity of the platinum thermometer beyond the thermocline resulted in a total failure of the conductivity cell. This was confirmed by dismantling the sensor head. The sensors and their associate wiring were thoroughly cleaned in freshwater and then gently dried with a heat gun. The "O" ring faces were cleaned and polished and new "O" rings installed. The oxygen sensor was replaced with a blanking cap. Future deployments with the RVS CTD were restricted to 300m in case there were further leaks. The standby deep CTD loaned by IOSDL was used for the deep casts, although it lacked a fluorometer, oxygen sensor and a compatible transmissometer input. With both systems the temperature data compared well with the reversing thermometer data.

Figure 1 shows the CTD salinities plotted against the salinometer values.

CP

8.2 Neil Brown CTD - IOSDL system

This CTD was operated to full ocean depth (4800m) with good consistent results. Derived salinities were 0.3 PSU too low compared with salinity samples measured on the cruise and also compared with historical data sets. The temperature data compared well with the reversing thermometers.

The CTD salinities plotted against the salinometer values are shown in figure 2.

CP

8.3 General Oceanics Rosette sampler

Initial problems with non-latching of the deck unit "sample" function was traced to a faulty relay within the deck unit prior to sailing. While at sea there were still occasions when the rosette sampler failed to confirm a bottle had fired, although the bottle always did. This occurred progressively less often as the cruise continued until it no longer appeared to be a problem.

CP

8.4 TSG 103 Thermosalinograph

Initial failure of the instrument was traced to the 15v power supply. This was replaced by a Farnell dual power supply for the remainder of the cruise. Salinity and temperature readings became erratic during the first few days of operation and a replacement A to D card 3032 was installed. Comparison of the salinity output to sampled salinities taken from the non-toxic sea-water supply indicated that the output was reading 0.06 PSU too low. The processes Level C output appeared to be reading 0.3 PSU too high for reasons not yet determined.

CP

8.5 Marine Snow Profiler (MSP)

This is a system for photographing the large amorphous aggregates commonly know as marine snow in the water column. It consists of a camera which is attached to the CTD frame and a flash unit giving a collimated beam of light at right angles to the direction of the camera. If the optics of the system are correct, then both the numbers and the sizes of the particles in the water can be measured.

The production of a collimated light beam from a flash gun source, requires a lens to be placed in the diverging beam. The lens has to be positioned so that its focal point is at the light source, otherwise a parallel beam is not produced. Fresnal plastic lenses are used which have a refractive index very close to that of the water. Although the focal distance was calculated and tank tested, fine tuning of the system was still needed at sea.

The need for split second timing of the flash firing frequency, resulted in modifications being made to the electronic circuitry at sea. The current being drawn by the charging circuit caused a voltage drop in the timing circuit, which destablised the timer, and resulted in the trigger pulse deviating from its timing. This was overcome by using the camera-to-flash trigger pulse to start both the charging cycle and fire the flash pulse.

There were 14 deployments with only a single failure, so overall the system worked reliably once the initial teething problems had been overcome. The use of an external re-chargeable battery pack proved to be very effective, each charge lasting three deployments; speeding up the turn around time. No problems were encountered with power loss through the cables, and the flash energy remained constant so there were no variations experienced in the exposures. Camera P4-09 gave no flash pulse at 1 minute intervals, but worked perfectly well at 15 second intervals.

Future improvements include the design of a point light source and associated reflector which will give more even illumination, and will also reduce the energy required, reduce the battery requirements and minimise control problems. A frame needs to be developed for use on moorings. The flash control circuitry need to be re-designed and circuit diagrams need to be added to the handbook.

NG

8.6 Bathysnap

The bathysnap retrieved on the 16/5 had been deployed on a previous year's BOFS cruise on 26/5/89. It was the first Bathysnap system to use the new IOS mk 5 camera and flash unit. The film had gone through and the data back was still functioning. The batteries were dead, but there was no serious corrosion to the unit. Similarly the flash unit was still functional, and its batteries still held charge, the timing circuitry was still accurate and the flash energy level was still correct. However, there was heavy corrosion on the pressure housing body which was stressing the Pyrex dome so that failure was imminent. When the system was powered up , it performed correctly so that the film should have been correctly exposed. The only slight misgiving was that one of the connectors supplied by IOS stores was not a standard type and this may have caused a problem under pressure. Subsequently it was found that a component failure in the flash unit resulted in the failure to obtain any benthic pictures.

The new external battery pack should overcome any battery problems, but a re-design of the pressure housing body should be considered.

NG

8.7 Net release gear and flow meters

The release gear leaked on its first deployment causing the premature cycling of the nets. The volume of water which had leaked into the pressure casing was small, indicating that it had been a low-pressure leak. When the gear was stripped down there were no marks on any of the "o" rings nor on their grooves. The water had not reached the lithium battery pack, but the micro-switches had been damaged. The unit was cleaned and dried, rewired and all the switches replaced. The "o" ring grooves and surfaces were polished and the "o" rings were replaced. There were no further problems for the rest of the cruise.

One flow meter was damaged possibly through hitting the side of the ship. It was replaced with a spare unit and will be repaired back at IOS.

NG

8.8 Marine Snow Catcher (MSC)

Macroaggregates, commonly termed marine snow, are both fragile and sparsely distributed. Previously it had not proved possible to collect them satisfactorily using either standard water bottles or *in situ* filtering pumps; the only effective method had been to involve SCUBA divers, which is not a practical option in

the cold rough waters of the North Atlantic. A large volume water bottle has been designed and constructed at IOSDL so that snow aggregates can be sampled more or less intact with the minimum amount of damage caused by turbulence. The MSC has a volume of 100 litres. It is deployed open and is closed by messenger at the sampling depth. After retrieval the device is left standing upright on deck for two hours, which allows the aggregates to settle out onto the bottom. The top 95 litres of sea-water can then be drained off and the lower portion of the sampler detached, giving access to the settled aggregates. Initially the samples are photographed so that their abundances and sizes can be compared with the data derived from the Marine Snow Profiler (see 8.5). The aggregates can then be removed for examination, selection, analysis and experimentation (see 13.4). 27 deployments were carried out mainly at 45 and 300m depth and almost all were entirely successful.

RSL

8.9 Stand Alone Pumps (SAPS)

A total of eleven casts were accomplished which covered a bathymetric range of 30-4200m, using three new Challenger Oceanics SAPS (CO-SAPS) with redesigned filter-holders (Table 2). All samples were collected on precombusted (380^{o}C for >12h) GFF filters. On eight of the casts, one pump was fitted with a modified filter-holder containing a support plate for a 53µm Nitex prefilter to enable the large particles contributing to the sinking flux to be separated from the suspended particles which form the bulk of the POC. This pump was deployed at the same depth as an unmodified pump using a double deployment frame.

A new plastic impregnated wire was used to minimize contamination. This wire performed well with no signs of chaffing, cutting or peeling of the plastic, as had been experienced with the plastic-coated wire used the previous year. Newly designed pump clamps and safety clamps showed no signs of slippage during a deployment in moderate sea states (about 5-6).

The overall ease of handling the CO-SAPS and filter-holder loading was good. Volumes filtered by paired pumps deployed on the double deployment frame agreed within 10-20%. A problem was initially encountered with the electronics board of one of the pumps, but once the board had been changed the pump worked reliably. Pump performance was generally good, but major problems were encountered with the new filter-holder design which may have seriously compromised qualitative sampling (Table 3). These were:-

1. Rupturing of the filters: The majority of the filters showed evidence of tearing along the edge of the filter, or of having been pulled out of the O-ring. We hypothesize that filter rupturing was caused by back-pressure during either deployment or recovery. Examination of the particle loading revealed that the tears were sealed during pumping. Two 0.45µm Nucleopore filters (used to obtain trace metal samples for P. Newton, UEA) were completely split.

2. Uneven distribution of particles and excessive flow velocities in the central area of the filter: The central 10cm diameter of the filter had about twice the particle density as the outer area. This area corresponded to a recess in the baseplate, indicating flow resistance and thus velocities were uneven across

the filter. Concentric tears in the GFF were found in the central area indicating excessive flow velocities there. A few samples also included large copepods, which suggests that, as a result of the relatively small cross-sectional areas of the narrow intake slits in the top-hat, the intake velocities were high enough to entrain the animals.

These problems (also encountered with the new holders on IOS SAPS deployed on the *Darwin*) indicate that a redesign of the filter-holders is required. The support plate insert for a pre-filter which we tested, enabled us to obtain size-fractionated samples, but this also needs redesigning.

MC, LM

9. MOORING OPERATIONS

Mooring operations commenced on passage to the 60°N sediment trap mooring, when one Metocean and one IDB drifting buoy were recovered. The Metocean buoy which had been deployed 390 days earlier, had lost its drogue and was quite heavily encrusted with goose barnacles. The IDB buoy had been deployed as part of the drifter pattern in the area of 48°N during *Discovery* Cruise 190, and had moved quickly northwards.

By Tuesday 15/5 the vessel arrived at the site of the sediment trap mooring (59° 00.2'N; 21° 57.9'W) and an acoustic search was begun. No signals were detected from either of the two CR 200 release units or the transponder. A box search, carried out at one mile intervals, failed to detect the mooring; a search further to the east was also unsuccessful, so the search was abandoned. There was a successful recovery of the Bathysnap mooring at 59° 16.848'N; 21° 03.050'W, and its current meter indicated that there had been periods when the current a metre above the sea-floor were in excess of 0.25m.s^{-1}. Interrogation for the sediment trap mooring continued throughout the morning of 16/5 during the CTD and multicorer deployments (Stn 12055), but without success.

The ARIES rig was successfully recovered at 49° 15.3'N 18° 14.8'W at 2120h 18/5, in failing light and very poor visibility. The mooring was located initially with the RVS RDF system and the IOS HFR3 RDF with a modified antenna. Final location was achieved using the acoustic release signals. The mooring was badly tangled, but recovery was straight forward. All surface components of the mooring were badly contaminated with oil. A transmission test on the ARIES instrument showed that it was not working and it was decided to cancel the intended redeployment.

The long-term drifting Parflux sediment trap array was deployed on 19/5. Prior to deployment confirmation was received from PML that the ARGOS positional data were being received via satellite. The ARGOS antenna had been removed and replaced with a modified assembly to overcome the difficulties experience during deployment of a similar rig during *Discovery* Cruise 190. The buoy was slipped from a "no load hook" and streamed astern. The mooring line was led over a wide throated block hung from the Schatt davit and stopped off on 13mm chain for the insertion of the sediment traps. The deployment was uneventful with the ship steaming at 0.5-1.5 kts. The anchor was cut away at 1648h at 48° 28.341'N 17° 25.234'W. The

ship stayed alongside the buoy to watch the rig settle out. Both the ARGOS and the RDF transmissions were checked out. During the rest of the cruise positions were regularly received from PML.

There were five deployments of a short-term drifting sediment trap rig, which were picked up and redeployed every 2-3 days. Each time, deployment was close by the central buoy (Table 4).

Throughout the cruise the RDF frequency of the long-term drifting sediment trap rig which went missing during *Discovery* Cruise 190 was scanned on the RVS homing system but no signals were received.

KG

10. WATER CHEMISTRY

10.1 Level 1 Measurements

Level 1 water bottle casts were at the JGOFS standard depths from 0-300m Twice at the northern station, and at two day intervals at the position of the central drifting buoy. The requirements for water were in excess of 10 l, so replicate casts were done normally as quickly as possible in succession. Productivity measurements were carried out on water samples collected separately, early enough before dawn to start the incubations prior to sunrise. The station data are summarised in Table 5.

IM

10.2 Dissolved oxygen measurements

Dissolved oxygen measurements were carried out using precision photometric endpoint detection on all level 1 water bottle casts at each of the twelve standard depths. Each determination was based on four replicate samples; overall analytical precision was better than ±0.1%, but was normally better than ±0.05%. The precision required for these measurements was achieved without problems and the data have been passed to the responsible staff at PML.

IM

10.3 ^{14}C Productivity

Sufficient isotope for five 24h incubations had been provided by PML, and pre-dawn bottle casts were carried out at five of the level 1 stations on 19, 21, 23, 27 and 29th May. The sample depths were 2, 5, 10, 15, 25, and 35m, which covered the wind-mixed layer. The samples were collected and spiked in the dark and then incubated for 24h in a deck incubator which provided six simulated light depths. Subsequently the samples were filtered onto 0.2µm membrane filters using low vacuum (<0.3bar) and then stored for later counting at PML. No problems were encountered and the aft chemistry laboratory was left clean and free of any isotope contamination.

IM

10.4 Dissolved oxygen productivity

Small dissolved oxygen bottles were available which fitted the tubes of the deck incubator. So the opportunity was taken to carry out additional productivity measurements based on dissolved oxygen at the level 1 stations when no ^{14}C work was possible. In all four sets of observations were made on 22, 25, and 31 May and on 3 June.

IM

10.5 Chlorophyll

Samples were collected from all level 1 water bottle depths. Each sample was duplicated; one for extraction and analysis onboard and the other was stored frozen as a back-up. The samples were extracted in 90% acetone and the fluorescence measured using a JASCO spectrofluorometer kindly made available by Dr Gerhardt Herndl. The Turner fluorometer normally used onboard was not in a usable condition, and but for the fortunate availability of Dr Herndl's instrument, reliable chlorophyll measurements could not have been achieved. Calibrations were carried out using pure chlorophyll *a* extracts provided by Dr Alison Weeks (SUDO), and these provided an excellent, linear calibration line.

IM

10.6 Nutrients

The analyses were conducted using a four line autoanalyser by Gavin McNeill, who considering his inexperience of carrying out nutrient analyses, achieved a commendably high level of accuracy. Changes had to be made to the chemistry of the ammonium and phosphate lines before repeatable results could be achieved. After these changes had been made the analyses were problem free.

Analyses were carried out on samples from all level 1 depths, on surface samples collected from the non-toxic sea-water supply during the transect from the northern station to the central buoy position, and from those samples used for dissolved oxygen productivity analysis. There were also some minimal attempts at intercalibrating the different analysers onboard *Discovery* and *Darwin* during both the overlapping *Darwin* cruises. However, despite difficulties encountered in interpreting the data from the 1989 cruises, there was, disappointingly, a lack of interest by personnel on the *Darwin* to put much effort into this rare opportunity to conduct analyses on the same water samples at sea.

IM

10.7 TCO_2 samples

Sufficient bottles were available to collect and preserve water samples for TCO_2 analysis from eight stations. Samples were collected at both the northern stations (one of which was a deep station) and at the five level 1 stations sampled on the 21, 25, 27, 29 May and 1 June. In addition samples were collected at a

deep station at the central buoy position on 4/6. The samples are to be analysed by Dr Carol Robinson (UCNW).

IM

10.8 pCO_2 and dissolved N_2

Samples were collected from a total of eleven CTD rosette casts for high precision onboard analyses of pCO_2 and the concentrations of dissolved argon and nitrogen by gas chromatography. Measurement precisions were ±0.2% (pCO_2), ±0.2% (N_2) and ±1% (Ar). Two casts were made close to 59°N 22°W, the remaining nine were made in the vicinity of the central drifting buoy in the BOFS study area close to 48°N 17°W (see Table 6).

Despite a number of technical problems, pCO_2 was analysed in all samples. Unfortunately, however, the Ar/N_2 detector was irreparably damaged on 1/6 and so no measurements were possible on the samples from the last three casts. Furthermore, a computer failure meant that the Ar/N_2 data could not be fully worked up at sea; the pCO_2 data have been fully processed.

At 59°N, pCO_2 values were constant at about 390µatm in the upper 30 metres, rising linearly to about 520µatm at 900m, below which values were approximately constant.

Measurements at 48°N coincided with the early stages of the spring phytoplankton bloom. Surface values were in the range of 230-240 µatm and increased steeply across the thermocline, becoming constant at about 360 µatm below about 40-100m. Detailed analysis of the data will be possible when the full suite of chemical and physical data from the cruise are available.

RU-G

11. LIPID BIOGEOCHEMISTRY IN THE WATER COLUMN AND SURFACE SEDIMENTS

11.1 General Studies

The purpose of our participation in this leg of the BOFS Lagrangian experiment was to continue our investigations of production and flux of lipid biomarker compounds in the water column and of their early sedimentary diagenesis.

1. Particulate material was collected at 59°N 22°W and at the central drifting buoy position using the Stand Alone Pumps (SAPS). We successfully collected size-fractionated samples of particulate material using a modified SAP filter holder fitted with a 53µm Nitex prefilter. These samples will assess differences between the composition of large particles contributing to the sinking flux and the suspended particles which comprise the bulk of the POC. Additional samples of particulate material in the euphotic and subeuphotic zones (0-100m) were collected using the 10 l Niskin bottles on CTD casts to assess variability in POC composition in surface waters. An experiment to assess decomposition/transformation rates of particulate lipid compounds in the midwater column was also conducted.

2. Sediment trap material from depths of 51, 101, 201 and 301m was collected from an unpreserved , 3-day drifting sediment trap deployment (Stn 12059) at the drifting buoy position.

3. Surface sediment samples were collected at the northern position and at three positions along the track of the drifting buoy, using the multicorer in order to investigate the early diagenesis of lipid biomarker compounds. We successfully fine-sectioned these cores at millimetre scale intervals onboard ship using a Precision Core Extruder newly designed at Bristol.

4. Mesozooplankton samples were collected in the upper 100m for lipid analyses at interval at the drifting buoy position using WP2 nets (Table 7).

In addition to our own sampling programme, we conducted JGOFS Level 1 sampling for POC/PON, pigments, 0-100m mesoplankton biomass and grazing rates, microzooplankton and phytoplankton species composition during the interim period between the two *Darwin* cruises. We also collected samples for phytoplankton genetic studies and culturing.

