I.O.S.

RRS DISCOVERY

CRUISE 146

27 MARCH – 24 APRIL 1984

BIOLOGICAL AND PHYSICAL INVESTIGATIONS AT 39°30'N 15°W TO 46°N 14°W OF THE EVENTS LEADING UP TO AND ASSOCIATED WITH THE ONSET OF THERMAL STRATIFICATION

CRUISE REPORT NO. 168
1984

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

RRS DISCOVERY

Cruise 146

27 March - 24 April 1984

Biological and physical investigations at 39°30'N 15°W to 46°N 14°W of the events leading up to and associated with the onset of thermal stratification

Principal Scientist

M.V. Angel

CRUISE REPORT NO. 168

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N.A.C. Jonas	Chief Officer
J.J. Price	2nd Officer
A.R. Louch	3rd Officer
D.C. Rowlands	Chief Engineer
D.E. Anderson	2nd Engineer
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A. Grattidge	3rd Engineer
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K. Sullivan	5th Engineer
B.A. Smith	Electrician
R.M. Morris	Purser/Catering Officer
Miss C.A. Langley	Radio Officer

OBJECTIVES

The cruise had an interdisciplinary physical and biological programme. The physical element of the programme was designed to investigate the phenomena associated with the seasonal change over from winter cooling to summer heating of the surface waters of the ocean, and hence the seasonal development of thermal stratification within the surface layers of the water column. It consisted of a continuation of the studies begun during Cruise 145, and described in full detail in its Cruise Report. It centred around the deployment of two sets of current moorings in the vicinity of 40°N 15°W and 46°N 14°W. Each set of moorings included a subsurface current meter string, a toroid buoy with thermistor chains and meteorological instruments, and a free-drifting spar buoy carrying nine current meters. Repeated SeaSoar surveys were run around the spar buoy

The biological element of the programme was designed to capitalise on the substantial quantity of physical background information available for the two main localities, and to describe the changes in the structure and vertical distributions of the pelagic communities associated with the physical changes. Using the fluorometer fitted in SeaSoar the spatial distribution of chlorophyll was examined in relation to the physical structure of the water. The fluorometer observations were related to the vertical distribution of particulates, light attenuation and nutrients as well as temperature and salinity by the use of shallow CTD profiling and water sampling. A number of productivity observations were made mostly using water samples collected in the chlorophyll maximum. Series of midwater trawls were taken with the RMT1+8M system in order to try to relate the vertical distributions of plankton and micronekton at the two main stations with the physical regime. Oblique trawls down to 1000m were made at intervals between the main stations to examine the gross community changes which occurred from north to south in this region which is the transition zone between where thermal stratification is permanent and where it occurs only seasonally.

NARRATIVE

The vessel sailed from Oporto (Leixoes) at 1300/27 March. The PES fish was streamed at 1734h. Once the edge of the shelf had been reached, the brakes of the main winch which had been renewed in port were adjusted by streaming a one ton weight on the end of the trawl warp and paying out 1000m of wire. This was completed by 2110h and the vessel got underway again. Throughout the night heavy seas and strong winds slowed the ship but by 1322h on the following day (28th) the vessel was making enough speed to deploy the SeaSoar. However, at 1937h a malfunction caused by private wireless transmissions meant the instrument had to be recovered. Repairs were quickly effected and the SeaSoar was redeployed at 2018h. The delay resulted in the decision being taken not to continue on to the position of the toroid mooring set at 40°20.2'N 15°01.37'W during Cruise 145, but to a slightly more southerly position clear of a frontal system shown up by satellite sea surface temperature pictures.

The SeaSoar run was completed at 1530/29 March and the vessel steamed back along its track for an hour to set the spar buoy at 39°32'N 14°54'W. Deployment was completed by 1740h and SeaSoar was deployed once again at 1955h to begin a series of triangular surveys to define the physical structure of the water around the spar buoy. This survey was completed by 0845h/31 March. The original plan had been to start biological sampling using the RMT1+8M system, but a combination of poor weather, a very slippery deck caused by leaks of hydraulic fluid from the aft davit and the relative inexperience of the fishing team led to its postponement Consequently a series of deep CTD stations to 2000m were carried out around the spar buoy during the next 24 hours. On the morning of 1 April weather conditions had improved enough for biological sampling to begin. Over the next three days the top 1100m of the water column were fished and a number of shallow CTD dips made. A number of problems with the new net monitors and with a major leak of hydraulic fluid hampered the sampling, but eventually an adequate set of observations was achieved. The netting was completed by 1443/3 April and it was then planned to begin immediately another set of triangular SeaSoar surveys around the spar buoy. However, the computer sampling of the CTD readings showed up a software fault which was eventually circumvented but not cured by using an older, less well-calibrated CTD for the surveys. Eventually SeaSoar was deployed at 1850/3 April and the surveys began. These surveys were completed at 1500/4 April, so SeaSoar was recovered and the sparbuoy was picked up. SeaSoar was immediately redeployed at 1835/4 April and the vessel steamed north toward the next position.

This long SeaSoar northward transect showed the existence of a number of fronts at which there were sharp drops in sea surface temperature of >1°C at three places around 39°40'N, 41°30'N and 43°20'N. Surface water samples showed that nitrate concentrations likewise tended to show step-like increases across the fronts (i.e. nutrient concentrations were inversely correlated with temperature).

Just after 1500/6 April the vessel arrived in the vicinity of the northern set of moorings deployed during Cruise 145. A triangular SeaSoar survey was carried out until midnight, when SeaSoar was brought inboard and the remainder of the night was devoted to trying to fix positions of the moorings deployed during Cruise 145. The release for the toroid was located, but no sign was found of the subsurface mooring. At 0400/7 April the vessel made course for the position at which it was planned to deploy the spar buoy and deployment began at 0600h, and was completed by 0845h. A SeaSoar survey was begun but soon after launch a strange trace appeared on the echo-sounder surrounded by a dense scattering layer. Because this could conceivably have been the subsurface buoy of the mooring we had failed to locate, SeaSoar was brought inboard and the area resurveyed, but without success. So at 1245h SeaSoar was redeployed and a triangular survey run around the spar buoy. This survey finished at 1940h and the trawl was rigged for fishing. In the early part of the night a successful tow was made between 500-800m, but the second tow not only had to be terminated early because of the rapidly deteriorating weather, but also it was found that one of the release strops had parted and so neither of the samples collected were of value. The vessel returned to the vicinity of the spar buoy and a shallow CTD station was completed. The continuing high winds meant the abandonment of the planned programme, and a 24h series of yo-yo CTD's to 300m was carried out. This was completed at 0904/9 April. The vessel then proceeded to relocate the toroid release and to carry out an intensive grid search for the subsurface mooring. The search for the latter was again unsuccessful and was abandoned at 2230h and the vessel returned to the vicinity of the spar buoy. SeaSoar was deployed at 0200/10 April and another triangular survey run around the spar, although this survey was not particularly effective because the vessel could only maintain adequate speed for proper 'SeaSoaring' when running down wind. The survey was completed by 1045h. The weather had been moderating and it was then possible to continue the biological sampling over the next twenty-four hours.