MC, LM

11.2 SAP sample processing

Quantitative large subsamples of the GFF filter were taken using stainless steel punches, and these were stored in 2:1 chloroform:methanol filled vials at -20^{o}C. Replicate punches from the inner 10cm area and outer area were taken for C:N analysis so that the total amount on the filter and of the lipid subsamples could be quantified. The remainder of the sample was stored in solvent-filled jars for qualitative analyses.

Large particles collected on the Nitex pre-filter were preserved for microscopic, as well as lipid, analysis. Roughly two-thirds of the total filter area were carefully rinsed off using MilliQ water onto 47mm precombusted GFF filters, filtered down and preserved in solvent at -20^{o}C. The remaining one-third of each filter was stored frozen in a petri-dish. A portion of the prefilter of some samples was also taken for microbiological analyses. The total >53µm material will be quantified by the difference between the 1-53µm fraction collected on the underlying GFF filter and the total >1µm material collected on the GFF filter from the unmodified SAP in the paired deployments.

Subsamples of material collected on GFF filters from depths of 250m and 500m were incubated in 0.22µm filtered sea-water for 0-5 days at *in situ* temperatures to investigate decomposition/transformation of lipid biomarkers by particles-associated microbial populations.

MC, LM

13. SEA-WATER MICROBIOLOGY

12.1 Bacterial and cyanobacterial numbers

Measurements of bacterial and cyanobacterial numbers were carried out at sea on a number of stations and water depths (see Table 8). These will be compared with a) samples prepared at sea, stored frozen and counted on land and b) fixed Sea-water sample preparations carried out on land in order to assess the JGOFS level 1 storage and counting protocol.

Bacterial numbers were highest in the top 20m, ranging from 2.5-4.1x10^6 cells/ml. There was a sharp drop in numbers across the thermocline and a subsequent steady decrease with depth. Cyanobacteria were also highest above the thermocline with 0.6-1.0x10^5 cells/ml before the storm on 25/5. After the storm the cyanobacterial numbers in the surface 20m were considerably lower, 0.03-0.22x10^5 cells/ml.

CMT, DH, GH

12.2 Bacterial production and activity

Measurements of bacteria productivity were carried out by the recommended JGOFS technique of ^{3}H-thymidine incorporation into bacterial DNA and extraction by ice cold 5% TCA at stations and depths indicated in Table 8. These measurements of bacterial productivity were compared with those obtained from hot TCA ^{3}H-thymidine extraction method and those obtained from measurements of the rate of bacterial protein synthesis based on leucine uptake. The rate of amino acid uptake by bacteria was also measured on the samples indicated in Table 8 by the uptake of ^{14}C amino acid mixture.

The general picture which is emerging from a preliminary study of the results is high bacterial production and activity above and on the thermocline, a sharp decline below the thermocline and then a more gradual decline with increasing depth. A second peak of bacterial activity, in particular bacterial protein synthesis, may occur at the deep-sea sediment-water interface. Measurement of bacterial protein synthesis was a more sensitive measure of bacterial activity in the bathypelagic and mesopelagic waters than that of thymidine incorporation into DNA. The relation between bacterial protein synthesis and DNA production with depth may emerge with detailed examination of the data, as will the effects of pressure on bacterial production and activity.

CMT, DH, GH

12.3 Extracellular enzymatic activity (EEA).

A significant proportion of the primary production becomes available to heterotrophic bacteria via extracellular release of phytoplankton. Much of this DOM is composed of high molecular weight compounds, and is, therefore, not directly available for bacteria. They have to hydrolyse the high molecular weight fraction of the DOM outside the cytoplasmic membrane. Sensitive techniques, using fluorescent substrate analogs (α-glucoside and MCA-aminopeptide as representatives of the carbohydrate and protein pool, respectively)

have been used to study the EEA at the stations and depths shown in Table 8. Samples were also taken for carbohydrate and amino acid analysis.

Preliminary results indicate that highest EEA activity occurred in the top 20m of the water column, below which there was a steady decrease with depth, although enzyme activity was still detectable at 4250m. At the deep-sea sediment water interface EEA was of the same order as in the top 20m. These data will be compared with bacterial density and production in order to elucidate the interaction between hydrolysis activity and growth in heterotrophic marine bacteria.

CMT, DH, GH

12.4 Intercalibration between ships

Sea-water samples were exchanged between the *Darwin* and *Discovery* for intercalibration of the JGOFS bacterial production and enumeration methods.

13. MACROAGGREGATE STUDIES

13.1 Distribution

In situ photographs were taken of the macroaggregates in the water column using the MSP (see 8.5) mounted on the CTD while lowering at a slow rate. Pictures were taken every 15 seconds to give detailed profiles of the distributions. The films were developed onboard so that from the negatives the main concentrations of the aggregates could be identified and sampled. The majority of the 14 deployments were completely successful. Most were to a maximum depth of 300m, but two went to 4000m. The images will be analysed using a Kontron Image Analyser to provide data on the abundance and size distribution of the aggregates throughout the duration of the cruise.

RSL

13.2 Macroaggregate composition

The macroaggregates were sampled using the MSC (see 8.8). Once the aggregates had settled out, the lower section of the sampler was placed in a CT room at 10^{o}C and photographed for later enumeration. The macrobial and microbial composition of the aggregates was examined by using three different aggregate preparations (acridine orange staining of the DNA, autofluorescence on a stained black background, autofluorescence mounted in glycerol) under an epifluorescent microscope and different filter blocks. This resulted in the fluorescence of different cellular and structural components of the aggregates so that the aggregates could be characterised and the changes in their composition followed with depth and time. Many of these characteristics and changes have been successfully recorded photographically.

CMT, GH

13.3 Interactions with microbiota

Aggregates were removed from the MSC for measurements of EEA, bacterial protein synthesis (^{3}H-leucine uptake), respiration (O_2 consumption), bacterial density and carbohydrate, amino acid and POC concentration. Initial study of the results indicate that aggregates exhibited about three orders of magnitude higher respiration rates and EEA than comparable volumes of ambient sea-water, indicating that they may play an important role in nutrient cycling in the upper mixed layer.

CMT, GH

13.4 Interactions with macrobiota

The epifluorescent methods proved invaluable for following the fate (ingestion, excretion and transformation) of some of the components of the aggregates. Naturally occurring autofluorescent biomarkers, such as lorica of two species of tintinnid *Dictyocysta* and the picoplankton matrix of autofluorescing cyanobacteria and chlorophytes (all typical components of the aggregates) were looked for in the faecal pellets of variety macrozooplankton species to see which had been feeding on the aggregates. Several species appeared to be grazing directly on macroaggregates, particularly the amphipod *Themisto compressa.* Since these aggregates contain high concentrations of photosynthetic organisms which would normally be far too small to be grazed directly by species which are normally thought to be carnivores and scavengers, the process of aggregation was making primary production, even by picoplankton, directly available to these macrophagous feeders.

It was confirmed experimentally that several macroplanktonic species would feed directly on the aggregates. Fresh aggregates were incubated in jars slowly rotated on a wheel in an incubator (provided by courtesy of D. Robbins PML). A variety of macroplanktonic and micronektonic species were added to some of the jars, and the jars were examined at regular intervals to examine the aggregates remaining and the faecal pellets produced for the biomarkers. Parallel experiments were conducted in which the faecal production by starved animals was followed.

The observations on the amphipods were probably highly relevant to understanding carbon flux, because not only were they consuming the aggregates but the trawling programme showed them to be undergoing diurnal migrations of 300-400m. Their gut retention times proved to be long enough for a substantial proportion of the carbon they ingested in the surface waters to be transported into the deep water well below the upper mixed layer and excreted as faecal pellets. The fact that there exists a single food chain step, from very small primary producers to amphipod, rather than a 3 or even 4-step chain primary producer-protozoans/microzooplankton-macrozooplankton-amphipod, increases the importance of these combined biological processes (aggregation, vertical migration, aggregate grazing and defaecation at depth) in the transport of carbon from the mixed upper ocean.

KW, RSL, CMT

14. PARTICLE FLUX STUDIES

14.1 Short-term Deployments of sediment traps

Four single sample IOS sediment traps were deployed for periods of 2 or 3 days on five occasions on a drifting mooring within a kilometre of the central drifting buoy (DR10-14). The depths sampled were 300, 100 and 50m and either 200 or 20m. No preservative was added to the cups prior to deployment, so that the microbial community collected could be examined experimentally (see 15.1)

RSL

14.2 Medium-term Deployments of sediment traps

Following the loss of the deep drifting sediment trap rig on Discovery Cruise 190 (DR8, Station 12031), a second similar mooring was deployed soon after we arrived at the drifting buoy. There were four Parflux-6 traps set at depths of 300, 600, 1000 and 2500m. Most of the traps were set to sample at 4-day intervals, but in the trap set at 600m the software controlling which of the sampling cups was in place had been modified (courtesy of McLane Research Labs. Inc), to partition the flux into time of day. The aim was to see if a significant diurnal cycle in the flux could be detected, possibly correlated with the diel migration activity of pelagic organisms.

The traps worked perfectly, but as we were steaming back to Barry, there were reports from PML that the signal from the Argos tracker were weakening. The decision was made to terminate the experiment prematurely. *Darwin* was asked to interrupt its programme to pick-up the mooring, and we gratefully acknowledge the willingness of the scientists on the B2 cruise to compromise their programme. The rig was safely recovered. However, this has of necessity, reduced the period for which flux data was originally planned to be available for the BOFS 1990 field programme. Furthermore some of the samples have been compromised by the traps being retrieved midway through the sampling cycle.

The possible reasons for the loss of the original mooring (DR8) remain unclear, but will be the subject of a separate report. The Argos failure on (DR9) seems to have been caused by a substantial impact on the spar buoy some time after deployment.

RSL

14.3 Long-term sediment trap mooring

The intention had been to recover and redeploy the fixed long-term mooring at 59^{o}N. However, despite a thorough 5-hour search of the deployment position in excellent sea conditions, no signal for the mooring was detected. We can only presume that the exceptionally high current velocities recorded three metres above the sea-bed by the nearby Bathysnap, had caused the mooring to drag its anchor. This loss was a severe blow to the particle flux study at this northern site. The severity of the regional hydrographic

environment in the deep water have resulted in the abandonment of the plans to examine the long-term trends in the particle flux in this region which seems to play a significant role in the fluxes of the North Atlantic.

RSL

15. MICROBIOLOGY OF SEDIMENT TRAP, STAND ALONE PUMP AND MULTICORER MATERIAL

15.1 Short-term sediment traps

Bacterial numbers, bacterial extracellular enzymatic activity, rates of bacterial protein synthesis and microbial respiration rates were measured on particulate material collected on several different series of 2-3 day deployments of unpoisoned drifting sediment traps at depths of 50, 100, and 20 or 200m (see 14.1).

CMT, DH, GH

15.2 Stand Alone Pumps

Particulate samples collected on GFF's for bacterial protein synthesis, cell numbers and EEA analysis were taken using the SAP's at 45, 100, 300, 1530m and at 1000mab at 47°N. Both the sediment trap and the SAP data, on further analysis, give some insight into the role of micro-organisms in the remineralization of sinking particles. A further insight may be gained from pressure tolerance experiments carried out on bacteria associated with particles caught in a 200m sediment trap.

CMT, DH, GH

15.3 Isolation of oceanic flagellates

Oceanic flagellates were isolated using enrichment culture techniques from water samples collected throughout the water column (Table 9) and from the sediment/water interface at 60°N and 47°N and from the SAP samples. These will be described and their autecology recorded in the BOFS Flagellate Video library by Dr D.J. Patterson. They will also be used for physiological experiments in the laboratory. Some were also isolated under deep-sea pressure for continuation of our pressure tolerance work.

CMT, DH, GH

15.4 Deep-sea benthic Foraminifera

Grazing experiments, using mixed algal cultures, were carried out on Foraminifera in surficial sediments. They were sampled using the multicorer and incubated under *in situ* pressure and temperature.

CMT, DH, GH

16. LONG TERM OBSERVATIONS OF THE SEABED

The Bathysnap which had been deployed close to the 59°N long-term trap array was recovered without problem (Bathysnap deployment 33, Discovery Station 12054), after being on the sea-bed for nearly 12 months. The camera had worked perfectly, but a component failure in the flash electronics resulted in the

flash failing as the temperature cooled soon after it had entered the water (see 8.6). Consequently no benthic photographs were obtained. The current meter data do, however, provide a possible explanation for the loss of the long-term fixed sediment trap mooring. Currents of up to 30cm s^{-1} were recorded just 3m above the sediment, which persisted for many days at a time. Both the speed and the direction of the current were contrary to the previously accepted understanding of this region.

RSL

17. MIDWATER TRAWLING

The IOS multiple rectangular midwater trawl, (RMT1+8)M, was used extensively during the cruise to examine the vertical profiles of the macroplankton and micronekton around the central drifting buoy. Initially a series of hauls provided a day-time profile to a depth of 1100m, and two further sets of samples to 500m showed how the populations changed during the course of the cruise. A night profile to 800m was also collected, but towards the latter end of the cruise sampling was concentrated around dawn and dusk to study the timing of the vertical migrations and to quantify the organic material being exported out of the euphotic zone into deeper water by the migrating animals. Two sets of samples were collected at 200m and one each at 150m and 50m.

The initial day-time profile showed the usual vertical pattern in the distribution of biomass (Table 10). In the surface layers the macroplankton had a sixty-fold higher biomass than the micronekton. With increasing depth the macroplankton declined steadily, whereas the micronektonic biomass remained relatively constant. A unexpected feature of the first profile was the rather small numbers of siphonophores taken at depths of 200-400m. However, in the second set of samples taken after the storms of the 26-27/5, when there had been a major change in the microbiological populations, massive numbers of siphonophores were taken in the shallow mesopelagic zone. The final set of samples taken on the last day of sampling, showed a remarkably clear zonation with the catch being dominated by euphausiids at 200-300m, by the amphipod, *Themisto*, at 300-400m and by gelatinous species, including the large pteropod *Cymbulium*, at 400-500m.

At night the biomass taken by the RMT8 (micronekton) in the top 100m increased twenty-fold. Although reduced net avoidance will have contributed to some extent to this increase, the effects of vertical migrations were the dominant cause. The migrants included fishes such as *Benthosema glaciale* and rather surprisingly the hatchetfish *Argyropelecus hemigymnus*, several species of euphausiids, decapod crustaceans (such as *Systellaspis debilis* and *Acanthephyra purpurea*), but most striking was the migration of the amphipod *Themisto*. This amphipod dominated the catches in the surface hundred metres, although the adults tended to stay below the wind-mixed layer. Their migrations were somewhat variable. After the stormy weather they seemed to remain shallow, whereas after a few days of more settled weather they were again migrating to depths of 300-400m and their migrations were more predictable. The amphipods were actively spawning, samples were full of eggs and in the surface 50m the RMT1 samples contained high concentrations of newly hatched larvae, so another possibility is that while spawning they ceased to migrate.

Animals kept in the laboratory spawned and the eggs hatched quickly. The maximum concentration of the *Themisto* was 1 individual per 2.5m^3, a very high concentration for open ocean.

The dusk ascent tended to be more predictable than the dawn descent. At 50m, a half hour tow taken immediately prior to sunset caught many siphonophores and medusae, a few small euphausiids, pteropods and *Themisto*. The succeeding sample taken at and after sunset caught many salps, few siphonophores, several myctophid fishes, large numbers of euphausiids and a few *Themisto*. The net which was fished the second half-hour after sunset had a catch which was dominated by *Themisto*. The RMT1 catches showed that there was a marked decline in gelatinous organisms after sunset, which were predominantly the medusa *Aglantha*.

In the dawn hauls the decapods and fishes left prior to sunrise and were followed by the euphausiids. The *Themisto* tended to migrate down just prior to sunrise, but in several tows there were still quite large numbers remaining well after sunrise. The order of migration reflected the day-time depth stratification. It was unfortunate that the ADCP system had flooded on the previous cruise, and that the *Darwin* system was not turned on during her second cruise to the working area. Interpretation of these hauls would have been greatly enhanced if they could have been carried out in conjunction with simultaneous high frequency sonar observations.

MVA, BB, KW

18. GOOSE BARNACLES

On the Argos float 3909, which was retrieved on 13/5, were quite large numbers of the goose barnacle *Lepas anatifera*. The float had been deployed 390 days earlier and had been drifting in a frontal system between 51-52^{o}N for most of that period. On the underside of the float around the shackle point, about 1.5m below the water-line, were extremely large specimens which had probably settled very soon after the float had been deployed. There were other barnacles on the sides of the floats in small clumps; the largest being on the Velcro strip which had held the magnetic switch in place. All the specimens on the underside were collected and their umbo length measured to the nearest millimetre; about 60% of those on the sides were also collected and measured. There were a very few cyprids attached to the sides which must have just settled, but had not yet metamorphosed. The underside population were dominated by animals with umbo lengths of 24-41mm, and these had probably settled during the previous year. There were also quite a large number of smaller animals in amongst, and on, the larger ones, with umbo lengths of 4-17mm. On the sides the largest specimens had umbo lengths of only 34mm, and there were size peaks at 4-5mm and 13-15mm, although specimens occurred in all size categories from 2-34mm. Thus either settlement is more or less continuous, or growth is non-uniform depending on where settlement had occurred. The larger specimens in

particular showed quite well defined growth lines on the shell valves, and these may show, not only just how variable the growth rates are, but also whether surges in growth might be related to events like storms or phases of the moon. This material is being studied as an MSc project at Southampton University.

MVA

TABLE 1

Drift of salinity sensor on RVS CTD

Stn 12053#1 CTD salinity = salinometer values + 0.1

Stn 12055#1 CTD salinity = salinometer values + 0.13

Stn 12055#2 CTD salinity = salinometer values + 0.13

Stn 12056#1-3 CTD salinity = salinometer values + 0.4

After maintenance (see figure 1)

Stn 12058 etc CTD salinity = salinometer values + 0.042

TABLE 2

Details of SAP deployments

Station	SAP Cast	GMT Pumping Start	SAP	Filter	Depth	Pumping Time	Vol Filtered	L/HR	Pre/Post Deployment Voltage	Comments
12053#2	1	2206	2	GFF	75	30	313.6	627.2	-/16.22	Pump #1 bad batteries
			3	GFF+Nitex*	75	30	327.6	655.2	-/16.30	
12058#2	2a	2156	1	Nu	300*	150	-13.7	-5.5	-	
			2	GFF	500**	150	1257.4	503.0	-	Noisy - bad bearings?
			3	GFF	500**	150	1467.3	586.9	-	
12058#4	2b	0229	1	GFF	30*	30	10.8	21.6	-	
			2	GFF	75	30	348.2	696.4	-	
			3	GFF+Nitex*	75	30	310.3	620.6	-	
12063#1	3	2034	1	GFF	300	160	1947.2	730.2	16.71/-	Wouldn't take charge
			2	GFF	600	180	1608.7	536.2	17.22/-	
			3	GFF+Nitex*	600	40	445.7	668.6	17.22/-	Mistake w/ timer
12065#1	4a	1847	1	GFF	200*	180	-6.4	-2.1	17.15/-	Bad electronics board
			2	GFF	350	180	1584	528.0	17.34/-	
			3	GFF+Nitex*	350	180	1512.8	504.3	17.32/-	
12065#5	4b	0151	2	GFF	75	60	597.6	597.6	17.60/-	Pump #1 new board?
			3	GFF+Nitex*	75	60	555	555.0	17.60/-	
12067#1	5	1747	1	GFF	200	180	1942.4	647.5	17.17/-	
			2	GFF	1000	180	1692.7	564.2	17.44/-	
			3	GFF+Nitex*	1000	180	2051.4	683.8	17.30/-	
12070#7	6	1600	1	GFF	50	160	1102.8	413.6	17.14/15.52	
			2	GFF	150	160	1507.9	565.5	17.34/15.79	
			3	GFF+Nitex*	150	160	1592.7	597.3	17.30/15.63	

Station	SAP Cast	GMT Pumping Start	SAP	Filter	Depth	Pumping Time	Vol Filtered	L/HR	Pre/Post Deployment Voltage	Comments
12072#3	7	1312	1	GFF	1000mab	180	2045.5	681.8	17.17/15.20	Bottom at 4443m
			2	GFF	950mab	180	2234.6	744.9	17.38/15.38	Crane leaking oil badly
			3	GFF	250mab	180	2183.2	727.7	17.38/15.22	
12073#8	8	0206	3	GFF	241**	160	1387.4	520.3	17.48/15.15	
			2	GFF	250**	160	1261.6	473.1	17.52/15.87	
			1	GFF	301	160	2587.6	970.4	17.32/15.74	Leakage
12076#3	9	1720	1	GFF	300	180	1921.6	640.5	17.30/14.77	
			2	GFF	600	180	1484.2	494.7	17.40/15.63	
			3	GFF+Nitex*	600	180	1558.6	519.5	17.41/15.48	
12091#1	10	1305	2	GFF	1530	180	1693.6	564.5	17.28/15.54	Microbial analysis
			3	GFF	2500	180	2300.6	766.9	17.22/15.52	
12100#1	11	1035	1	GFF	45	120	1203.8	601.9	17.04/15.89	
			2	GFF	100	120	1059.2	529.6	17.26/16.20	
			3	GFF	300	120	1179.1	589.6	17.32/16.08	

* -size fractionated, 53µm prefilter of Nitex
** - for incubation experiment

TABLE 3

Observations on the state of the filters of SAP samples. *Filter state:- A: 10cm centre area of higher abundance; B: tear in corner; C: creasing on edge; D: concentric tears in centre; E: pulled out of O-ring (?for not quantitative?).

Station	SAP Cast	Filter	Depth	Filter State*	Comments
12053#2	1	GFF	75	A,B	10 agg/punch
		GFF+Nitex*	75	A	Numerous round "pepper" aggregates, 1/3 Nitex saved for micro
12058#2	2a	Nu	300#	OK?	Did not pump
		GFF	500*	A,C,D	"Loaded w/agg.", some jellies, for incubation exp.
		GFF	500*	A,C,D	Same as 2, for incubation exp.
12058#3	2b	GFF	30#		Did not pump, small amphipods
		GFF	75	A	Blotchy
		GFF+Nitex*	75	A,B	"Fine, gooey, green-brown slime", 1/3 Nitex samed for micro
12063#1	3	GFF	300	C, even	Long, thin green-brown, 1x5mm max.
		GFF	600	A,D,E?	Copepods, a few larger aggr. + filamentous, small <mm round pellets
		GFF+Nitex*	600*	A	Same as 2, 1/3 Nitex saved for micro
12065#1	4a	GFF	200#	?	Did not pump, particles visible, passive filtration?
		GFF	350	A,E	?
		GFF+Nitex*	350*	A	"Loaded w/ green filamentous", samples for Turley, Herndl, 6 copepods on GFF but no evidence of leakage of Nitex???
12065#5	4b	GFF	75	A,D	Large filamentous green
		GFF+Nitex*	75*	A,D	Same as 350m, no faecal pellets
12067#1	5	GFF	200	even	Greenish blobs
		GFF	1000	A,E?	<0.5mm round pellets
		GFF+Nitex*	1000*	Bad split	Greenish, no visible blobs

Station	SAP Cast	Filter	Depth	Filter State*	Comments
12070#7	6	GFF	50	A,C,D,E?	No filamentous, "speckled", photo
		GFF	150	A,D	<0.5mm round pellets, photo
		GFF+Nitex*	150*	A,D	Large particles on GFF?? No aggregates, samples for Turley/Herndl
12072#3	7	GFF	1000mab	A,B	For C. Turley, particles in centre
		GFF	950mab	A,E?	A few large particles
		GFF	250mab	A,B,E?	A few large particles
12073#8	8	GFF	241**	A,B	For incubation exp.
		GFF	250**	A,B	For incubation exp.
		Nu	301	Shredded	
12076#3	9	GFF	300	A,B	Speckled w/ brown aggr. 2mm max.
		GFF	600	A,B	Speckled w/<mm "pepper", some 3-4mm
		GFF+Nitex*	600*	A,B	Blobs, not filamentous, samples for Turley, Herndl
12091#1	10	GFF	1530	A,B?	Grease Blobs from ship on centre
		GFF	2500	even, B	Some particles as above
12100#1	11	GFF	45	?	?
		GFF	100	A,D	Photo
		GFF	300	A,E	Uneven distr. of aggr.

TABLE 4

Summary of the short-term sediment trap deployments

1. Stn 12059	Deployed	0713h	140	48°26.3'N 17°38.9'W
	Recovered	1438h	143	48°17.5'N 17°34.8'W
2. Stn 12068	Deployed	0558h	144	48°25.0'N 17°37.8'W
	Recovered	0648h	146	48°23.6'N 17°30.6'W
3. Stn 12072	Deployed	0934h	146	48°27.2'N 17°30.3'W
	Recovered	0747h	148	48°26.6'N 17°27.2'W
4. Stn 12080	Deployed	1501h	149	48°23.9'N 17°27.6'W
	Recovered	0945h	152	48°16.0'N 17°02.4'W
5. Stn 12092	Deployed	1834h	152	48°11.4'N 16°57.7'W
	Recovered	1905h	154	47°45.4'N 16°40.2'W

TABLE 5

Summary of nutrient, productivity and chlorophyll work

Date	Station	Determinands
15/5	12053/1	D.O., chl, nutr's, TCO_2 (northern to 2750m)
16/5	12055/1	D.O., chl, nutr's, TCO_2 (northern to 300m)
19/5	12056/2	Pre-dawn ^{14}C productivity,
	12058/1	D.O., chl, nutr's.
21/5	12061/1	Pre-dawn ^{14}C productivity.
	12061/6	D.O., chl, nutr's, TCO_2 (to 300m).
22/5	12063/4	Pre-dawn D.O. productivity, nutr's, chl.
23/5	12065/6	Pre-dawn ^{14}C productivity.
	12065/8	D.O., chl, nutr's. (to 300m).
25/5	12070/1	Pre-dawn D.O. productivity, nutr's, chl.
	12070/4	D.O., chl, nutr's, TCO_2 (to 300m).
27/5	12073/9	Pre-dawn ^{14}C productivity.
	12073/11	D.O., chl, nutr's, TCO_2 (to 300m).
29/5	12079/3	Pre-dawn ^{14}C productivity.
	12079/4	D.O., chl, nutr's, TCO_2 (to 300m).
31/5	12086/1	Pre-dawn D.O. productivity, nutr's, chl.
1/6	12090/4	D.O., chl, nutr's, TCO_2 (to 300m).
2/6	12095/2	D.O., chl, nutr's. (to 75m).
3/6	12097/1	Pre-dawn D.O. productivity, nutr's, chl.
	12099/1	D.O., chl, nutr's. (to 300m).
4/6	12106/2	TCO_2 deep cast.

TABLE 6

CTD stations at which gas analyses were carried out

Station No.	Time(z)-Date	pCO_2	Ar	N_2
12053#1[a]	1500-15/5	Y	Y	Y
12055#1	0820-16/5	Y	Y	Y
12058#1	1930-19/5	Y	Y	Y
12061#6	0600-21/5	Y	Y	Y
12065#8	0630-23/5	Y	Y	Y
12070#3	0630-25/5	Y	Y	Y
12073#11	0650-27/5	Y	Y	Y
12079#4	0700-29/5	Y	Y	Y
12090#4	0640- 1/6	Y	-	-*
12095#2[b]	2110- 2/6	Y	-	-
12099#1	0800- 3/6	Y	-	-

All casts were to 300m sampling at the standard JGOFS depths of 300, 200, 150, 125, 100, 75, 50, 40, 30, 20, 10, 2m.
except for a: deep cast to 2750m, and b: shallow cast to 75m. * failure of Ar/N_2 detector - no further data thereafter.

TABLE 7

Summary of stations and depths at which lipids, phytoplankton and level 1 microzooplankton samples were collected.

Station	Comments
12055#1	2 casts taken. Genetics + cultures at 30m only.
12056#4	Genetics + cultures at 10m only
12061#4	Genetics + cultures at 10m and 50m
12065#7	Microzoopl. samples also at 600, 1000, 2250m
12070#2	
12073#10	No microzoopl. samples

Nominal depth	Samples
3	Lipids, POC/PON, pigments, microzoopl. phyto. species comp.
10	Lipids, POC/PON, pigments, microzoopl. phyto. species comp. + genetics + cultures
20	Microzoopl. phyto. species comp.
30	Lipids, POC/PON, pigments, microzoopl.phyto. species comp. + genetics + cultures
40	Microzoopl. phyto. species comp.
50	Lipids, POC/PON, pigments, phyto. species comp., microzoopl.
75	Lipids, POC/PON, pigments, phyto. species comp., microzoopl.
100	Lipids, POC/PON, pigments, phyto. species comp. microzoopl.
150	POC/PON, pigments, phyto. species comp., microzoopl.
300	POC/PON, pigments, phyto. species comp., microzoopl.

*At station 12055#1 sampling depths differ for lipids and pigments

TABLE 8

Summary of stations and depths at which microbiological tests were carried out. AODC = Acridine Orange direct counts; CYANO = Cyanobacterial direct counts; 3H-TdR = Thymidine incorporation rate into bacterial DNA - cold = cold TCA extraction method, hot = hot TCA extraction method; 3H-Leuc = Bacterial protein synthesis rates (based on 3H-leucine incorporation); 14C-AA = Amino acid uptake rates by bacteria; EEA = Extra cellular enzymatic activity; RESP = Rate of oxygen consumption.

Station	Sample	Depth (m)	AODC	CYANO	3H TdR Cold/ Hot	3H LEUC	14C AA	EEA	RESP
12053# 1	1	2250			+	+	+	+	
12055# 1	2	11	+	+	+ / +	+	+	+	+
12055# 1	3	40	+	+	+	+	+	+	+
12055# 1	4	75	+	+	+	+	+	+	+
12056# 3	7	600	+		+	+	+	+	+
12056# 3	6	1000	+		+ / +	+	+	+	+
12056# 3	5	2710	+		+	+	+	+	+
12061# 6	16	2	+	+	+	+		+	+
12061# 6	15	10	+	+	+ / +	+	+	+	+
12061# 6	14	20	+	+	+	+		+	+
12061# 6	13	30	+	+	+	+	+	+	+
12061# 6	12	40	+	+	+ / +	+	+	+	+
12061# 6	11	50	+	+	+	+		+	+
12061# 6	10	75	+	+	+	+		+	+
12061# 6	9	100	+	+	+	+	+	+	+
12061# 6	8	300	+	+	+	+		+	+
12065# 8	34	2	+		+			+	+
12065# 8	33	10	+		+			+	+
12065# 8	32	20	+		+			+	+
12065# 8	31	30	+		+			+	+
12065# 8	30	40	+		+			+	+
12065# 8	29	50	+		+			+	+
12065# 8	28	75	+		+			+	+
12065# 8	27	100	+		+			+	+
12065# 8	26	300	+		+			+	+
12070# 3	25	2	+	+	+	+	+	+	+
12070# 3	24	10	+	+	+	+	+	+	+
12070# 3	23	20	+	+	+	+	+	+	+
12070# 3	22	30	+	+	+	+	+	+	+
12070# 3	21	40	+	+	+	+	+	+	+
12070# 3	20	50	+	+	+	+	+	+	+
12070# 3	19	75	+	+	+	+	+	+	+
12070# 3	18	100	+	+	+	+	+	+	+
12070# 3	17	300	+	+	+	+	+	+	+
12073#11	43	2	+		+	+	+	+	+
12073#11	42	10	+		+			+	+
12073#11	41	20	+		+			+	+
12073#11	40	30	+		+			+	+
12073#11	39	40	+		+			+	+
12073#11	38	50	+		+			+	+
12073#11	37	75	+		+			+	+
12073#11	36	100	+		+			+	+
12073#11	35	300	+		+			+	+

Station	Sample	Depth (m)	AODC	CYANO	3H TdR Cold/ Hot	3H LEUC	14C AA	EEA	RESP
12079# 4	61	2	+		+			+	+
12079# 4	60	10	+		+			+	+
12079# 4	59	20	+		+			+	+
12079# 4	58	30	+		+			+	+
12079# 4	57	40	+		+			+	+
12079# 4	56	50	+		+			+	+
12079# 4	55	75	+		+			+	+
12079# 4	54	100	+		+			+	+
12079# 4	53	300	+		+			+	+
12079# 2	65	600	+		+			+	+
12079# 2	64	1000	+		+			+	+
12079# 2	63	2750	+		+			+	+
12079# 2	62	4350	+		+			+	+

TABLE 9

Samples taken for isolation of oceanic flagellates

Station	Sample	Depth (m)
12053# 1	FL10	75
12053# 1	FL9	100
12053# 1	FL8	400
12053# 1	FL7	600
12053# 1	FL6	900
12053# 1	FL5	1000
12053# 1	FL4	1500
12053# 1	FL2 *	2250
12053# 1	FL1	2750
12055# 1	FL22	2
12055# 1	FL21 *	11
12055# 1	FL20	20
12055# 1	FL19	30
12055# 1	FL18 *	40
12055# 1	FL17	50
12055# 1	FL16 *	75
12055# 1	FL15	100
12055# 1	FL14	125
12055# 1	FL13	150
12055# 1	FL12	200
12055# 1	FL11	300
12104# 1	FL70	40
12104# 1	FL69	50
12104# 1	FL68	75
12104# 1	FL67	100
12104# 1	FL92	125
12104# 1	FL91	150
12104# 1	FL90	200
12106# 2	FL131	250
12104# 1	FL66	300
12106# 2	FL130	400
12106# 2	FL129	600
12106# 2	FL128	750
12106# 2	FL127	900
12106# 2	FL126	1000
12106# 2	FL125	1500
12106# 2	FL124	2250
12106# 2	FL123	2750
12106# 2	FL122	3500
12106# 2	FL121	4250

* = also analysed for level 1

TABLE 10

Standing-crop (mls displacement volume per 1000m^3) in the RMT(1+8)M vertical series.