At 0850/11 April after a shallow CTD station and water sampling for productivity measurements, the recovery of the spar buoy started. This was followed by another run across the position at which the sub-surface mooring had been deployed to the toroid mooring position. The afternoon was spent again unsuccessfully searching for the toroid. The search was abandoned at dusk and the night of the 11/12 April was spent completing a triangle of deep CTD observations. Once they were completed a trawl was fished obliquely to 1000m as the first of a north-south transect. Once the trawl was inboard (0800/12 April) the vessel steamed once again to the toroid position and the release fired. Initially the release rose at a rate of 7½m per minute and finally stopped rising when it reached a depth of 1700m by mid-afternoon. No sign was found of the rope at the surface and the search was abandoned at dusk.

At 1930/12 April the vessel began to steam south again. During this passage run stops were made at 44°N, 42°30'N and 41°N to make CTD observations to 2000m and oblique trawls to 1000m, in order to examine the gross changes in zooplankton and micronekton in relation to the frontal features observed during the earlier northward SeaSoar transect. The position of the southern toroid mooring at 40°20'N 15°01'W was reached at 0140/15 April but once again no sign of the mooring was found. The tide gauge and the subsurface mooring were successfully interrogated and at 0340h/15 April the tide gauge release was operated and brought inboard by 0548h. Once again a series of runs were made across the toroid position but no sign of it was found. So the search was abandoned and the subsurface mooring released at 0950/15 April. Recovery of this mooring was finally completed by 1230/15 April.

The vessel then set course for the position at which the spar buoy had been deployed earlier in the cruise. Once the position had been reached, a set of three CTD stations to 2000m were made with an oblique net fished between the first two. At 0940/16 April the spar buoy was deployed within the triangle formed by the three CTD stations. The deployment was completed by 1245h and SeaSoar was launched to carry out the standard series of triangular profiles around the spar position. At 1540/17 April during one of the outer legs of the triangles a toroid buoy was spotted, so the SeaSoar was brought in and the vessel moved to pick up the buoy. It proved to be the toroid deployed at station 10889 at 40°20.2'N, 15°01.37'W during Cruise 145, and had drifted to 39°32.7'N 15°11'W. Apart from the release which had been lost when the mooring rope broke, all the instrumentation was intact. After this piece of good fortune, the vessel returned to fix the position of the spar buoy, and the biological sampling began. Midwater trawls were fished day and night at 100m intervals from the surface to 1100m, interspersed with shallow CTD dips to 300m. On the 19th April a further 7 hours of SeaSoar profiling was carried out around the spar buoy until 2000h. During the night 19/20 April a series of nine repeat half-hour tows were taken at 50-100m to examine the small-scale variability of the near surface communities. The following day the biological sampling was extended down to depths of 1800m and completed. The final SeaSoar survey was conducted from 0830/21 April until 1545/22 April. The sparbuoy was then recovered and the vessel set course for Oporto. Crossing the slope a few hours work on a vertical wire were carried out on the near-bottom echo-sounder system for the midwater trawls. The vessel finally docked in Oporto at 0900h/24th April

MOORINGS (I. Waddington, R.T Pollard)

It was intended to recover the four moorings and the tide gauge deployed during Cruise 145 (See Cruise 145 Report, Table 1). In the event only the southern moorings and the tide gauge were recovered (Table 1).

a) Mooring 370 Northern subsurface; current meters.

The mooring could not be located acoustically on site and an intensive search around the area failed to establish any acoustic contact. Three independent acoustic systems had been incorporated in the mooring, so the implication is that the buoyancy was adrift following the mooring's failure at or below the acoustic release latch. It was therefore abandoned and thus ten Aanderaa current meters were lost.

b) Mooring 371 Northern surface toroid, with meteorological sensors and a subsurface thermistor chain array.

No sign of the toroid was found on site, either visually or on radar. However, good acoustic contact was made with the C.R. (Command Release), which was indicating 60° of tilt. A search was made covering the whole area that could have been covered by the maximum scope of the mooring but no contact was made with the buoy either visually or by radar. On day 103 (12 April) the C.R. was fired. It began rising at $7.5 m.min^{-1}$. This low rate of ascent indicated that the toroid was no longer attached and that enough rope was still attached to the release to provide buoyancy for its ascent. Assuming that most of the rope was still attached to the release over 1km of rope should have laid out on the surface once the ascent had halted. Sea conditions were fair so there was a good chance of spotting this quantity of rope. A search grid was laid out navigating according to the rising acoustics of the release. The ship was navigated within 200m of the acoustic release (horizontal range) and yet no sign of the rope was found. Despite continuous attempts to locate the rope the search had to be abandoned at dusk.

c) Mooring 368. Southern surface toroid with meteorological sensors, subsurface thermistor array and a VACM

An attempt to fix the position of the toroid at the end of Cruise 145 had been unsuccessful, but was nevertheless repeated on this cruise. Conditions were ideal for searching, visibility was excellent and the seas were calm. The toroid should have been visible at several miles range, but was no longer in position, so the search was abandoned.

However on the afternoon of day 108 (17th April) during a Sea Soar survey the toroid was spotted by the officer of the watch at a range of 3 n.m. It was over 50 n.m. south of its deployment position.

The rubber boat was launched to facilitate recovery and this proved to be a wise precaution, because the recovery line was found to be badly entangled, passing through the buoy tower and keel. The line was cleared and the buoy recovered aft with the assistance of the boat crew, using the crane and the auxillary winch.

The mooring had parted 262.3m down from the top of the 12mm polypropylene rope length. All the instrumentation was recovered in good order, although the thermistor chain had spiralled many times around the non-torque balanced 12mm wire to which it was attached. The rope failure is to be thoroughly investigated on return to IOS. The future procedure for recovery and handling of these buoys needs further development.

d) Mooring 369. Southern subsurface; current meters.

The mooring was located successfully at its deployment site and released. It was recovered using the foreward double barrelled capstan without any problem and the mooring appeared in excellent condition with the exception of a severely strained wire rope fitting at ACM 2109 which had possibly been caused during deployment. The instrumentation was in good condition. ACM 7517 had a small amount of water in the electronics housing, but, there was no corrosion and the leakage probably occurred during recovery, possibly because of the pressure change.

e) Tide Gauge.

The Bidston tide gauge was recovered without any problems.

DRIFTING SPAR BUOY (I. Waddington, R.T. Pollard, R.W. Pascal, J. Smithers.

Spar buoy operations have been described in detail in the cruise report for Cruise 145. During Cruise 146, there were three further deployments (Table 1) and no significant problems were encountered. An ORE light was taped to the surface-piercing spar in addition to that on the pitch/roll float. Both lights worked well and provided a major safety improvement over the Cruise 145 deployments. They allowed the Bridge to locate the spar at night at sufficient range to take any necessary avoiding manoeuvres. Transponder ranges decreased as the surface stratification built up, but were generally in excess of 3km.

The rope harness showed abrasion after deployment 1461 and was replaced, but the new harness was still in good condition at the end of the experiment. In future deployments all ropes should be fitted with nylon thimbles to reduce this abrasion. On deployment 1462 a 38m strop of Kevlar was used successfully to increase the maximum current meter depth. During this northern deployment, although it was of rather short duration, the strongly formed surface thermocline was remixed down to 150m depth over a period of three days, as a result of the strong winds which sprang up within a day of the launch. In contrast both the deployments at the southern position (1461 and 1463) in the vicinity of 39.5°N 15°W occurred during light wind conditions resulting in restratification and considerable horizontal variability.