DAY SERIES # 1 Stations 12062-12069

Depth m	Biomass: mls displacement volume per m^2. RMT1	RMT8	RMT1/RMT8 Ratio
0-50	165.5	2.5	65.7
50-100	122.2	5.6	22.0
100-200	45.1	10.8	4.2
200-300	41.0	4.2	9.7
300-400	61.4	10.5	5.9
400-500	53.9	13.3	4.1
500-600	60.3	9.7	6.3
600-700	45.9	10.0	4.6
700-800	21.7	14.2	1.5
800-900	23.4	8.8	2.7
900-1000	11.2	14.8	0.8
1000-1100	16.2	18.6	0.9

NIGHT SERIES Stations 12071 - 12082

Depth m	Biomass: mls displacement volume per m^2. RMT1	RMT8	RMT1/RMT8 Ratio
0-25	578.7	105.7	5.5
25-50	250.9	66.9	3.8
50-100	37.1	13.7	2.7
100-200	37.3	6.0	6.2
200-300	120.6	59.8	2.0
300-400	35.8	24.4	1.5
400-500	31.4	15.6	2.0
500-600	19.8	10.1	2.0
600-700	16.8	6.8	2.5
700-800	18.2	7.3	2.5

DAY SERIES #2 Stations 12087 - 12088

Depth m	Biomass: mls displacement volume per m^2. RMT1	RMT8	RMT1/RMT8 Ratio
5-50	57.6	25.6	2.4
50-100	76.2	25.7	2.4
100-200	58.0	22.1	2.6
200-300	28.9	6.8	4.3
300-400	n.s	21.9	-
400-500	23.5	21.9	1.1

DAY SERIES #3 Station 12105

Depth m	Biomass: mls displacement volume per m^2. RMT1	RMT8	RMT1/RMT8 Ratio
5-50	86.6	4.1	21.4
50-100	60.6	5.5	11.1
100-200	30.0	4.1	7.3
200-300	36.0	13.8	2.6
300-400	53.3	8.5	6.3
400-500	37.3	42.2	0.9

STATION LIST

Gear codes used

CTD	Conductivity, temperature, depth probe
TRANSM	Transmissometer
MS	Multisampler
BSNAP	Bathysnap
MLT.CORER	Multiple corer
MSP	Marine snow profiler
MSC	Marine snow catcher
SAP	Stand alone pump
SED.FLOAT	Floating sediment trap array
RMT1M/1-3	Multiple 1m^2 rectangular midwater trawl 0.32µm mesh /order in sequence of three
RMT8M/1-3	Multiple 8m^2 rectangular midwater trawl 4.5mm mesh /order in sequence of three
WP2	Standard 0.25m^2 ring net with 200µm mesh
APSTEIN	40cm diameter closing plankton net, 20µm mesh

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12053 # 1	15/ 5	58 59.5N 58 59.5N	21 57.1W 21 57.3W	CTD TRANSM MS	0-2920	1417-1614 Day	To 10mab. RVS CTD-Salinities suspect	2930
12053 # 2	15/ 5	59 1.8N 59 1.6N	21 47.3W 21 46.1W	SAP	75- 75	2200-2255 Night	Filtered for 45 min.	
12054 # 1	16/ 5	59 16.9N	21 3.0W	BSNAP	2879-2879	0302-	Deployed 26/5/89. Surfaced at 0347h	2879
12055 # 1	16/ 5	59 0.2N 59 0.5N	21 55.7W 21 54.1W	CTD TRANSM MS	0- 300	0816-0904 Day	Standard Level1/Dip2 WB depths ex 2m	
12055 # 2	16/ 5	59 0.7N 59 0.8N	21 52.7W 21 52.2W	CTD TRANSM MS	0- 100	0933-0950 Day	WB@100,75,50m. Data logging problems	
12055 # 3	16/ 5	59 1.0N 59 1.6N	21 51.5W 21 49.2W	MLT.CORER	2910-2910	1012-1130 Day	On bottom 1130h. 6 good cores	2910
12056 # 1	19/ 5	48 34.4N 48 34.3N	17 19.7W 17 19.5W	CTD TRANSM MS MSP	0- 300	0421-0439 Dawn	WB @ standard productivity depths	
12056 # 2	19/ 5	48 33.9N 48 32.2N	17 19.5W 17 20.4W	CTD TRANSM MS	0-4355	0522-0823 Dawn	Salinity in error. O2 sensor leak	4365
12056 # 3	19/ 5	48 32.0N 48 32.0N	17 21.3W 17 21.8W	CTD TRANSM MS	0- 300	0942-1021 Day	Standard Level1/Dip1 WB depths	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12057 # 1	19/ 5	48 27.3N	17 26.2W	SED.FLOAT	300-2500	1800-	DR9. Traps @ 300, 600, 1000 & 2500m	
12058 # 1	19/ 5	48 31.1N 48 31.3N	17 26.0W 17 26.1W	CTD TRANSM MS	0- 300	1924-2006 Day	Standard Level1/Dip2 WB depths	
12058 # 2	19/ 5 20/ 5	48 31.3N 48 31.1N	17 25.4W 17 27.8W	SAP	300- 500	2050-0048 Night		
12058 # 3	19/ 5	48 31.1N 48 31.1N	17 25.7W 17 25.8W	MSC	35- 35	2200-2215 Night		
12058 # 4	20/ 5	48 31.2N 48 31.3N	17 29.2W 17 30.0W	SAP	30- 75	0208-0321 Night		
12058 # 5	20/ 5	48 29.0N 48 29.3N	17 34.5W 17 34.9W	CTD TRANSM MS MSP	0- 35	0431-0509 Dawn	WB @ standard productivity depths	
12059 # 1	20/ 5 23/ 5	48 26.3N 48 17.5N	17 38.9W 17 34.8W	SED.FLOAT	50- 300	0713-1438	DR10. Traps @ 50, 100, 200 & 300m.	
12060 # 1	20/ 5	48 20.3N 48 21.9N	17 45.6W 17 45.4W	RMT1M/1 RMT8M/1	0- 50	0840-0937 Day	Net trial - no sample	
12060 # 2	20/ 5	48 21.9N 48 21.9N	17 45.4W 17 45.5W	MSC	45- 45	0937-0947 Day		
12060 # 3	20/ 5	48 26.2N 48 27.7N	17 44.0W 17 45.6W	MLT.CORER	4310-4310	1440-1736 Day	On bottom 1612h. 48 26.9'N,17 44.9'W	4310

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12060 # 4	20/ 5	48 29.7N 48 32.0N	17 44.5W 17 42.8W	RMT1M/1 RMT8M/1	180- 225	1923-2025 Dusk	200m Dusk Series - dull conditions Flow Dist. 4.853 km.	
12060 # 5	20/ 5	48 32.0N 48 34.0N	17 42.8W 17 41.2W	RMT1M/2 RMT8M/2	200- 225	2025-2125 Dusk	200m Dusk Series - dull conditions Flow Dist. 4.224 km.	
12060 # 6	20/ 5	48 34.0N 48 35.9N	17 41.2W 17 39.7W	RMT1M/3 RMT8M/3	200- 225	2125-2225 Night	200m Dusk Series - night Flow Dist. 3.775 km.	
12061 # 1	21/ 5	48 30.0N 48 30.0N	17 46.7W 17 46.7W	WP2	0- 100	0044-0053 Night	Level 1 Zooplankton Tow	
12061 # 2	21/ 5	48 30.1N 48 29.8N	17 46.9W 17 47.6W	CTD TRANSM MSP	0- 300	0143-0310 Night	MSP camera failed	
12061 # 3	21/ 5	48 29.8N 48 29.7N	17 47.6W 17 47.7W	CTD TRANSM MS	0- 45	0326-0342 Night	WB @ standard productivity depths	
12061 # 4	21/ 5	48 29.8N 48 29.9N	17 47.9W 17 48.0W	CTD TRANSM MSP	0- 300	0417-0442 Dawn	Timing Problems on Flash	
12061 # 5	21/ 5	48 29.9N 48 30.0N	17 48.1W 17 48.2W	CTD TRANSM MS	0- 300	0453-0524 Dawn	Level 1/ Dip1	
12061 # 6	21/ 5	48 30.2N 48 30.4N	17 48.2W 17 48.2W	CTD TRANSM MS	0- 300	0557-0630 Dawn	Level 1/ Dip2	
12061 # 7	21/ 5	48 31.2N 48 32.0N	17 48.2W 17 48.3W	CTD TRANSM	0-4345	0859-1152 Day	IOS CTD	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12061 # 8	21/ 5	48 31.6N 48 31.6N	17 48.3W 17 48.3W	MSC	45- 45	1023-1030 Day		
12061 # 9	21/ 5	48 32.0N 48 32.2N	17 48.3W 17 48.2W	WP2	0- 100	1203-1253 Day	Level 1 Zooplankton Tow	
12062 # 1	21/ 5	48 27.3N 48 27.2N	17 40.4W 17 37.4W	RMT1M/1 RMT8M/1	400- 500	1436-1536 Day	Flow Dist. 3.325 km.	
12062 # 2	21/ 5	48 27.3N 48 27.1N	17 37.4W 17 34.8W	RMT1M/2 RMT8M/2	300- 410	1536-1636 Day	Flow Dist. 3.370 km.	
12062 # 3	21/ 5	48 27.1N 48 27.0N	17 34.8W 17 31.8W	RMT1M/3 RMT8M/3	200- 300	1636-1736 Day	Flow Dist. 3.549 km.	
12063 # 1	21/ 5 22/ 5	48 26.5N 48 27.7N	17 49.3W 17 51.1W	SAP	300- 600	2024-0023 Night		
12063 # 2	21/ 5	48 26.6N 48 26.7N	17 49.4W 17 49.5W	MSC	45- 45	2035-2050 Dusk		
12063 # 3	22/ 5	48 28.1N 48 28.5N	17 51.5W 17 51.6W	CTD TRANSM MSP	0- 300	0141-0246 Night		
12063 # 4	22/ 5	48 28.4N 48 28.7N	17 51.7W 17 51.6W	CTD TRANSM MS	0- 35	0257-0322 Night	Productivity WB @ 35m 20, 15 & 1m	
12064 # 1	22/ 5	48 29.6N 48 29.7N	17 49.9W 17 46.6W	RMT1M/1 RMT8M/1	190- 210	0434-0534 Dawn	Dawn Repeat Series. Sunrise 0520h Flow Dist. 3.595 km.	
12064 # 2	22/ 5	48 29.7N 48 29.8N	17 46.6W 17 43.3W	RMT1M/2 RMT8M/2	190- 200	0534-0634 Dawn	Dawn Repeat Series. Sunrise 0520h Flow Dist. 3.775 km.	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12064 # 3	22/ 5	48 29.8N 48 29.9N	17 43.3W 17 40.0W	RMT1M/3 RMT8M/3	190- 200	0634-0734 Day	Dawn Repeat Series. Sunrise 0520h Flow Dist. 3.730 km.	
12064 # 4	22/ 5	48 29.7N 48 29.7N	17 39.2W 17 39.2W	MSC	55- 55	0815-0825 Day		
12064 # 5	22/ 5	48 30.2N 48 31.6N	17 39.5W 17 42.6W	RMT1M/1 RMT8M/1	100- 200	0852-0952 Day	Flow Dist. 4.630 km.	
12064 # 6	22/ 5	48 31.6N 48 33.3N	17 42.6W 17 45.2W	RMT1M/2 RMT8M/2	50- 105	0952-1052 Day	Flow Dist. 4.720 km.	
12064 # 7	22/ 5	48 33.3N 48 35.1N	17 45.2W 17 47.7W	RMT1M/3 RMT8M/3	10- 50	1052-1152 Day	Flow Dist. 4.473 km.	
12064 # 8	22/ 5	48 35.5N 48 34.4N	17 46.4W 17 43.8W	RMT1M/1 RMT8M/1	710- 800	1308-1408 Day	Flow Dist. 3.145 km.	
12064 # 9	22/ 5	48 34.4N 48 33.2N	17 43.8W 17 41.1W	RMT1M/2 RMT8M/2	610- 710	1408-1508 Day	Flow Dist. 3.235 km.	
12064 #10	22/ 5	48 33.2N 48 32.2N	17 41.1W 17 38.6W	RMT1M/3 RMT8M/3	500- 610	1508-1609 Day	Flow Dist. 3.414 km.	
12065 # 1	22/ 5	48 26.4N 48 27.4N	17 47.9W 17 48.7W	SAP	200- 350	1816-2200 Dusk		
12065 # 2	22/ 5	48 26.6N 48 26.6N	17 47.9W 17 48.0W	MSC	45- 45	1850-1905 Day		
12065 # 3	22/ 5	48 26.8N 48 26.9N	17 48.6W 17 48.7W	MSC	45- 45	2000-2021 Dusk		

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12065 # 4	23/ 5	48 28.1N 48 28.5N	17 48.8W 17 48.8W	CTD TRANSM MSP	0- 300	0003-0125 Night		
12065 # 5	23/ 5	48 28.6N 48 29.0N	17 48.9W 17 48.8W	SAP	75- 75	0147-0257 Night		
12065 # 6	23/ 5	48 29.3N 48 29.3N	17 48.3W 17 48.3W	CTD TRANSM MS	0- 35	0311-0319 Night	WB @ standard productivity depths	
12065 # 7	23/ 5	48 29.4N 48 29.5N	17 48.2W 17 48.0W	CTD TRANSM MS	0- 300	0357-0426 Night	Level 1/ Dip 1	
12065 # 8	23/ 5	48 29.9N 48 30.0N	17 46.9W 17 46.6W	CTD TRANSM MS	0- 300	0628-0657 Day	Level 1/ Dip 2	
12066 # 1	23/ 5	48 27.0N 48 27.0N	17 45.0W 17 45.0W	MSC	45- 45	0855-0905 Day		
12066 # 2	23/ 5	48 27.0N 48 26.9N	17 45.0W 17 42.9W	CTD TRANSM MS MSP	0-4385	0908-1145 Day	Level 1-Deep CTD. WB@Standard depths	
12067 # 1	23/ 5	48 26.2N 48 25.6N	17 43.3W 17 43.1W	SAP	200-1000	1620-2120 Day		
12067 # 2	24/ 5	48 25.5N 48 25.7N	17 41.5W 17 40.9W	MSC	300- 300	0118-0158 Night		

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12067	24/ 5	48 25.6N	17 40.8W	MSC	45- 45	0209-0221		
# 3		48 25.6N	17 40.6W			Night		
12067	24/ 5	48 25.5N	17 39.6W	CTD	0- 40	0306-0315		
# 4		48 25.5N	17 39.5W	TRANSM		Night		
12068	24/ 5	48 25.0N	17 37.8W	SED.FLOAT	20- 300	0558-0648	DR11. Traps @ 20, 50, 100 & 300m.	
# 1	26/ 5	48 23.6N	17 30.6W					
12069	24/ 5	48 22.1N	17 37.9W	RMT1M/1	1020-1100	0742-0843		
# 1		48 19.5N	17 38.9W	RMT8M/1		Day	Flow Dist. 3.999 km.	
12069	24/ 5	48 19.5N	17 38.9W	RMT1M/2	900-1020	0843-0943		
# 2		48 16.9N	17 40.3W	RMT8M/2		Day	Flow Dist. 4.540 km.	
12069	24/ 5	48 16.9N	17 40.3W	RMT1M/3	800- 900	0943-1043		
# 3		48 14.4N	17 41.8W	RMT8M/3		Day	Flow Dist. 4.315 km.	
12069	24/ 5	48 18.9N	17 42.3W	RMT1M/1	980-1025	1353-1453	1000m Repeats. RMT1 cod-end lost	
# 4		48 17.1N	17 41.8W	RMT8M/1		Day	Flow Dist. 3.325 km.	
12069	24/ 5	48 17.1N	17 41.8W	RMT1M/2	980-1030	1453-1546	1000m Repeats. RMT1 cod-end lost	
# 5		48 15.4N	17 41.7W	RMT8M/2		Day	Flow Dist. 3.016 km.	
12069	24/ 5	48 15.4N	17 41.7W	RMT1M/3	950-1025	1546-1646	1000m Repeats	
# 6		48 13.6N	17 41.3W	RMT8M/3		Day	Flow Dist. 3.505 km.	
12070	25/ 5	48 27.7N	17 34.4W	CTD	0- 35	0341-0354	Productivity Samples @ 35,25,25,1m	
# 1		48 27.8N	17 34.4W	TRANSM		Night		
				MS				
12070	25/ 5	48 28.1N	17 33.7W	CTD	0- 300	0446-0548	Level 1/ Dip 1	
# 2		48 28.4N	17 33.5W	TRANSM		Dawn		
				MS				
				MSP				

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12070 # 3	25/ 5	48 28.3N 48 28.4N	17 32.8W 17 32.5W	CTD TRANSM MS	0- 300	0624-0654 Day	Level 1/ Dip 2	
12070 # 4	25/ 5	48 28.9N 48 28.7N	17 34.7W 17 34.5W	MSC	300- 300	0925-0947 Day		
12070 # 5	25/ 5	48 28.7N 48 28.7N	17 34.5W 17 34.5W	MSC	45- 45	1000-1005 Day		
12070 # 6	25/ 5	48 28.1N 48 28.1N	17 34.5W 17 34.3W	WP2	0- 100	1200-1249 Day	Level 1 Zooplankton Tow	
12070 # 7	25/ 5	48 27.8N 48 28.8N	17 35.9W 17 35.7W	SAP	50- 150	1545-2132 Day		
12071 # 1	25/ 5	48 28.9N 48 28.8N	17 36.6W 17 39.4W	RMT1M/1 RMT8M/1	100- 200	2153-2253 Dusk	Flow Dist. 3.670 km.	
12071 # 2	25/ 5	48 28.8N 48 28.9N	17 39.5W 17 41.5W	RMT1M/2 RMT8M/2	65- 100	2253-2339 Night	Premature close. Sample ca.70-100m. Flow Dist. 2.842 km.	
12071 # 3	25/ 5	48 28.9N 48 28.9N	17 41.5W 17 42.3W	RMT1M/3 RMT8M/3	50- 80	2339-2359 Night	Premature open, mostly fished @ 50m. Flow Dist. 0.843 km.	
12071 # 4	26/ 5	48 28.6N 48 28.3N	17 43.4W 17 46.5W	RMT1M/1 RMT8M/1	400- 500	0124-0224 Night	Battery Failure. Only Net 1 fished. Flow Dist. 3.955 km.	
12072 # 1	26/ 5	48 27.4N 48 27.4N	17 31.5W 17 31.6W	MSC	300- 300	0805-0825 Day		
12072 # 2	26/ 5 28/ 5	48 27.2N 48 26.6N	17 30.3W 17 27.2W	SED.FLOAT	20- 300	0934-0747	DR12. Traps @ 20, 50, 100 & 300m.	