All the current meters were processed onboard within a day of recovery. No VACM problems were found. Some of the VAECMs gave trouble; shifts of the zero resulting in increased noise in the vector averaged velocities were the commonest problem. One EM head had to be changed prior to 1463, so further laboratory calibrations will be required.

SEASOAR (R.N. Bonner, J.Smithers, R.T. Pollard, M.J.R. Fasham)

Nearly nine days of the cruise were taken up with 'SeaSoaring' (Tables 2,3,4). Apart from passage legs for part of the run from Oporto to the southern site and from the southern to the northern sites, all the runs were surveys of the water structure in the vicinity of the spar buoy deployed at the two sites. Triangular surveys were run at the beginning and end of the end of the first spar deployment at the southern site (Deployment 1461) totalling 56.6h. (Table 2, Runs 3 and 4; Figure 2a). Surveys at the northern site (Figure 2b) around the spar (Deployment 1462) were severely curtailed both by bad weather and by the need to search extensively for the moorings. A large (24nm) triangular survey was run at the end of the passage north (Run 5) to determine the best position at which to deploy the spar buoy. After its launch, only two circuits of a 12nm triangle were completed (Run 7) shortly after the spar was deployed (following an abortive Run 6), and Run 8 a day prior to the spar buoy recovery. During the final spar buoy deployment at the southern site (Deployment 1463) three surveys were run, a) a set of triangles over a period of 27h immediately after spar deployment (Run 9, Figure 2c), b) a partial repeat three days later (Run 10, Figure 2c) and c) a 30h creeping-line-ahead survey (Runs 11, 12, Figure 2d) immediately before the spar buoy was recovered.

A few technical problems were encountered. An unofficial amateur radio transmission from the ship during Run 1 interfered with the controls of SeaSoar and produced a sudden change in wing angle. Control of the instrument was lost and it had to be recovered. Once inboard the hydraulics were found to be operating freely again. Apparently a split pin on the wing operating arm had jammed against the stop pin head. Thereafter all radio transmissions official and unofficial were stopped during SeaSoar runs. The routine overhaul of the hydraulics unit after Run 3, showed serious leakage. This was traced to scoring by a stainless steel end cap rubbing a ram as the wing cycled. Run 11 had to be aborted when all signal was lost. This proved to be caused by a poorly seated Brantner connector which had water on its contacts; a fault which was quickly identified and fixed.

Data handling also caused serious delays. The start of Run 4 was delayed by four hours because the raw CTD data-logging program on the S1 computer proved to have a long-standing but intermittent fault. The program was causing the logger to synchronise on the characters FØ in the oxygen word which precedes the true FØ or ØF synchronising pulse in the data stream. The problem was bypassed by replacing the new shallow CTD (which had been used in the SeaSoar since the start of Cruise 145 and had a broken oxygen sensor) with the old shallow CTD. Besides getting work restarted again, this had two other beneficial consequences. First, the acquisition of oxygen data was restarted. Second, the slower sampling rate of the old CTD, 8hz as against 16hz for the new, greatly relieved the processing load on the computer through the averaging program (CTDAVG). Consequently the sea surface temperature and surface irradiance could be sampled simultaneously with the SeaSoar without slowing down the real-time profile plots to the point where some had to be abandoned (as had previously been the case). Although communication with RVS resulted in a permanent debug of the sampling program, the old shallow CTD continued to be used for the remainder of the cruise. This did cause minor problems with ship programming because the old shallow CTD was being used for shallow CTD profiling for the biological studies; transferring the instrument package from SeaSoar on to the vertical wire is a simple half-hour operation but at sea any transfer of a well-functioning instrument invites trouble.

All the SeaSoar data were processed through to reasonably well-calibrated contour plots within three to six hours of collection, as described in the Cruise Report for Cruise 145.

CTDs (J. Smithers, M.J.R. Fasham, R.T. Pollard)

32 CTD casts were made during the cruise (Table 5, Fig. 3), of which 16 were 2000m casts with the "new, deep" CTD, 14 were 300 or 600m casts with the "old, shallow" CTD, and two were extended (10 and 13 hour) 300m yoyos also with the latter CTD.

Cable termination problems occurred on the first three casts, but were then cured until Station 11091, when the wire caught over a protrusion on the A-frame during launch. The station was attempted but had to be aborted early, and the cable end cut back and remade.

The need to exchange the shallow and deep CTDs brought to light a longstanding bug in the sampling program (see SeaSoar section). Once this had been cured, swopping the CTDs was not a difficult process. The old shallow CTD and fluorometer were used for both CTD casts and towed SeaSoar work, with the addition of transmissometer and sometimes light meter for the shallow casts.

Deep CTDs were done in a cross pattern at the southern site (11030-35), a triangle round the northern toroid's nominal position (11061-63), prior to every oblique between the northern and southern sites (11063-73), and in a triangle at the southern site (11073-76). Shallow CTDs were done between nets, generally in the vicinity of the drifting spar buoy.

METEOROLOGY (R.T. Pollard, R.W. Pascal)

Routine one second sampling of standard navigational and meteorological parameters continued throughout the cruise. One minute averages were archived and some parameters are shown in Figure 4. Additional anemometers mounted by P.K. Taylor for Cruise 145 (see Cruise Report) on the foremast and both wings of the monkey island, and a vane on the foremast, were left in position for Cruise 146. The one minute averages were logged throughout the cruise on a field logger.

THERMOSALINOGRAPH AND SEA SURFACE TEMPERATURE FISH (R.T. Pollard, G. Knight, R. Pascal, R. Wild)

Temperature and salinity data of the non-toxic seawater supply (intake at a depth of 5m) were measured by a Plessey Thermosalinograph and logged and plotted throughout the cruise. A gradual degradation of the signal was suspected probably caused by a build-up of biological fouling visible within the plastic pipework and presumably affecting the sensors. On day 106, while moorings were being retrieved, the non-toxic pumps were stopped. The sensors and the degassing tank were cleaned and several leaks in the pipework were repaired.

Computer logging of the FM signal from the sea surface fish and surface irradiance meter had been fixed in Oporto. So from the start of the cruise the SST data collected by the old fish electronics could be logged. However, the towing arrangement proved to be unsatisfactory. The lead from the tow point into the fish, although it was armoured and non-strain-bearing, worked back and forth so that the armouring gradually broke and the frayed strands broke the electrical leads. Consequently the fish was only deployed during SeaSoar surveys. Later in the cruise the towing arrangement was improved by inserting two shackles immediately above the fish. The increased drag of the shackles resulted in the fish's motion through the water becoming steadier, thus reducing its tendency to snatch and jump clear of the water when it hit the bow wave.

The northern site survey was run with the temperature-only fish. But for the second spar deployment at the southern site the new pressure/temperature electronics were put back again. The tube had to be widened to take these electronics, but then it was found that the thermistor bead had been damaged, most likely as a result of the electronics being forced partially into the tube on Cruise 145. The bead was replaced, so needs post-cruise calibration.

The temperature signal was subject to a quantitising effect, the cause of which was eventually traced to a variable ship's power supply, and was cured by the use of a more stable supply.

CHLOROPHYLL AND NUTRIENTS (M.J.R. Fasham, P.R. Pugh, A. Smith)

Chlorophyll *a* distribution was measured using a Chelsea "Subaquatraka" *in situ* fluorometer deployed either in the Sea Soar or in conjuction with the CTD on the vertical wire. The surface chlorophyll distribution was also measured continuously by passing the pumped sea water supply through a Turner Designs fluorometer.

The Chelsea instrument worked satisfactorily on the early batfish runs, although there was an obvious low signal cut-off at 1-2 volts which had not been observed on previous cruises. On the early CTD profiles (11037 and 11041) there was a noticeable jump in fluorescence values during the dip and this was attributed to a small change in the voltage supply causing the detector system to switch into one of the two states. This sensitivity of the fluorometer to voltage supply became more marked on stations 11052 to 11054 and during the Sea Soar survey made on the 10/4 it effectively ceased to work. On taking it apart it was found that the DC/DC converter was faulty and this was replaced. Thereafter the instrument gave no further trouble and also the low voltage cut-off disappeared. The chlorophyll calibration before and after this repair was different. At the time of the first SeaSoar survey of the southern stations there were a series of shallow thermoclines representing recent heating events and the chlorocline was between 50 and 70m. Above the chlorocline chlorophyll *a* values were in the range 0.4 to 0.6 mg m^{-3} with surface nitrate values around 2 µM. The depth of the 1% light level was 50m. Over the next few days the surface chlorophyll increased twofold.

During the SeaSoar run between the southern and northern stations three fronts were crossed at approximately 39°50'N, 41°30'N and 43°20'N. At only the first of these fronts was there any marked increase in chlorophyll biomass relative to the area on either side of the front. However there was a gradual decrease in chlorophyll a values from 1.3 mg m^{-3} to 0.9 mg m^{-3}. This decline was correlated with an increase in the surface nitrate concentrations from 0.5 µM in the south to 7 µM in the north. The very stormy weather on the 8th and 9th of April mixed the water column down to 150m and reduced the surface chlorophyll concentration to 0.4 mg m^{-3}.

On returning to the southern station the SeaSoar survey showed that the surface chlorophyll a levels had declined to 0.2-0.3 mg m^{-3} and surface nitrate to zero. A deep chlorophyll maximum was formed at around 50m having a chlorophyll a concentration in the range 0.7-1.0 mg m^{-3}.

PRODUCTIVITY EXPERIMENTS (P. Domanski, A. Smith)

Four primary productivity experiments were carried out using the Carbon-14 labelled sodium bicarbonate innoculation technique. Water samples were collected with 30ℓ niskin bottles during CTD stations. In addition to water for the experiment, the niskins also provided samples for species identification, chlorophyll determination and particle size spectra.

Two sets of samples were incubated simultaneously in a water cooled light box, each set comprised 40 culture bottles in file in front of a 2000W light source. The absorption of light by the cultures provided a sequence of light levels from <1 to 250Wm^{-2}.

Three experiments were done at the southerly position but because of the motion of the ship during adverse weather, only one experiment could be done at the northern position.

In two of the experiments (B and C) a single depth was sampled but two different filters were used (0.7 and 1µm). In the other experiments (A and D) cultures were collected on 1µm filters but two depths were incubated, above and within the chlorophyll maximum.

Run	Station	Position	Depth(m)	Phytoplankton condition
A	11046#3	39°36'N	5x25	bloom
B	11059#2	45°40'N	2x25	pre-bloom
C	11080#2	39°34'N	2x40	post-bloom
D	11093#1	39°43'N	10x40	post-bloom

TRANSMISSOMETER (M.J.R. Fasham)

A Seatek 1m path length transmissometer was deployed both on shallow CTD dips (0-600m) in conjunction with the Chelsea fluorometer and on deeper CTD dips by itself. At a number of stations bottle samples were taken for particle size analysis and a good correlation was obtained between beam attenuation coefficient, obtained from the transmissometer, and particle concentration. There was also a good correlation between beam attenuation and chlorophyll fluorescence, although this correlation was modified by fluorescence inhibition in the surface layers during the daytime. Observations made through the deep chlorophyll maximum at the southern station showed that a different attenuation-fluorescence relationship occurred above and below the maximum. This difference may be due to photoadaptation of the deeper phytoplankton resulting in increased chlorophyll concentrations per cell.

At Stations 11084 to 11093 a peak of attenuation was observed in the surface 20m that had no associated chlorophyll fluorescence peak. This suggests a bloom of microplanktonic organisms containing little or no chlorophyll and some water samples from this depth were preserved in the hope of identification in the future.

PARTICLE COUNTING (P.R. Pugh)

Initial determination of the size spectrum of particles in surface waters showed that the great majority of particles had an equivalent spherical diameter of less than 10µm. Thus, for most of the cruise, the HIAC PC320 Particle Counter was used in conjunction with the CMH150 sensor, which measures particles in the 2.5 to 150µm diameter size range. However, because of the small size of the sensor's orifice, clogging was a persistant problem and it proved impossible to use the instrumentation "on-line", i.e. with a constant flow of sea water through the sensor. This was unfortunate as much effort had gone into developing the electronics side of the system so that the data could be sampled by the shipborne computer.

Instead, counts were made on discrete samples of sea water using a new "bottle sampler" designed and built by Roy Wild. This proved to be a great success. Attention was focussed on the counting of samples taken, using the CTD/Multisampler system, from the top 100m of the water column. The measured concentrations of particles were compared with the values of transmittance obtained from the transmissometer, and a good correlation between the two sets of data was established. Unfortunately, before more detailed experiments could be carried out, the sensor lamp failed and it proved impossible to effect a repair. Several other problems with the particle counter also occurred during the cruise and most of these, it seemed, were caused by spikes and other quirks in the "dirty" mains supply on the ship.

MIDWATER TRAWLING (Biology Group)

The objective of the midwater biological programme was two-fold. Firstly to gain some insight into the changes in community structure and vertical distribution patterns associated with the change in hydrographical regime from deep winter mixing of the surface water to shallow winter mixing (and hence permanent stratification). Secondly to supplement the information on spatial variability with data on temporal variability by repeating one of the main stations during or just after the spring bloom.

Originally the aim was to sample both southern and northern stations both by day and by night to a depth of 1100m. However, bad weather curtailed the sampling slightly at the first visit to the southern station and much more extensively at the northern station (see Table 6). The locations of the sampling are shown in Figure 5 (a-b). In addition to the series of samples aimed at providing vertical distribution data in the two main areas, a series of five 0-1000m oblique tows were made at approximately 1½° latitude intervals from the northern to the southern sites (see Figure 5b). The hauls were located outside the frontal zones where both surface temperature and nutrients changed rapidly. Each of these oblique tows was subdivided to give a standard 0-100m sample and two oblique samples from 100m down to the top of the Mediterranean water, as identified in a CTD observation made immediately prior to the tow, and from there to 1000m depth.

At the southern site three repeated 50-100m tows were made (i.e. giving 9 samples) to examine the inter-sample variability within the thermocline, where the variability can be expected to be maximal.