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12072 # 3	26/ 5	48 28.9N 48 26.8N	17 32.3W 17 30.7W	SAP	3443-4193	1012-1825 Day		
12072 # 4	26/ 5	48 29.0N 48 28.9N	17 32.1W 17 31.7W	MSC	45- 45	1316-1356 Day		
12073 # 5	26/ 5	48 26.8N 48 26.3N	17 28.7W 17 29.7W	CTD TRANSM MS MSP	0-4378	2015-2319	Level 1 -Deep CTD	4388
12073 # 6	26/ 5	48 26.3N 48 26.3N	17 29.2W 17 29.2W	MSC	45- 45	2151-2156 Dusk		
12073 # 7	27/ 5	48 26.3N 48 26.4N	17 30.4W 17 30.5W	WP2	0- 100	0003-0054 Night	Level 1 Zooplankton Tow	
12073 # 8	27/ 5	48 26.5N 48 26.9N	17 30.5W 17 28.8W	SAP	241- 301	0140-0518 Night		
12073 # 9	27/ 5	48 26.5N 48 26.5N	17 30.1W 17 29.9W	CTD TRANSM MS	0- 35	0334-0346 Night	Productivity Samples @ 35, 25 & 1m.	
12073 #10	27/ 5	48 26.9N 48 26.6N	17 29.5W 17 29.3W	CTD TRANSM MS	0- 300	0530-0600 Dawn	Level 1/ Dip 1	
12073 #11	27/ 5	48 26.7N 48 26.6N	17 27.2W 17 26.7W	CTD TRANSM MS	0- 300	0645-0722 Day	Level 1/ Dip 2	
12074 # 1	27/ 5	48 28.1N 48 28.2N	17 27.6W 17 27.5W	CTD TRANSM	0- 300	0805-0817 Day	North of Central Buoy	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12075 # 1	27/ 5	48 29.5N 48 29.5N	17 27.7W 17 27.5W	CTD TRANSM	0- 300	0844-0904 Day		
12076 # 1	27/ 5	48 27.1N 48 27.5N	17 29.1W 17 28.9W	WP2	0- 100	1238-1317 Day	Level 1 Zooplankton Tow	
12076 # 2	27/ 5	48 27.6N 48 27.8N	17 28.8W 17 28.8W	MSC	300- 300	1418-1445 Day		
12076 # 3	27/ 5	48 28.0N 48 28.2N	17 28.9W 17 26.7W	SAP	300- 600	1635-2049 Day		
12076 # 4	27/ 5	48 28.3N 48 28.3N	17 27.0W 17 26.9W	MSC	45- 45	2017-2025 Dusk		
12077 # 1	27/ 5	48 29.8N 48 30.1N	17 27.1W 17 30.5W	RMT1M/1 RMT8M/1	50- 100	2206-2306 Night	Flow Dist. 3.730 km.	
12077 # 2	27/ 5	48 30.1N 48 30.4N	17 30.5W 17 32.1W	RMT1M/2 RMT8M/2	25- 55	2306-2336 Night	30 min Tow Flow Dist. 1.865 km.	
12077 # 3	27/ 5 28/ 5	48 30.4N 48 30.9N	17 32.1W 17 33.7W	RMT1M/3 RMT8M/3	5- 25	2336-0006 Night	30 min Tow Flow Dist. 2.045 km.	
12077 # 4	28/ 5	48 32.0N 48 32.4N	17 37.6W 17 40.3W	RMT1M/1 RMT8M/1	400- 500	0127-0227 Night	Flow Dist. 3.190 km.	
12077 # 5	28/ 5	48 32.4N 48 33.0N	17 40.3W 17 42.5W	RMT1M/2 RMT8M/2	300- 400	0227-0327 Night	Flow Dist. 3.595 km.	
12077 # 6	28/ 5	48 33.0N 48 33.5N	17 42.5W 17 45.2W	RMT1M/3 RMT8M/3	200- 300	0327-0427 Night	Flow Dist. 3.843 km.	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12078	28/ 5	48 25.9N	17 28.6W	MSC	45- 45	0841-0846		
# 1		48 25.9N	17 28.6W			Day		
12079	28/ 5	48 26.0N	17 27.8W	WP2	0- 100	2246-2303	Level 1 Zooplankton Tow	
# 1		48 26.0N	17 28.0W			Night		
12079	28/ 5	48 26.0N	17 28.0W	CTD	0-4222	2320-0135	Deep CTD	
# 2	29/ 5	48 25.8N	17 28.6W	TRANSM MSP		Night		
12079	29/ 5	48 25.8N	17 27.3W	CTD	0- 35	0259-0317	WB @ Standard Productivity Depths	
# 3		48 25.8N	17 27.3W	TRANSM MS		Night		
12079	29/ 5	48 24.8N	17 27.1W	CTD	0- 300	0656-0724	Level 1/ Dip 2	
# 4		48 24.7N	17 27.1W	TRANSM MS		Day		
12079	29/ 5	48 24.5N	17 27.2W	MSC	300- 300	0750-0808		
# 5		48 24.4N	17 27.3W			Day		
12079	29/ 5	48 24.2N	17 27.5W	MSC	45- 45	0832-0845		
# 6		48 24.0N	17 27.5W			Day		
12080	29/ 5	48 23.6N	17 25.7W	MLT.CORER	4121-4121	1024-1350	On Bottom 1209h. 48 23.1'N,17 26.5'W	4121
# 1		48 23.4N	17 27.3W			Day		
12080	29/ 5	48 23.9N	17 27.6W	SED.FLOAT	50- 300	1501-0945	DR13. Traps @ 50, 100, 200 & 300m.	
# 2	1/ 6	48 16.0N	17 2.4W					
12081	29/ 5	48 27.2N	17 45.2W	MSC	300- 300	1730-1750		
# 1		48 27.1N	17 44.8W			Day		

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12081 # 2	29/ 5	48 26.9N 48 26.9N	17 44.1W 17 44.1W	APSTEIN	0- 100	1846-1857 Day		
12081 # 3	29/ 5	48 27.0N 48 26.9N	17 44.1W 17 43.9W	CTD TRANSM MS MSP	0- 300	1904-1927 Day		
12081 # 4	29/ 5	48 26.9N 48 26.9N	17 43.8W 17 43.7W	MSC	45- 45	1932-1941 Day		
12081 # 5	29/ 5	48 26.8N 48 26.8N	17 43.6W 17 43.5W	APSTEIN	0- 100	1946-1959 Day		
12082 # 1	29/ 5	48 26.2N 48 24.8N	17 43.2W 17 42.2W	RMT1M/1 RMT8M/1	120- 160	2024-2054 Dusk	Dusk. 30 min Tow Flow Dist. 2.135 km.	
12082 # 2	29/ 5	48 24.8N 48 23.7N	17 42.2W 17 41.2W	RMT1M/2 RMT8M/2	140- 160	2054-2124 Dusk	Flow Dist. 2.180 km.	
12082 # 3	29/ 5	48 23.7N 48 22.6N	17 41.2W 17 40.1W	RMT1M/3 RMT8M/3	145- 150	2124-2154 Dusk	Flow Dist. 2.113 km.	
12082 # 4	29/ 5 30/ 5	48 18.9N 48 16.6N	17 38.2W 17 36.2W	RMT1M/1 RMT8M/1	695- 800	2342-0042 Night	Flow Dist. 4.090 km.	
12082 # 5	30/ 5	48 16.6N 48 14.1N	17 36.2W 17 34.0W	RMT1M/2 RMT8M/2	600- 700	0042-0142 Night	Flow Dist. 4.450 km.	
12082 # 6	30/ 5	48 14.1N 48 11.7N	17 34.0W 17 32.0W	RMT1M/3 RMT8M/3	500- 600	0142-0242 Night	Flow Dist. 4.405 km.	
12082 # 7	30/ 5	48 10.1N 48 10.1N	17 31.5W 17 31.4W	APSTEIN	0- 100	0333-0344 Night		

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12082	30/ 5	48 9.0N	17 30.8W	RMT1M/1	140- 160	0430-0500	Dawn Tow. Sunrise 0515h	
# 8		48 8.1N	17 29.8W	RMT8M/1		Dawn	Flow Dist. 1.775 km.	
12082	30/ 5	48 8.1N	17 29.8W	RMT1M/2	145- 160	0500-0530	Dawn Tow. Sunrise 0515h	
# 9		48 7.3N	17 28.6W	RMT8M/2		Dawn	Flow Dist. 1.910 km.	
12082	30/ 5	48 7.3N	17 28.6W	RMT1M/3	145- 160	0530-0600	Dawn Tow. Sunrise 0515h	
#10		48 6.4N	17 25.6W	RMT8M/3		Dawn	Flow Dist. 1.910 km.	
12083	30/ 5	48 21.6N	17 28.8W	CTD	0-4128	1030-1241		
# 1		48 20.7N	17 27.3W	TRANSM		Day		
12084	30/ 5	48 21.1N	17 13.8W	CTD	0-4416	1415-1708		
# 1		48 20.3N	17 11.5W	TRANSM		Day		
12085	30/ 5	48 30.1N	17 20.9W	CTD	0-4333	1908-2142		
# 1		48 28.7N	17 19.8W	TRANSM		Dusk		
12086	31/ 5	48 23.7N	17 23.5W	CTD	0- 35	0408-0436	WB @ Standard Productivity Depths	
# 1		48 23.5N	17 23.4W	TRANSM MS		Night		
12087	31/ 5	48 24.6N	17 31.2W	RMT1M/1	400- 500	1324-1424		
# 1		48 26.6N	17 32.7W	RMT8M/1		Day	Flow Dist. 4.315 km.	
12087	31/ 5	48 26.6N	17 32.7W	RMT1M/2	300- 400	1424-1524		
# 2		48 28.6N	17 34.1W	RMT8M/2		Day	Flow Dist. 4.495 km.	
12087	31/ 5	48 28.6N	17 34.1W	RMT1M/3	195- 300	1524-1624		
# 3		48 30.5N	17 35.2W	RMT8M/3		Day	Flow Dist. 4.180 km.	
12088	31/ 5	48 31.5N	17 35.5W	RMT1M/1	100- 205	1801-1901	Heavy Swell	
# 1		48 30.9N	17 38.2W	RMT8M/1		Day	Flow Dist. 4.270 km.	

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12088 # 2	31/ 5	48 30.9N 48 30.5N	17 38.2W 17 39.5W	RMT1M/2 RMT8M/2	50- 100	1901-1931 Day	Flow Dist. 2.045 km.	
12088 # 3	31/ 5	48 30.5N 48 30.0N	17 39.5W 17 40.7W	RMT1M/3 RMT8M/3	5- 50	1931-2001 Day	Flow Dist. 2.270 km.	
12089 # 1	31/ 5	48 20.7N 48 20.6N	17 5.0W 17 5.1W	APSTEIN	50- 200	2325-2340 Night		
12089 # 2	1/ 6	48 20.2N 48 19.8N	17 4.8W 17 4.7W	APSTEIN	200- 400	0010-0041 Night		
12089 # 3	1/ 6	48 19.8N 48 19.7N	17 4.7W 17 4.7W	APSTEIN	0- 50	0044-0050 Night		
12089 # 4	1/ 6	48 19.0N 48 18.8N	17 4.8W 17 4.8W	WP2	0- 200	0140-0153 Night		
12089 # 5	1/ 6	48 18.5N 48 18.3N	17 4.9W 17 4.7W	MSC	300- 300	0207-0232 Night		
12089 # 6	1/ 6	48 18.2N 48 18.1N	17 4.6W 17 4.5W	MSC	45- 45	0243-0251 Night		
12090 # 1	1/ 6	48 17.6N 48 17.4N	17 4.1W 17 3.9W	WP2	0- 200	0525-0540 Dawn		
12090 # 2	1/ 6	48 17.3N 48 17.1N	17 3.8W 17 3.7W	APSTEIN	50- 200	0600-0620 Dawn		
12090 # 3	1/ 6	48 17.0N 48 16.9N	17 3.7W 17 3.8W	APSTEIN	0- 50	0625-0635 Dawn		

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12090 # 4	1/ 6	48 16.9N 48 16.7N	17 3.8W 17 3.9W	CTD TRANSM MS MSP	0- 300	0633-0713 Day	Level 1/ Dip 2	
12091 # 1	1/ 6	48 15.2N 48 11.8N	17 2.4W 17 1.9W	SAP	1530-2500	1054-1730 Day		
12092 # 1	1/ 6 3/ 6	48 11.4N 47 45.4N	16 57.7W 16 40.2W	SED.FLOAT	50- 300	1834-1905	DR14. Traps @ 50, 100, 200 & 300m.	
12093 # 1	1/ 6	48 8.7N 48 7.1N	16 57.9W 16 57.4W	RMT1M/1 RMT8M/1	45- 50	2030-2100 Dusk	Dusk Repeats. Sunset 2100h/c Flow Dist. 2.045 km.	
12093 # 2	1/ 6	48 7.1N 48 5.5N	16 57.4W 16 56.9W	RMT1M/2 RMT8M/2	45- 55	2100-2130 Dusk	Dusk Repeats. Sunset 2100h/c Flow Dist. 1.978 km.	
12093 # 3	1/ 6	48 5.5N 48 4.1N	16 56.9W 16 56.5W	RMT1M/3 RMT8M/3	50- 55	2130-2200 Dusk	Dusk Repeats. Sunset 2100h/c Flow Dist. 1.910 km.	
12093 # 4	1/ 6 2/ 6	48 4.2N 48 5.6N	16 59.5W 17 1.7W	RMT1M/1 RMT8M/1	700- 800	2327-0027 Night	Flow Dist. 3.865 km.	
12093 # 5	2/ 6	48 5.6N 48 7.3N	17 1.7W 17 3.5W	RMT1M/2 RMT8M/2	610- 700	0027-0127 Night	Flow Dist. 4.180 km.	
12093 # 6	2/ 6	48 7.3N 48 8.8N	17 3.5W 17 5.1W	RMT1M/3 RMT8M/3	500- 610	0127-0227 Night	Flow Dist. 4.000 km.	
12093 # 7	2/ 6	48 9.4N 48 10.0N	17 7.0W 17 7.7W	RMT1M/1 RMT8M/1	40- 60	0430-0500 Dawn	Dawn Repeats. Sunrise 0512h Flow Dist. 1.595 km.	
12093 # 8	2/ 6	48 10.0N 48 10.5N	17 7.7W 17 8.5W	RMT1M/2 RMT8M/2	40- 55	0500-0530 Dawn	Dawn Repeats. Sunrise 0512h Flow Dist. 1.685 km.	

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12093	2/ 6	48 10.5N	17 8.5W	RMT1M/3	50- 60	0530-0600	Dawn Repeats. Sunrise 0512h	
# 9		48 10.9N	17 9.4W	RMT8M/3		Dawn	Flow Dist. 1.730 km.	
12094	2/ 6	48 26.2N	17 43.9W	MLT.CORER	4300-4300	0952-1254	On Bottom 1130h. 48 26.2'N,17 43.8'W	4300
# 1		48 26.0N	17 44.7W			Day		
12095	2/ 6	47 59.9N	16 46.7W	MSC	300- 300	1809-1832		
# 1		47 59.8N	16 46.5W			Day		
12095	2/ 6	47 59.6N	16 46.3W	MSC	45- 45	1835-1839		
# 2		47 59.6N	16 46.3W			Day		
12095	2/ 6	47 57.8N	16 44.3W	CTD	300- 300	2057-2132	Level 1 - Shallow Samples	
# 3		47 57.2N	16 43.9W	TRANSM MS		Dusk		
12096	2/ 6	47 57.7N	16 46.7W	RMT1M/1	1190-1350	2309-0009	Non-standard Depths. Calibr. Problem	
# 1	3/ 6	47 57.8N	16 49.6W	RMT8M/1		Night	Flow Dist. 2.785 km.	
12096	3/ 6	47 57.8N	16 49.6W	RMT1M/2	1100-1200	0009-0109		
# 2		47 58.0N	16 52.5W	RMT8M/2		Night	Flow Dist. 3.370 km.	
12096	3/ 6	47 58.0N	16 52.5W	RMT1M/3	1000-1100	0109-0209		
# 3		47 58.2N	16 55.7W	RMT8M/3		Night	Flow Dist. 3.415 km.	
12097	3/ 6	47 58.2N	16 57.1W	CTD	0- 35	0316-0337	WB @ Standard Productivity Depths	
# 1		47 58.0N	16 57.0W	TRANSM MS		Night		
12097	3/ 6	47 58.0N	16 57.0W	WP2	0- 100	0339-0345	Level 1 Zooplankton Tow	
# 2		47 57.9N	16 57.0W			Night		
12097	3/ 6	47 57.9N	16 57.0W	WP2	0- 100	0348-0355	Level 1 Zooplankton Tow	
# 3		47 57.8N	16 57.0W			Night		

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12098	3/ 6	47 58.1N	16 57.0W	RMT1M/1	190- 210	0416-0456	Dawn Repeats. 40 min Tow	
# 1		47 58.1N	16 54.8W	RMT8M/1		Dawn	Flow Dist. 2.105 km.	
12098	3/ 6	47 58.1N	16 54.8W	RMT1M/2	195- 210	0456-0536	Dawn Repeats. 40 min Tow	
# 2		47 57.9N	16 52.7W	RMT8M/2		Dawn	Flow Dist. 2.194 km.	
12098	3/ 6	47 57.9N	16 52.7W	RMT1M/3	190- 210	0536-0616	Dawn Repeats. 40 min Tow	
# 3		47 57.9N	16 50.5W	RMT8M/3		Dawn	Flow Dist. 2.217 km.	
12099	3/ 6	47 53.5N	16 44.5W	CTD	0- 300	0755-0833	Level 1/ Dip 2	
# 1		47 53.4N	16 44.4W	TRANSM		Day		
				MS				
				MSP				
12100	3/ 6	47 52.6N	16 43.4W	SAP	45- 300	1026-1315		
# 1		47 51.7N	16 42.0W			Day		
12100	3/ 6	47 51.7N	16 42.0W	MLT.CORER	4691-4691	1331-1714	On Bottom 1536h. 47 50.3'N,16 42.1'W	4691
# 2		47 50.1N	16 42.6W			Day		
12101	3/ 6	47 45.4N	16 41.9W	RMT1M/1	170- 210	2010-2050	Dusk Series. 40 min Tow	
# 1		47 44.9N	16 44.7W	RMT8M/1		Dusk	Flow Dist. 3.230 km.	
12101	3/ 6	47 44.9N	16 44.7W	RMT1M/2	190- 200	2050-2130	Dusk Series. 40 min Tow	
# 2		47 44.4N	16 47.3W	RMT8M/2		Dusk	Flow Dist. 3.162 km.	
12101	3/ 6	47 44.4N	16 47.3W	RMT1M/3	190- 205	2130-2210	Dusk Series. 40 min Tow	
# 3		47 43.9N	16 50.1W	RMT8M/3		Dusk	Flow Dist. 3.207 km.	
12102	4/ 6	47 44.3N	16 44.4W	MSC	45- 45	0016-0022		
# 1		47 44.3N	16 44.5W			Night		
12102	4/ 6	47 44.3N	16 44.5W	MSC	22- 22	0031-0036		
# 2		47 44.3N	16 44.5W			Night		