MULTIPLE NETS SYSTEM (R.G. Aldred)

The RMT1+8M was used on 32 occasions, many of which were in weather conditions close to the limit for trawling work. Hence the fact we experienced only two mechanical failures was testimony to the strength of the rig. One failure (Station 11051) caused by the breaking of the strop on the release gear was the direct result of working in heavy seas. The second failure which was probably the result of the heavy wear and tear on the gear, occurred during the very last tow (11096) and was caused by one of the norselinks attaching the net to the side-wire catching over the eyebolt of the closing bar of the third RMT8. As a result the third net only half closed and was badly torn, and the second net was also held slightly open so that the catch was badly contaminated.

In an attempt to reduce leakage into the closed nets the number of norselinks used to attach the nets to the side-wires were reduced by half. Even so, in the early samples there was still evidence of contamination of catches with organisms from shallower depths. It was thought that this was resulting from the first and second nets being held slightly open by the open net fishing at the time, so the stoppers on the side wires were moved up 10cm and this effectively cured the problem.

During bad weather during the first half of the cruise there was heavy wear on the release gear strops and the plastic eyebolt inserts. The release gear strops wear heavily because of the tightness of the radius through which the wire is bent as it passes around the release bridle rings. This problem can only be solved by redesign. The problem of wear on the eyebolt inserts and the concomitant wear on the side-wires which can cause minor injury to net handlers because the side-wires kink and strands get broken, should be alleviated by redesign of 'eye-bolts'. A prototype roller system was used to replace the eyebolts at the end of one bar at the latter end of the cruise when the weather was relatively fine. It worked effectively and should be an improvement.

LAUNCH AND RECOVERY (R.G. Aldred)

The launch and recovery of the nets was relatively straightforward so long as the following procedure was adopted.

a) Launch. The davit was raised high and positioned facing directly aft. The net was deployed using the crane and lowered on the crane until the RMT8 bars were at water-level. The davit was slewed inboard and the winch hauled in while still maintaining some tension on the crane cable. It was important that the crane wire remained outboard of the davit arm otherwise difficulty was encountered taking the hook off. Once the hook was at rail level it could be released and the gear paid away, and the davit slewed aft again and lowered into the fishing position. Recovery was basically the reverse of this procedure. The davit needed to be kept high so that the crane wire did not foul on the davit guard-rail and then suddenly jerk free.

Kinking of the warp continued to be a problem and may be unavoidable with the present winch and davit system. The problem arises from there being no way of removing the twists in the wire between the hauler and the davit prior to releasing the tension on recovery. This problem was reduced by marking the warp so that only the minimum length needed to be paid out for recovery. Pulling slack wire off the winch required the efforts of two or three people. This effort could be reduced by paying out a considerable length of wire on the crane so that the drag of the net pulled the wire off. However, this can lead to additional contamination of the catches and to additional wear and tear on the nets as they snatch in the surface waves.

The winch control in the plotting office was experimented with on several occasions. The spring return lever means the operator cannot use both hands for measuring the monitor signals on the Mufax. It would be more useful for routine biological work if it could be replaced with a friction lever.

MIDWATER FISHES (J.Badcock)

Over the years a considerable amount of IOS midwater effort has gone into biological sampling within the temperate eastern North Atlantic, from 40°-60°N. Programme emphasis has been placed upon providing vertical and horizontal profiles of communities as well as, but to a lesser extent, insights into seasonality. The data obtained from Station 7406 (40°N : 20°W, Cruise 36) showed a number of anomalies relative to data from more northerly sampling sites, yet the satisfactory interpretation of these has been frustrated by the unknowns of seasonal effects. The collections from 40°N were made in autumn, whereas those from

42°N - 60°N were made in spring. Within the context of the present cruise, therefore, although the northern position was sampled less completely than one would desire, the perspectives already gained render this inadequacy relatively unimportant. The differences between the present 46°N and 39½°N collections were more or less as were expected and reasonably well marked. A number of subpolar-temperate forms, e.g. Lampanyctus macdonaldi and Protomyctophum arcticum, were absent from the southern site whilst the converse occurred with subtropical species, such as Valenciennellus tripunctulatus and Vinciguerria attenuata. The most striking faunal difference, however, was the change in species dominance, from a predomination by subpolar-temperate and temperate forms at the northern station, to one by temperate-semi-subtropical species in the south. This situation was also reflected in the oblique series catches. The dominant lantern fish at 46°N was Benthosema glaciale, and this and other regularly sampled species, such as Lampanyctus intricarius and Argyropelecus olfersi, were not collected in obliques south of 42½°N (Station 11069). However, for a number of reasons, oblique fishing is not a particularly good sampling method and the absence of a species in a collection does not neccessarily imply its absence in an area. Nevertheless, it can be presumed that for these species the area south of 42½°N was at best one of low abundance. Quite what significance this reduction in abundance may have remains, for the present, uncertain. Populations of some northern species, such as B. glaciale, may be largely expatriate south of c 45°N, maintained by drift from the propagative areas. The critical, definitive parameters upon which the extent of distribution inherently rests may, consequently, be limiting well north of the apparent low abundance area. The shallow, prolonged, oblique samples taken in the upper 100m were designed to provide data to resolve some of these problems, in that they were part of an attempt to locate the southern boundary of the distribution of B. glaciale larvae (a lanternfish generally regarded as the most abundant in the temperate zone) at a time when larvae should have been present. That they were not present in the samples lends support to the expatriation concept; but similar collections to be made during Cruise 148 (late May - early June) should provide an additonal measure of certainty.

DECAPODS (P.A. Domanski)

Preliminary examinations of the midwater decapods from the RMT8s, were made aboard ship. Particular attention was paid to the first southern vertical series at 39°30'N and the northern series at 45°40'N. The bad weather at the northern station curtailed fishing before the series was completed and so comparison between the two series is limited. Even so, there were observable differences in the decapod faunas.

The vertical distribution of the abundant species Acanthephyra purpurea is similar in both series, occurring between 200m and 800m at night. A. pelagica, however, which occurred from 300m to below 800m in the northern series at night, did not appear above 800m in the south. The southern series was richer in species, and the presence of Ephyrina spp. and Notostomus spp. were indicative of a more subtropical fauna.

In the oblique RMT hauls, split into three components: 0-100m, 100-600 or 700m (top of Mediterranean water) and 600 or 700 - 1000m, most of the abundant decapod species were extensive vertical migrators so comparison between hauls of similar depth but from different times of day can be misleading, but some of the gross features can be examined. The deepening of A. pelagica toward the southern end of the run could be seen and the most southerly obliques were qualitatively more subtropical in nature.

A number of specimens were collected for ^{210}Po and ^{210}Pb analyses at the International Atomic Energy Agency at Monaco, it is hoped that the results of this work will further our understanding of feeding behaviour particularly amongst the penaeids.

COD-END SIEVES (C.J. Ellis)

Cod-end sieves were fitted to the RMT1M nets and used on all the tows to split the catches into three size fractions during fishing (>4.5mm, 1.0-4.5mm and 0.32-1.0mm). Whilst rigging the sieves and washing down three liners for each net, are more laborious, and the proliferation of labels and jars an annoyance, the division of the catch into size fractions should make analysis of RMT1 catches and particularly analysis of the smaller macrozooplankton (0.32-1.0mm) significantly easier and faster. Last summer nine man-weeks were spent preparing 86 RMT1 samples to a similar level. The sieves seemed to cope adequately even with very large volumes of material, one haul had 780cc in the 1.0-4.5mm liner (mostly pteropods) and 930cc in the 0.32-1.0mm liner (mostly juvenile pteropods and copepods). The 4.5mm mesh proved most effective in keeping larger animals away from the smaller ones and would be especially appreciated by anyone who has faced the task of removing embedded copepods etc. from Pyrosoma, salps and cephalopods before working on a sample. The 0.32-1.0mm sample is suitable for fractionation and the 1.0-4.5mm can either be totally sorted, or if large quantities are present, can be fractioned first. Overall the system allows considerably more processing of RMT1 catches to take place onboard ship, and savings in time and effort required to work up RMT1 material.

RMT1M CATCHES (C.J. Ellis)

All the catches were split into three size fractions by the cod-end sieves. The $\geqq$ 4.5mm fraction was preserved for reference, material of this size is sampled better by the RMT8M nets.

Material from the three vertical series, both 0.32-1.0mm and 1.0-4.5mm fractions, were halved using a Folsom splitter. One half of each was deep frozen for shore-side analysis of biomass and the other half preserved in 5% seawater formalin, for two of the vertical series. For the first southern station vertical series both halves of the 1.0-4.5mm were pickled and later sorted into major taxa and counted, on board ship. The data will be used to assess the efficiency of shipboard splitting of the material. The preserved halves of the 1.0-4.5mm fraction from the northern station were likewise sorted and the data suggest that the community structures at the two stations differed markedly. Salps, medusae, siphonophores, doliolids, chaetognaths, amphipods and ostracods were commoner in the north, whilst pteropods, gymnosomes, fish, decapods and mysids were commoner in the south. Displacement volumes for the 0.32-1.0mm and 1.0-4.5mm fractions were measured onboard for these two vertical series and the oblique hauls, and the data showed some interesting aspects. Whilst overall catch displacement volume in the top 500m at the southern station was about twice that in the north, 36cc/m^2 (Day) and 44cc/m^2 (Night) compared to 19cc/m^2 (Day) and 18cc/m^2 (Night), this was largely due to the presence of large numbers of pteropods in the surface waters at the southern station. When the integrated displacement volumes for catches below 100m are examined it is evident that there was more material at the northern station deeper in the water column.

PTEROPODS (C.J. Ellis)

The density of one species of pteropod, Cavolinia inflexa, in the top 200m of the southern station was remarkable. For example, haul 11045#1, 1.0-4.5mm fraction had 289cc/1000m^3, an estimated 27 individuals per m^3. These pteropods were accompanied by a gymnosome which was also present at relatively high densities and probably preys on them. Two main size classes were seen, young juveniles whose shells had not developed the characteristic, backward-sweeping spines, and adults with fully developed shells. The species was apparently absent at the northern station though more detailed sorting may turn up a few specimens. On return to the southern station, Cavolinia inflexa was present, but not at such high densities and were mostly of an intermediate size with the spines just forming. Quite a few empty adult shells were present deeper in the water column, presumably the victims of predation.

Other pteropod species were caught in low numbers, Diacria trispinosa, Clio pyramidata, Peraclis triacantha and Clio retroversa in the north and a few Limacina helicoides in the south.

TABLE 1. MOORING DATA

MOORING RECOVERIES

Station	Mooring Number	Type	Recovery Time	Position °N	Position °W
10990	369	Subsurface	106/0940	40°15.4'	15°02.4'
10991	.	Tide Gauge	106/0329	40°17.5'	15°03.3'
10989	368	Toroid	108/1848	39°32.7'	15°11.5'

SPAR DEPLOYMENTS

Station	Deployment Number	Day/Time		Position °N	Position °W	Duration
11048	1461	Set	89/1742	39°31.9'	14°54.2'	5d 23h
		Recovery	95/1638	39°35.9'	14°51.9'	
11049	1462	Set	98/0734	45°38.9'	13°53.8'	4d 1h
(11060)		Recovery	102/0848	45°42.0'	13°49.1'	
11077	1463	Set	107/1238	39°30.6'	14°57.9'	6d 4h
		Recovery	113/1627	39°50.0'	15°05.8'	

SPAR INSTRUMENTATION

Deployment 1461 Instrument	Depth(m)	1462 Instrument	Depth(m)	1463 Instrument	Depth(m)
VACM 673	20	VACM 668	15	VACM 429	15
VACM 629	40	VAECM 2	35	VAECM 1	25
VAECM 4	58	VAECM 4	55	VACM 629	35
VAECM 2	78	VACM 627	75	VAECM 2	45
VACM 429	98	VAECM 1	95	VAECM 3	55
Transponder	107	Transponder	104	VACM 668	65
VAECM 3	117	VAECM 3	114	VAECM 4	103
VAECM 1	137	VACM 629	152	Transponder	122
VACM 668	157	VACM 673	190	VACM 627	142
VACM 627	195	VACM 429	230	VACM 673	172

TABLE 2. SEASOAR DEPLOYMENTS

Run No.	Day/Time in	Day/Time out	Duration h	Type of Run	Reason
1	88/1350	88/1950	6.0	Passage Oporto to southern site	Sudden change of wing angle caused by radio transmission - jammed wings - bent split pin.
2	88/2150	89/1515	17.4	Continue passage	End of run
3	89/1955	91/0815	36.3	Triangular survey southern site	End of run Major service of hydraulics unit
4	94/1850	95/1505	20.3	Repeat triangular survey of south site	End of run
5	95/1835	98/0000	53.4	Passage to north site with large triangle at end	End of run
6	98/0820	98/0940	1.3	Start triangle at north site	Search for unidentified 'echo'
7	98/1250	98/1900	6.2	Continue triangle	End of run
8	101/0220	101/1015	7.8	Repeat triangle	End of run
9	107/1330	108/1620	26.8	Triangles at southern site	2h early to recover toroid
10	110/1130	110/1940	8.2	Partial triangle survey	End of run
11	112/0830	112/1005	1.6	Begin creeping-line ahead survey around spar	Leaky Brantner connector on CTD
12	112/1120	113/1525	28.1	Complete survey	End of run
		Total	213.4	= 8.9 days	