STN.	DATE 1990	POSITION LAT.	LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT		MEAN SOUND. (M)
12103 # 1	4/ 6	47 46.1N 47 46.2N	16 37.7W 16 37.6W	WP2	0- 100	0255-0304 Night			
12103 # 2	4/ 6	47 46.2N 47 46.1N	16 37.6W 16 37.5W	WP2	0- 100	0306-0313 Night			
12103 # 3	4/ 6	47 46.0N 47 46.0N	16 37.5W 16 37.4W	WP2	0- 100	0316-0326 Night			
12104 # 1	4/ 6	47 43.8N 47 43.5N	16 33.6W 16 33.5W	CTD TRANSM MS	0- 300	0656-0726 Day	Level 1/ Dip 2		
12105 # 1	4/ 6	47 42.8N 47 42.3N	16 34.6W 16 36.8W	RMT1M/1 RMT8M/1	105- 200	0817-0857 Day	40 min Tow Flow Dist.	2.802 km.	
12105 # 2	4/ 6	47 42.3N 47 42.0N	16 36.8W 16 38.4W	RMT1M/2 RMT8M/2	50- 105	0857-0927 Day	30 min Tow Flow Dist.	2.090 km.	
12105 # 3	4/ 6	47 42.0N 47 41.7N	16 38.4W 16 40.0W	RMT1M/3 RMT8M/3	5- 50	0927-0957 Day	30 min Tow Flow Dist.	2.090 km.	
12105 # 4	4/ 6	47 41.2N 47 40.6N	16 42.4W 16 45.6W	RMT1M/1 RMT8M/1	400- 500	1043-1143 Day	Flow Dist.	3.685 km.	
12105 # 5	4/ 6	47 40.6N 47 40.1N	16 45.3W 16 49.2W	RMT1M/2 RMT8M/2	300- 400	1143-1243 Day	Flow Dist.	4.135 km.	
12105 # 6	4/ 6	47 40.1N 47 39.7N	16 49.2W 16 53.1W	RMT1M/3 RMT8M/3	195- 300	1243-1343 Day	Flow Dist.	4.270 km.	
12106 # 1	4/ 6	47 42.2N 47 42.2N	16 31.2W 16 31.0W	CTD TRANSM MS	0- 75	1624-1633 Day	WB @ 75 & 2m		

STN.	DATE 1990	POSITION LAT.	POSITION LONG.	GEAR	DEPTH (M)	TIMES GMT	COMMENT	MEAN SOUND. (M)
12106 # 2	4/ 6	47 42.2N 47 41.2N	16 30.9W 16 29.0W	CTD TRANSM MS MSP	0-4806	1645-1948 Day	Deep CTD. Standard Depths	4816

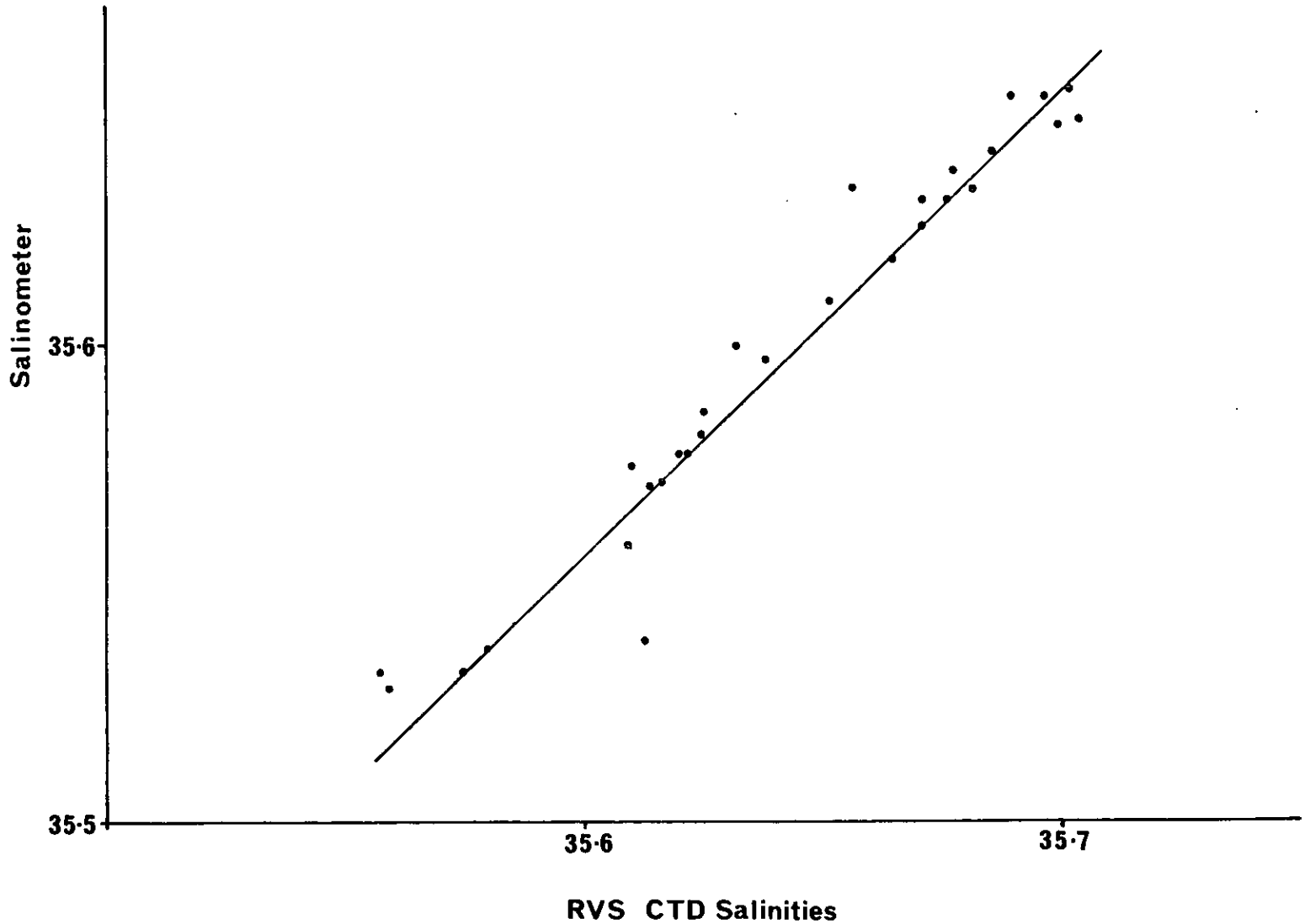

Figure 1. Calibration curve for the RVS CTD.

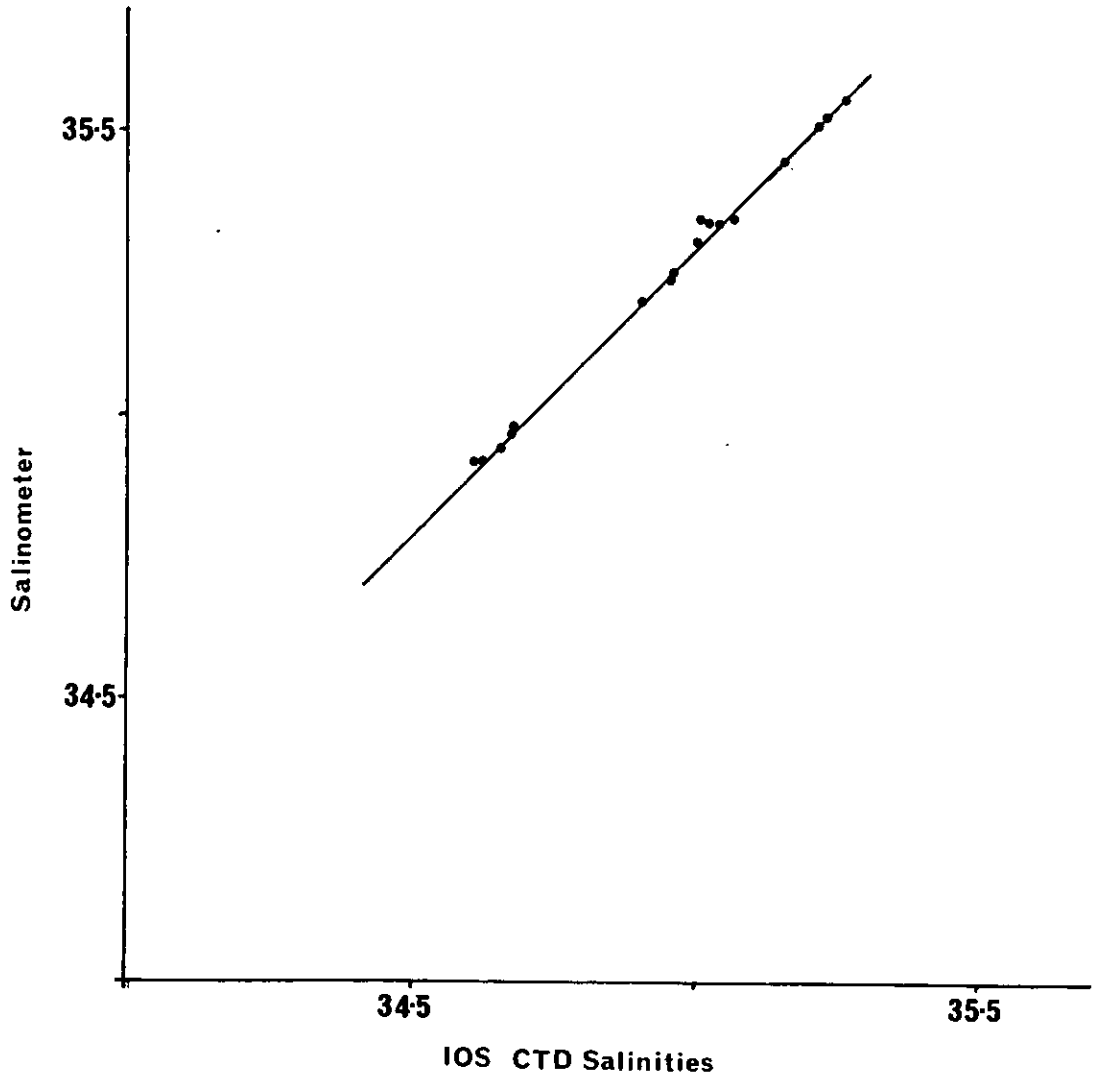

Figure 2. Calibration curve for IOSDL CTD.

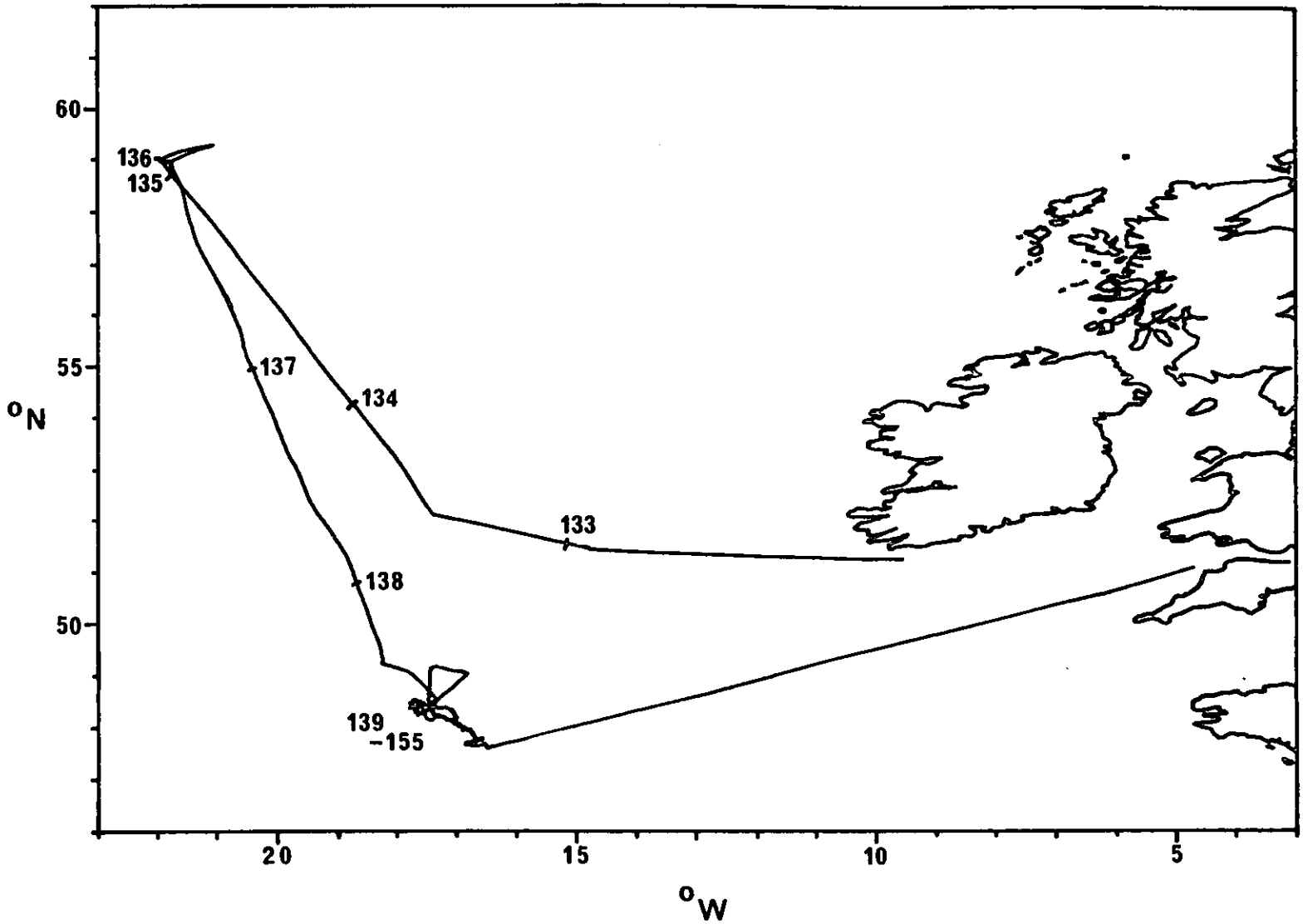

Figure 3. Track chart for *Discovery* Cruise 191, 11 May - 05 Jun 1990. Midday positions are shown for Julian days.

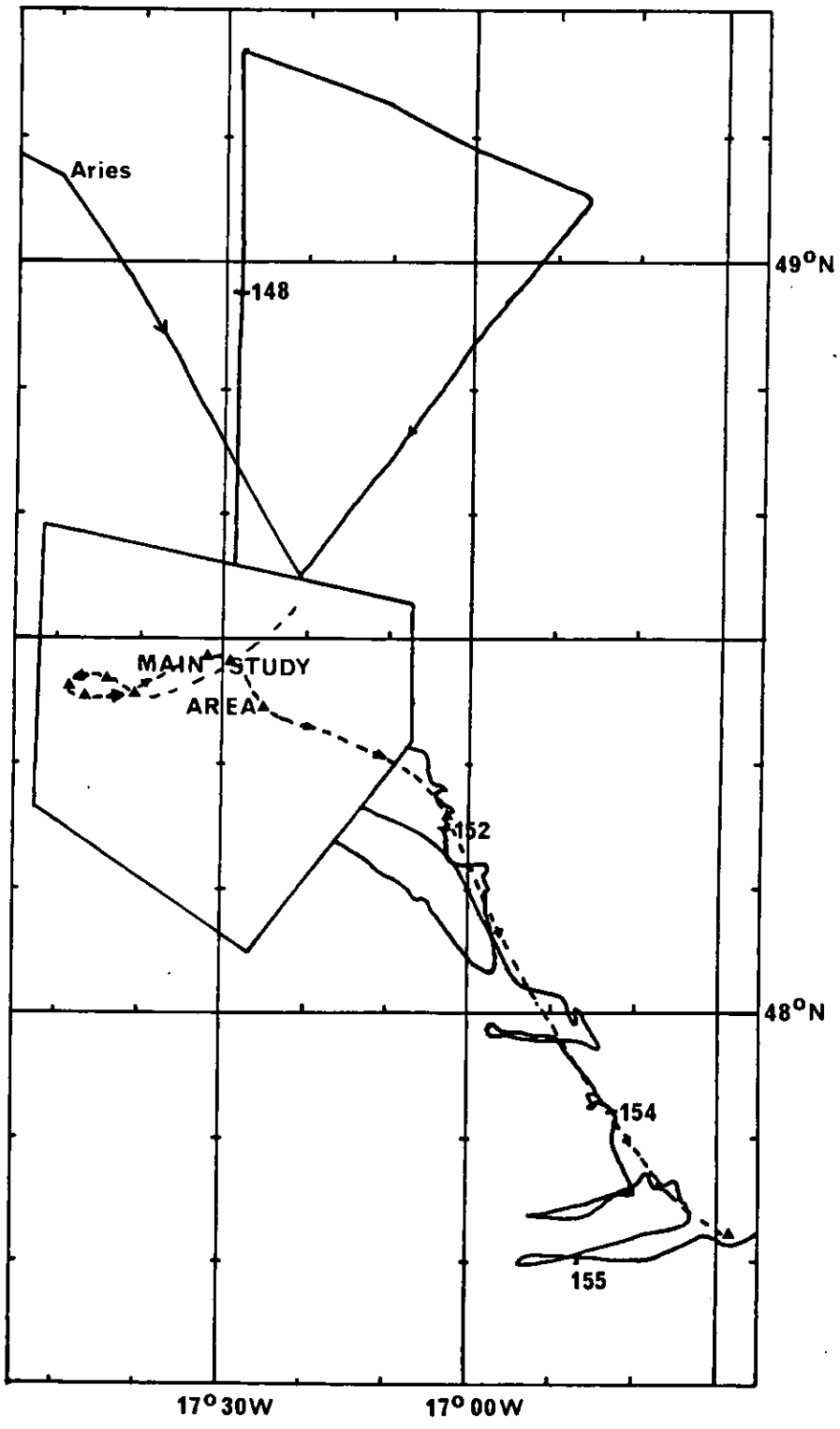

Figure 4. Track chart for sampling around central buoy during the Lagrangian experiment showing buoy track and the area of the main study area.

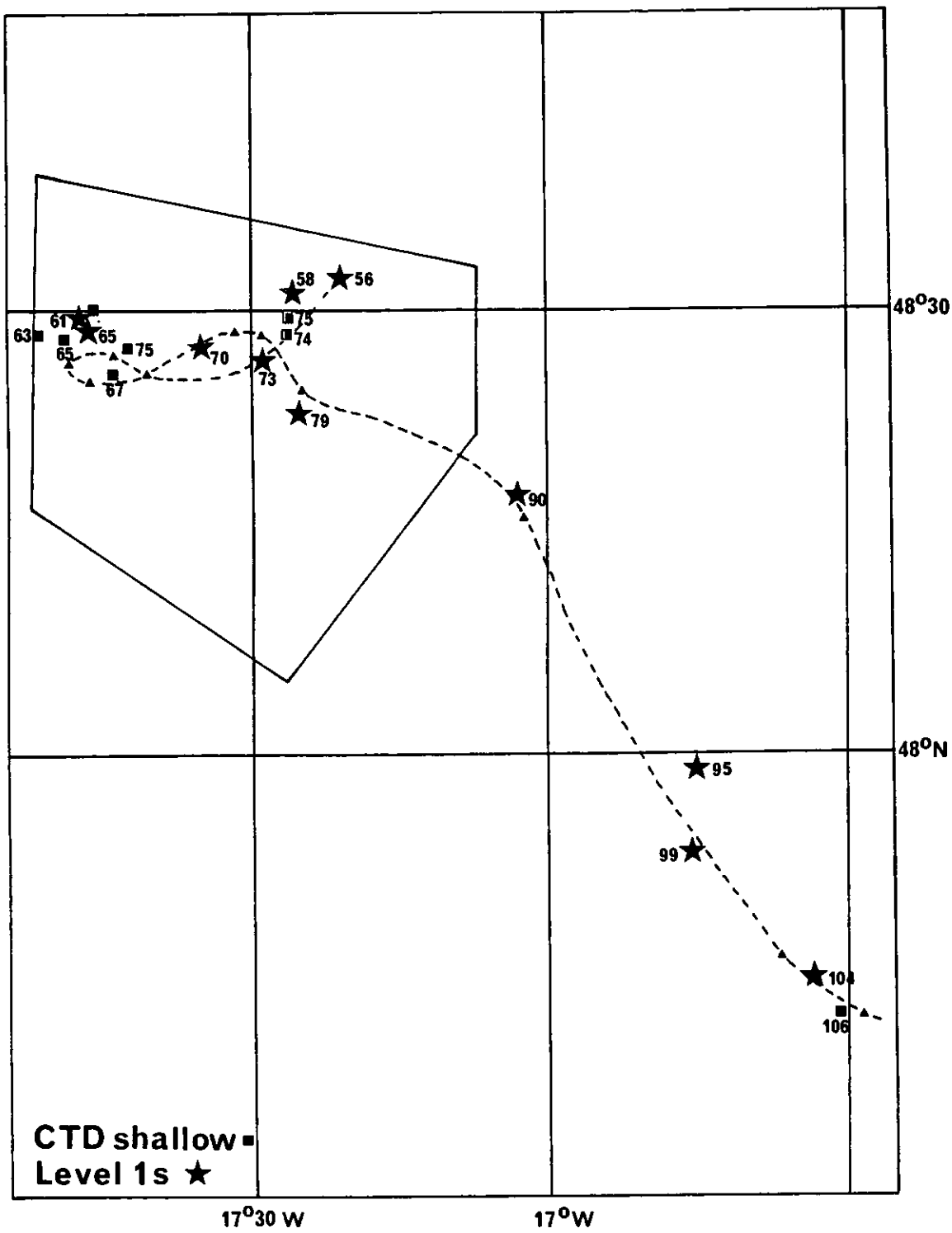

Figure 5. Chart of positions of Level 1 observations and other shallow CTD observations.

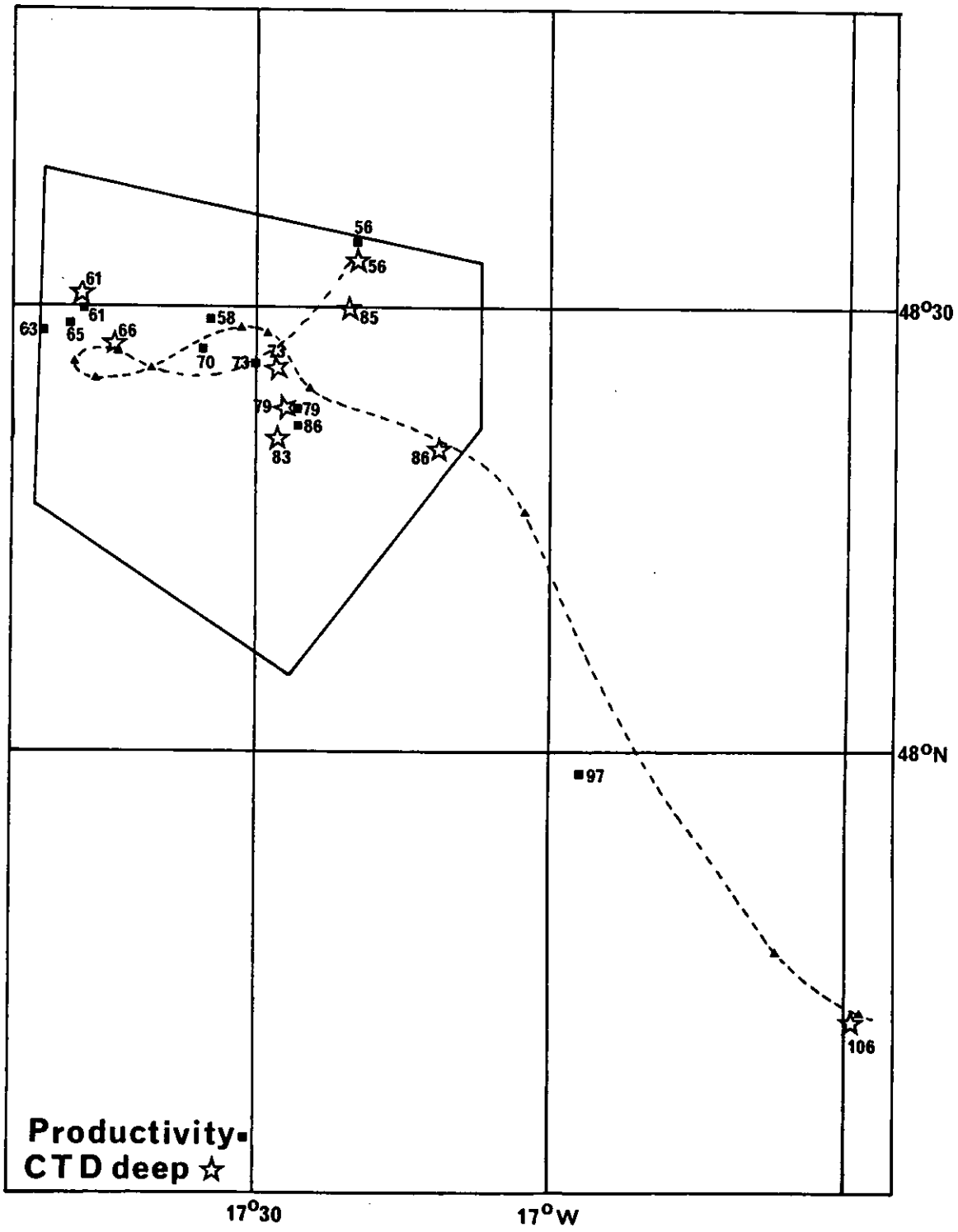

Figure 6. Chart of positions of productivity stations and deep CTD observations.

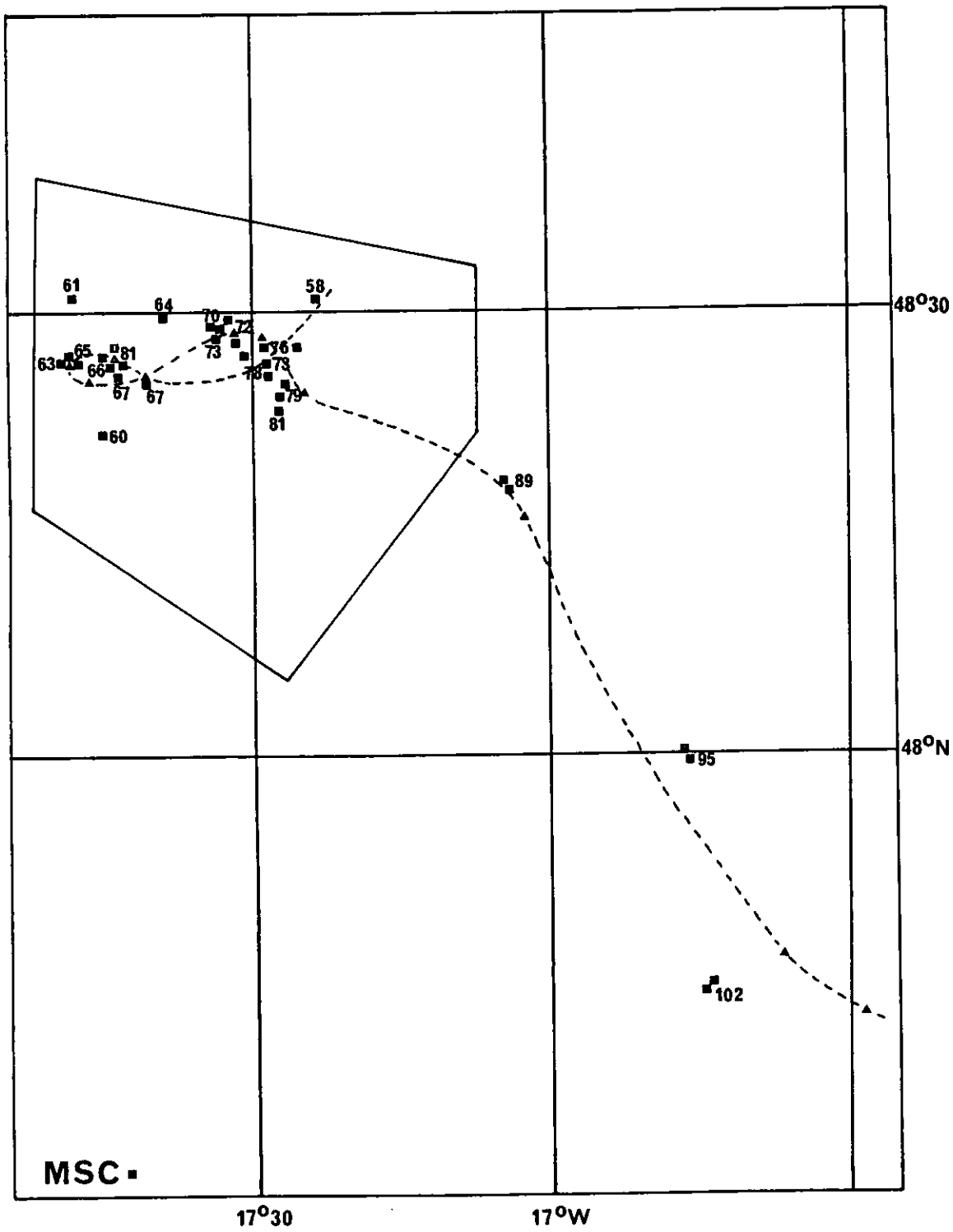

Figure 7. Chart of positions of Marine Snow Catcher (MSC).

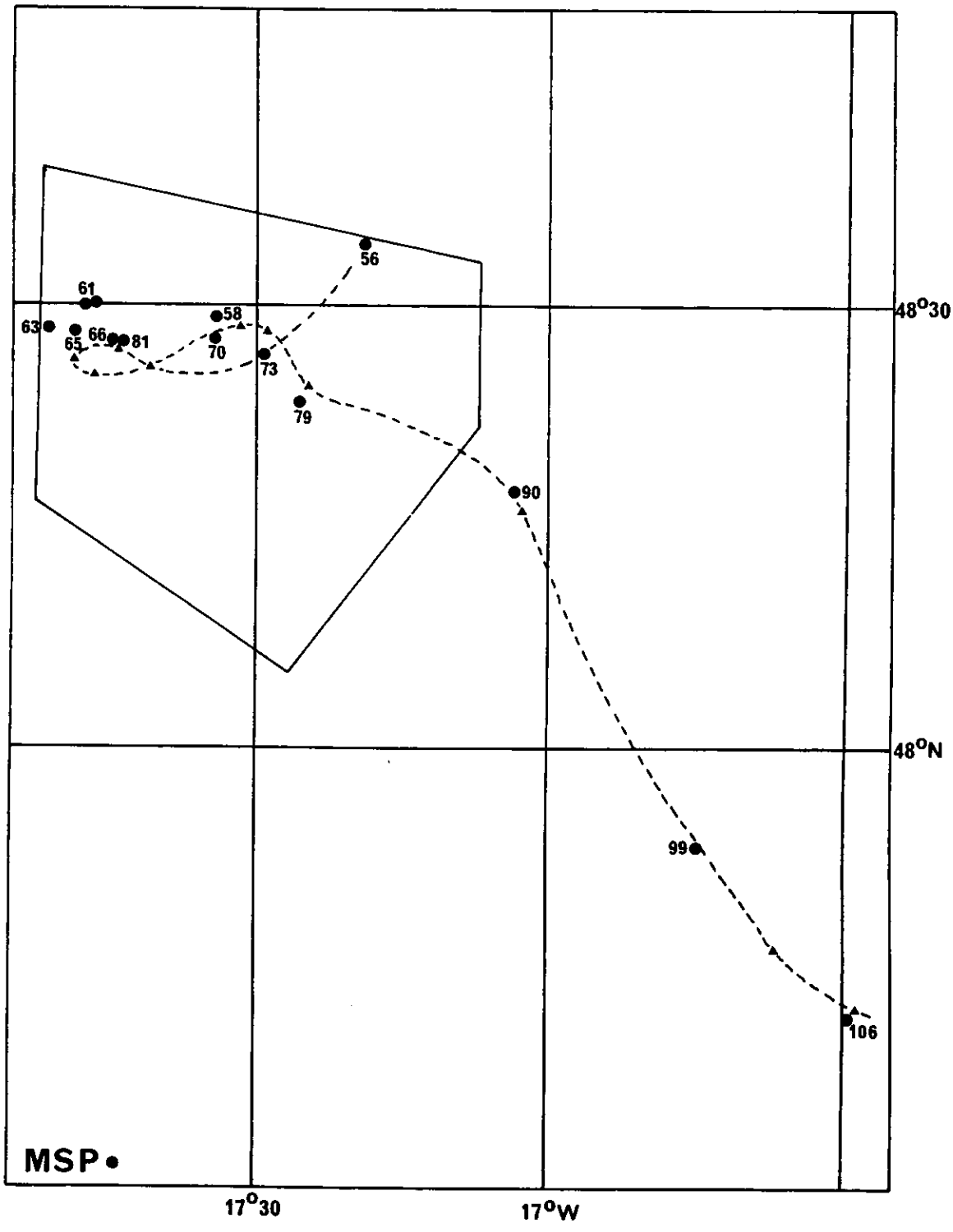

Figure 8. Chart of positions of Marine Snow Profiler (MSP).