TABLE 3. SEA SOAR COMPUTER RUN NUMBERS

Run	Date/Time Day of year/GMT		Distance run km		Archive tape/files	Comments
SS1460--	start	end	start	end		
On passage from 40°49.6N 11°30.3W to 39°32.9'N 14°53.5'W.						
01	88/1302	88/1816	239.6	303.4	1/1-3	
02	88/1736	88/2300	295.2	365.0	1/4-6	
03	88/2219	89/0300	355.0	423.0	1/7-9	
04	89/0227	89/0722	415.0	485.2	1/10-12	
05	89/0639	89/1144	475.1	545.3	1/13-15	
06	89/1100	89/1500	535.4	591.6	1/16-18	
Triangular Survey; South Site						
07	89/2001	90/0026	628.5	695.1	2/1-3	C1,A1,B1
08	89/2347	90/0418	685.2	755.0	2/4-6	B1,C2,D1,E1
09	90/0339	90/0812	745.4	815.4	2/7-9	E1,B2,C3,A2
10	90/0732	90/1154	805.5	875.4	2/10-12	A2,F1,G1,C4
11	90/1120	90/1543	865.4	935.5	2/13-15	C4,A3,B3
12	90/1504	90/2008	925.1	995.4	2/16-18	B3,H1,J1,A4
13	90/1926	91/0004	985.0	1055.3	2/19-21	A4,B4,C5,A5
14	90/2320	91/0500	1045.2	1116.4	3/14-16	A5,B5,K1,L1
15	91/0404	91/0830	1105.1	1168.4	3/17-19	L1,M1,C6
Second Triangular Survey; South Site						
16	94/1956	95/0006	1621.6	1685.2	3/20-22	C7,A6,B6
17	94/2328	95/0359	1675.1	1745.0	3/23-25	K2,L2,M2
18	95/0322	95/0754	1735.3	1805.1	3/26-28	M2,L8,A7,B7
19	95/0717	95/1147	1795.2	1865.2	4/1-3	B7,H2,J2
20	95/1107	95/1506	1855.3	1916.0	4/4-6	A8,B8,C9
On passage from 39°36.6'N 14°53.8'W to 45°57.4'N 13°37.3'W.						
21	95/1840	95/2235	1934.7	1994.9	4/7-9	
22	95/2156	96/0230	1985.0	2055.3	4/10-12	
23	96/0149	96/0622	2045.0	2115.0	4/13-15	
24	96/0544	96/1012	2105.3	2175.3	4/16-18	
25	96/0936	96/1405	2165.7	2235.1	4/19-21	
26	96/1329	96/1800	2225.7	2295.2	5/1-3	
27	96/1723	96/2152	2285.3	2355.0	5/24-26	
28	96/2114	97/0144	2345.3	2415.1	5/27-29	
29	97/0105	97/0536	2405.2	2475.0	5/30-32	
30	97/0458	97/0927	2465.6	2535.4	6/1-3	
31	97/0847	97/1321	2525.0	2595.2	6/4-6	
32	97/1242	97/1710	2585.4	2655.4	6/7-9	P
33	97/1632	97/2100	2645.3	2714.2	6/10-12	P,Q
34	97/2024	98/0004	2705.0	2762.4	6/13-15	Q,R
Triangle Round Spar; North Site						
35	98/0807	98/0943	2857.9	2881.7	6/16-18	A1
36	98/1240	98/1624	2908.9	2965.5	6/19-21	B1,C1,A2
37	98/1543	98/1928	2955.1	3010.3	7/1-3	A2,D1,E1

Table 3 continued

Run	Date/Time Day of year/GMT		Distance run KM		Archive tape/files	Comments
SS1460--	start	end	start	end		
CTD yoyo near Spar; North Site						
38	99/1003	99/1536	3064.9	3074.3	7/4-5	CTD 11053
39	99/1424	99/1911	3072.2	3079.9	7/6-7,10-11	"
40	99/2044	100/0336	3096.7	3107.9	7/8-9,8/1-2	CTD 11054
41	100/0200	100/0904	3105.5	3115.3	8/3-4	"
Triangle Round Spar; North Site						
42	101/0116	101/0741	3266.5	3325.2	9/3-4,7	A3,B2,C2
43	101/06??	101/1005	3315	3356	9/5-6	C2,A4
Third Triangular Survey; South Site; South Site						
44	107/1320	107/1625	4607.6	4664.8	10/38-40	C1,A1
45	107/1550	107/2000	4654.9	4726.0	10/41-43	A1,B1,K1
46	107/1918	107/2337	4714.6	4785.0	10/44-46	K1,L1,M1
47	107/2258	108/0314	4774.7	4845.0	9/8-10	C2,A2,B2,H1
48	108/0238	108/0700	4835.0	4905.6	9/11-13	H1,J1,A3
49	108/0622	108/1041	4895.0	4965.2	9/14-16	A3,B3,C3,A4
50	108/1003	108/1418	4955.4	5025.0	11/1-3	A4,F1,G1
51	108/1344	108/1641	5015.3	5061.0	11/4-6	G1,K2,L2
Fourth Triangular Survey; South Site						
52	110/1124	110/1500	5256.3	5314.7	11/16-18	A5,C4,M2
53	110/1425	110/1900	5305.0	5380.0	11/19-21	M2,L3,K3
54	110/1803	110/1957	5364.8	5391.5	11/22-24	B4
Creeping Line Ahead Survey; South Site						
55	112/0823	112/1240	5588.2	5645.0	12/1-3	A
56	112/1204	112/1632	5635.3	5705.0	12/4-6	B,C,D
57	112/1558	112/2024	5695.1	5765.1	12/7-9	D,E,
58	112/1942	113/0012	5755.0	5825.0	12/10-12	E,F,G
59	112/2330	113/0353	5815.2	5885.0	12/13-15	G,H,J
60	113/0313	113/0736	5875.0	5945.2	12/16-18	J,K
61	113/0702	113/1300	5935.3	6029.8	12/19-21	K,L,M,N,P
62	113/10??	113/1543	5986.5	6069.0	16/2-3	P

TABLE 4. SEA SOAR SURVEY DETAILS

Run	Day	Start Time	End Time	Leg/ Course	RELDIST at start (km)	Comments
a. Survey 1, Southern Site						
7	89	2000	2123	C1/075°	630	
		2135	2254	A1/315°	652.5	
8		2306	0014	B1/195°	673	
	90	0026	0130	C2	692	
		0136	0247	D1/015°	713	
9		0259	0419	E1/255°	733	
		0425	0536	B2	755	
		0548	0700	C3	776	
10		0712	0834	A2	800	
		0840	0957	F1/255°	822	
11		1009	1122	G1/135°	844	
		1128	1245	C4	867	
		1257	1409	A3	891	
12		1421	1535	B3	912	
		1540	1654	H1/135°	933	
		1707	1846	J1/015°	956)	1734 - 1937 reduced speed,
13		1852	2024	A4	978)	Engine room problem.
		2036	2145	B4	1000	a/c to avoid spar
		2157	2257	C5	1020	
14		2309	0028	A5	1041	
	91	0040	0150*	B5	1062	*spar abeam B5/K1 same course
			0400	K1/195°	1084	
15		0412	0544	L1/315°	1106	
		0556		M1/075°	1126	
		0721*	0815	C6	1147	*spar abeam, M1/C6 same course
				End	1168	
b. Survey 2, Southern Site						
16	94	1956	2050	C7	1621	SeaSoar deployed 1849, but data problems so short leg
		2102	2217	A6·	1637	
17		2229	2349	B6	1658	
		2349	0109	K2	1681	
	95	0121	0236	L2	1703	
18		0248	0406	M2	1724	
		0406	0526	C8	1747	
		0538	0654	A7	1770	
19		0707	0826	B7	1790	
		0832	0949	H2	1814	
20		1001	1117	J2	1836	
		1123	1243	A8	1858	
		1255	1407	B8	1880	
		1419	1505	C9	1902	
				End	1916	

Table 4 continued.