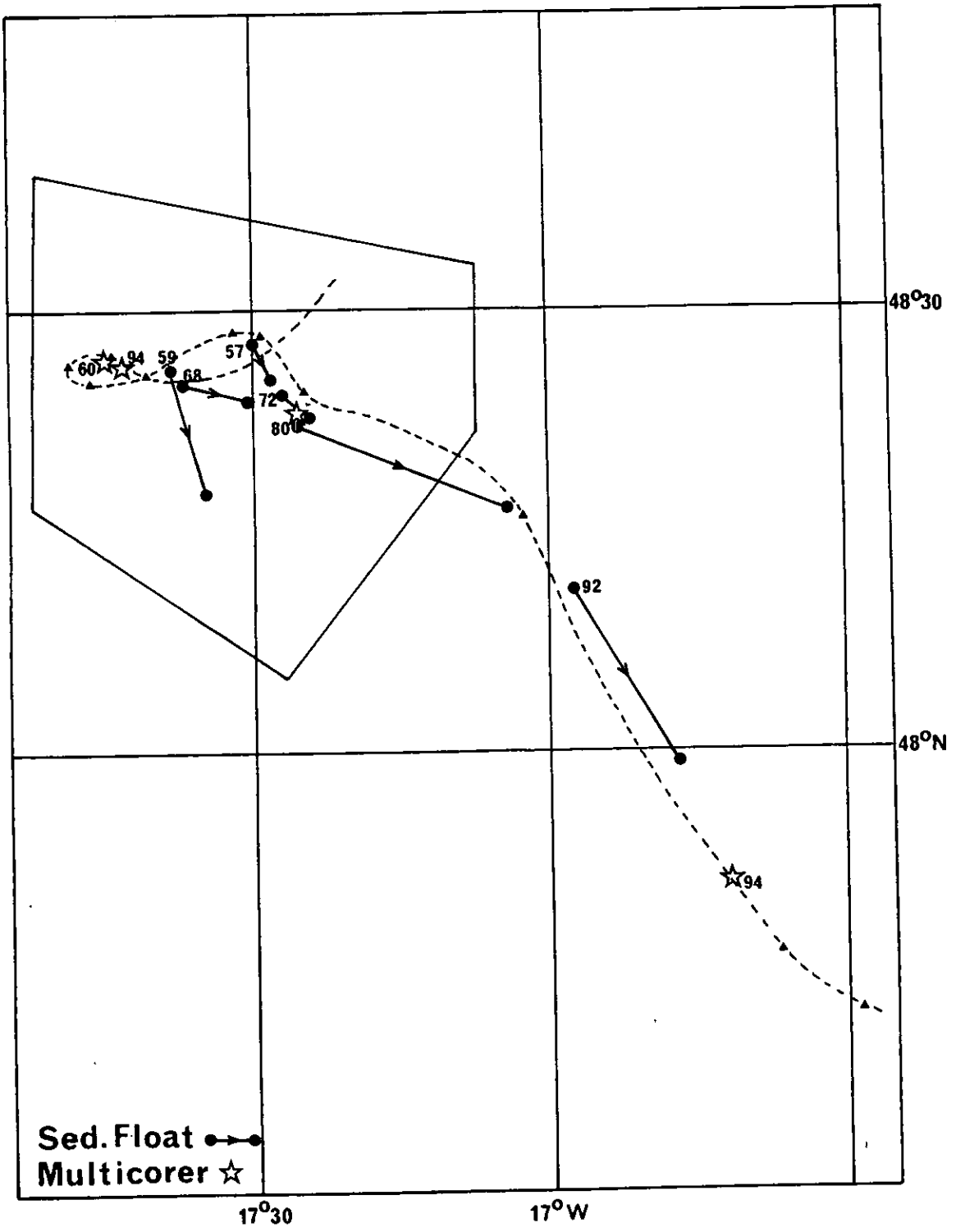

Figure 9. Chart of drifting sediment trap deployment and recovery positions and multicorer stations.

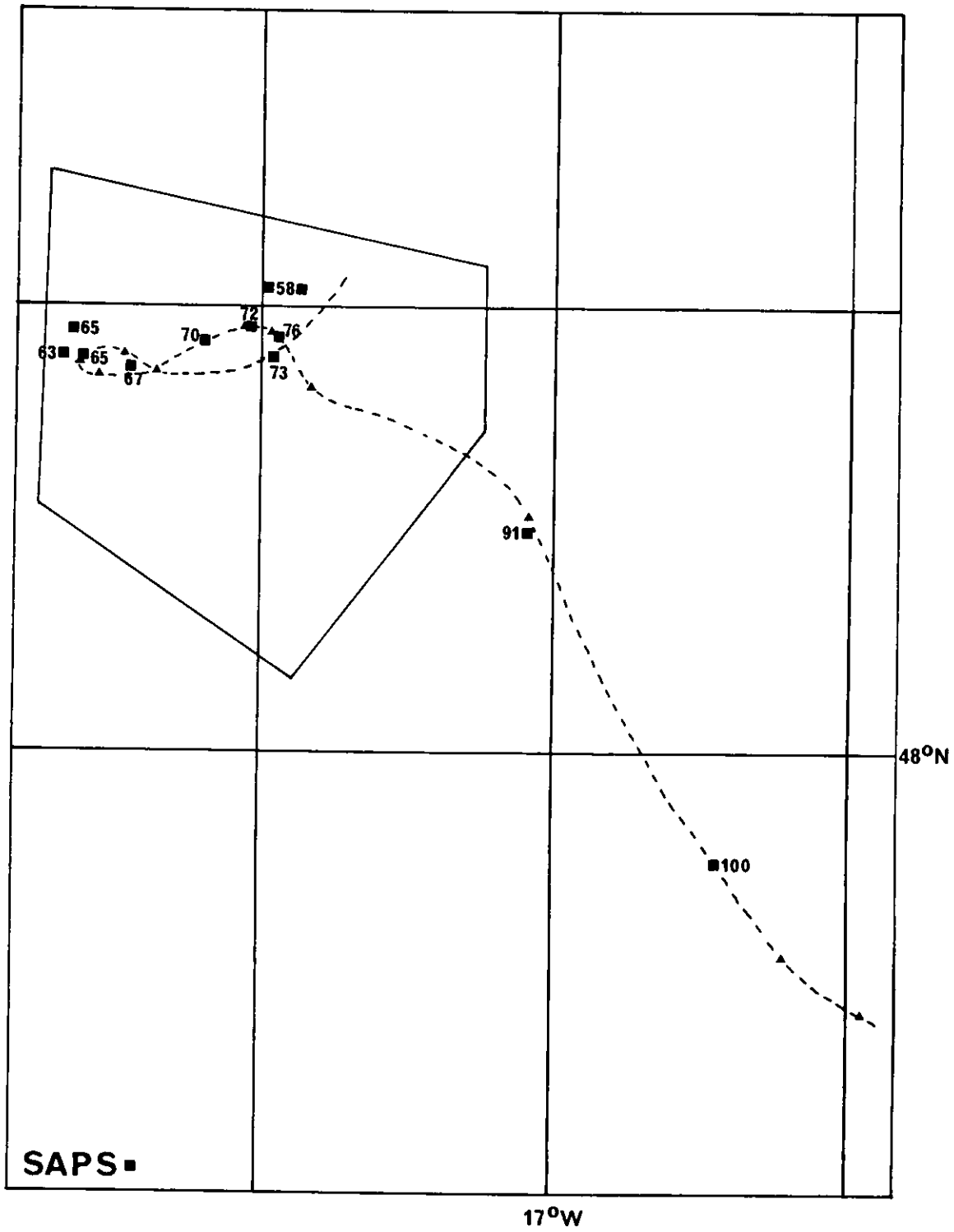

Figure 10. Chart of stand along pump deployments (SAPS).

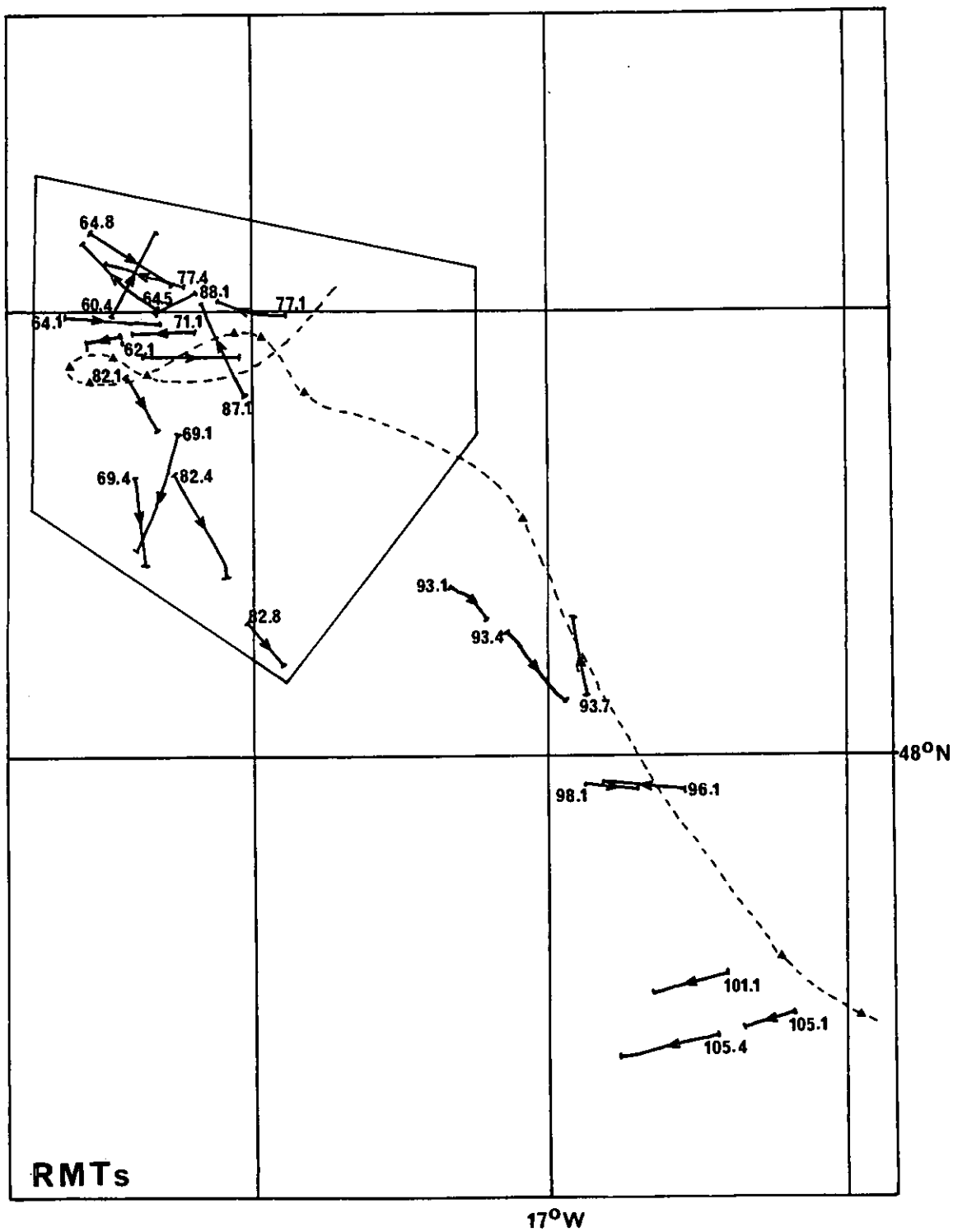

Figure 11. Chart of tracks of Rectangular Midwater Trawl tows (RMT).

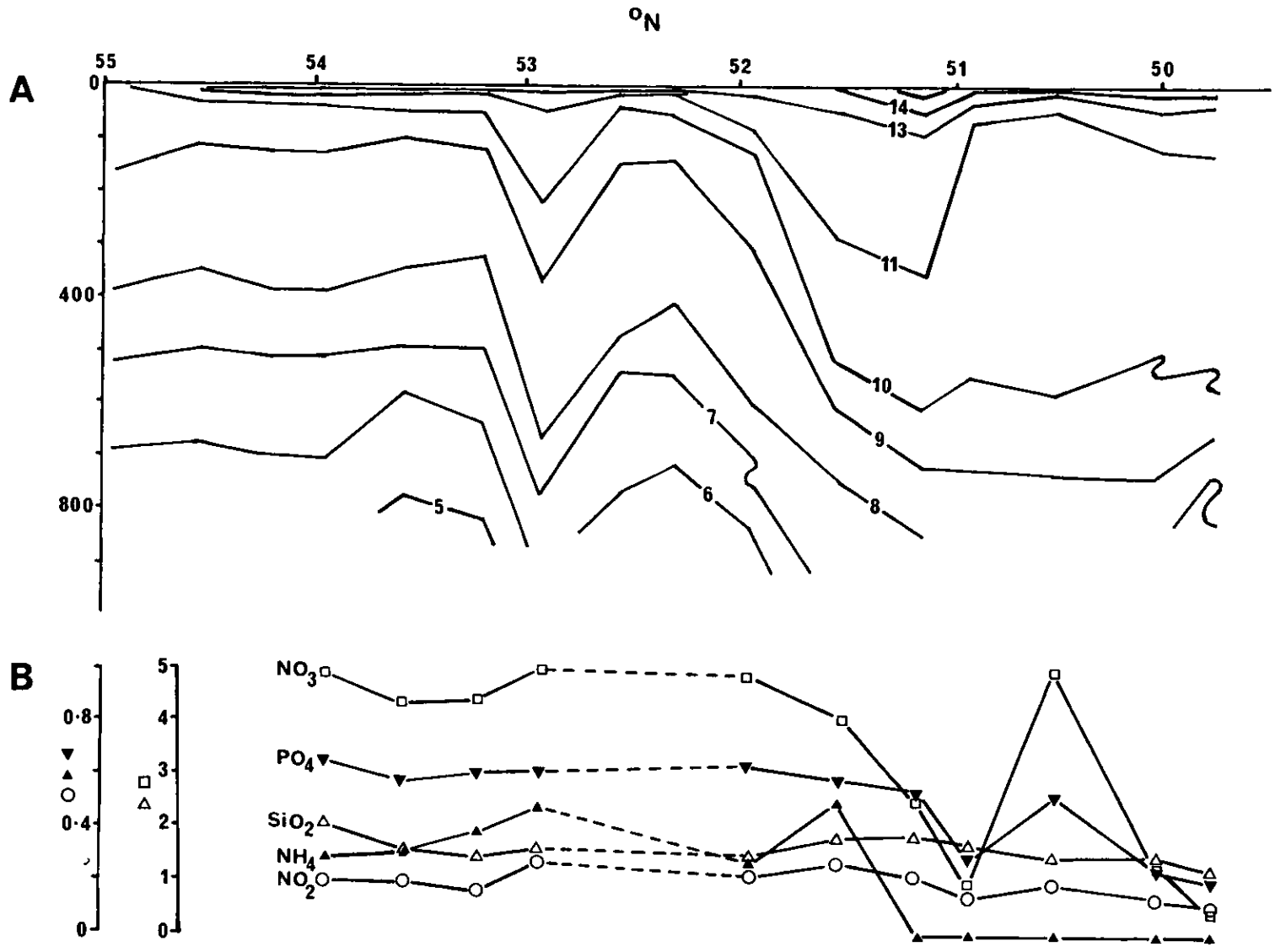

Figure 12. Temperature profile and surface nutrient concentrations between 55°N and 49°40'N along track from northern locality and the main study area.

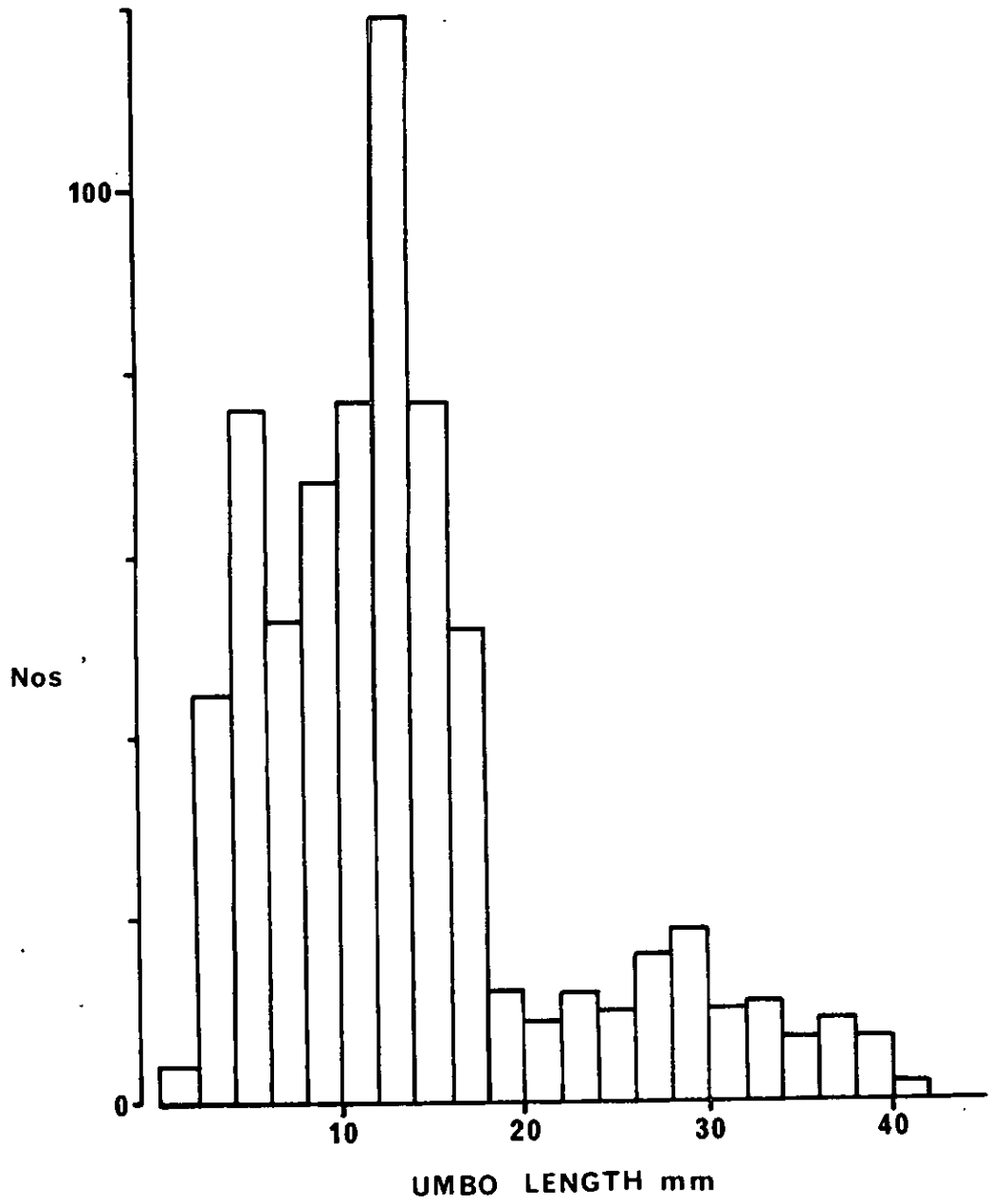

Figure 13. Umbo lengths of goose barnacles *Lepas anatifera* taken off the Argos drifter 3909 which had been deployed for 390 days and was recovered on 13 May.