Run	Day	Start Time	End Time	Leg/ Course	RELDIST at start	Comments
c. Surveys, Northern Site						
32/33	97	1517	1802	P/035°	2626	
34		1814	2059	Q/155°	2670	
		2111	0005	R/275°	2715	
				End	2762	
35	98	0843	0924	A1/296°	2867	
		0936	0940	B1/176°	2879	recover to search for possible mooring
36		1302	1413	B1/176°	2914	
		1425	1538	C1/056°	2935	
37		1550		A2/296°	2957	
		1642*	1827	D1/296°	2971	*spar abeam
		1839	1859	E1/176°	3000	
38/39	99	0943	1913		3065	drifting CTD yoyo
				End	3080	
40/41	99	2020			3096	drifting CTD yoyo
	100		0904		3115	
42	101	0222	0244	A3/255°	3275	
		0256	0517	B2/135°	3281	
43		0530	0754	C2/015°	3304	
		0818	1015	A4/255°	3332	
				End	3359	
d. Survey 3, Southern Site						
44	107	1346	1507	C1/110°	4619	
45		1519	1625	A1/350°	4645	
		1637	1740*	B1/230°	4667	*spar abeam to starboard
46		1740*	1921	K1/230°	4690	
		1936	2057	L1/350°	4717	
47		2109	2337	M1/110°	4742	
				C2	4764	
		2349	0049	A2	4787	
		0101	0213	B2	4806	
48		0218	0330	H1/170°	4828	
		0342	0458	J1/050°	4851	
		0506	0620	A3	4874	
49		0632	0745	B3	4896	
		0757	0906	C3	4920	
50		0918	1034	A4	4943	
		1040	1138	F1/290°	4964	shortened, to allow close spar pass on G1
		1150	1301	G1/170°	4983	spar abeam to starboard
51		1307	1445	K2	5004	
		1457	1621	L2	5033	ended early to recover toroid
				End	5058	

Table 4 continued

Run	Day	Start Time	End Time	Leg/ Course	RELDIST at start	RELDIST at end	Comments
e.	Survey 4, Southern Site						
52	110	1131			5257		SeaSoar streamed
		1146	1304	A5	5259		
53		1316	1440	C4	5284		
		1440	1602	M2	5309		
		1616	1723	L3	5333		
54		1734	1900	K3	5356		missed spar on long beam pass
		1900	1935	B4	5380		
				End	5390		
f.	Survey 5, Southern Site						
55	112	0823	1008	A/230°	5588	5615	Recover to fix plug
56		1108	1234	A	5622	5643	
		1240	1313	B/290°	5645	5654	
		1331	1540	C/110°	5658	5690	
57		1558	1744	D/290°	5695	5725	
58		1807	2017	E/110°	5732	5764	
		2035	2229	F/290°	5768	5800	
59	113	2247	0115	G/110°	5805	5840	
		0123	0312	H/290°	5843	5875	
60		0330	0535	J/110°	5879	5911	
61		0558	0751	K/290°	5917	5949	
		0809	1019	L/110°	5954	5986	
		1038	1232	M/290°	5991	6023	
		1250	1400	N/110°	6027	6045	
		1408	1543	P/192°	6047	6069	

Table 5. CTD STATION DATA

Station	Day	Start	Down	End	Latitude N	Longitude W	Depth m	ND/† OS	Comments
11030	91	0853	1040	1139	39°33.50'	14°37.53'	1700	ND-	(Loss of current, no (calibration on up
11031	91	1421	1532	1634	39°30.40'	14°53.63'	2000	ND-	(900-1400m wire (problems
11032	91	1859	1947	2055	39°46.92'	14°53.90'	2000	ND	Wire problems on up
11033	91/92	2341	0032	0115	39°33.55'	15°10.94'	2000	ND	
11034	92	0305	0342	0435	39°34.05'	14°51.70'	2000	ND	
11035	92	0600	0650	0734	39°20.89'	14°52.36'	2000	ND	
11037	92	2000	2020	2107	39°35.41'	14°49.40'	600	OS	
11041	93	1426	1435	1443	39°38.52'	14°48.62'	300	OS	
11043	93	1900	1921	1958	39°37.43'	15°00.97'	300	OS	
11044	93	2117	2237	2334	39°35.13'	14°49.31'	600	OS	
11046	94	0710	0852		39°36.63'	14°50.93'	300	OS	Cast 1
"	"		0955	1020	39°36.44'	14°50.96'	100	"	Cast 2
11052	99	0615	0748	0830	45°37.91'	13°51.09'	300	OS	
11053	99	0943	Yo-yo		45°35.23'	13°51.76'	300	OS	Yo-yo station
"	"			1913	45°35.97'	13°45.35'	"	"	
11054	99	2020	Yo-yo		45°33.53'	13°55.52'	300	OS	Yo-yo station
"	100			0904	45°39.86'	13°43.11'	"	"	
11059	102	0657	0706	0800	45°40.74'	13°50.57'	300	OS	
11061	102	1951	2055	2141	45°46.84'	13°32.88'	2000	ND	
11062	102/103	2248	2334	0024	45°54.50'	13°36.36'	2000	ND	
11063	103	0137	0226	0316	45°49.92'	13°40.90'	2000	ND	
11065	104	0806	0852	0948	44°01.22'	14°09.50'	2000	ND	
11067	104	1417	1455	1544	43°51.91'	14°10.49'	2000	ND	
11068	105	0102	0145	0248	42°30.54'	14°30.47'	2000	ND	
11070	105	1536	1611	1714	40°59.58'	14°51.86'	2000	ND	
11072	106	1430	1444	1518	40°15.62'	15°00.80'	300	OS	
11073	106	2130	2220	2323	39°30.39'	14°59.60'	2000	ND	
11075	107	0402	0433	0526	39°38.34'	14°47.95'	2000	ND	
11076	107	0700	0733	0828	39°27.17'	14°45.13'	2000	ND	
11080	109	0725	0732	0752	39°34.91'	14°58.74'	300	OS	
11082	109	1330	1354*	1420	39°45.56'	14°59.53'	300	OS	*Yo-yoed three times to test O_2 response
11084	109	1915	1931	2009	39°36.62'	15°01.28'	300	OS	
11087	110	0503	0532*	0558	39°41.62'	15°04.53'	300	OS	*Yo-yoed thrice
11091	111	0218	0231	0244	39°40.77'	15°03.93'	300	OS	Cable snagged
11093	111	0806	0823	0857	39°42.93'	15°02.86'	300	OS	

† OS = Old Shallow; ND = New Deep

TABLE 6. RMT1+8m STATIONS SHOWING THE DEPTHS COVERED BY EACH SET OF SAMPLES. *Nominal fishing depths, the calibration of the depth transducer on the monitors used appeared to be 25m too high.

	SOUTHERN SITE (1)		NORTHERN SITE		SOUTHERN SITE (2)	
	Day	Night	Day	Night	Day	Night
0-(50)* (50)-100 100-200	11047	11045	11056	(11051) 11058	11094	11086
200-300 300-400 400-500	11042	11038	11055	11057	11088	11079
500-600 600-700 700-800	11040	11039	-	11050	11083	11078
800-900 900-1000 1000-1100	11036	-	-	-	11081	11085
1100-1200 1200-1300	-	-	-	-	11095	

Repeat samples at 50-100m at Southern Site 11089, 11090, 11092

Oblique samples	Depths fished (m)	Day/Night
11064	0-100, 100-700, 700-1000	N
11066	0-100, 100-700, 700-1000	D
11069	0-100, 100-600, 600-1000	N
11071	0-100, 100-600, 600-1000	D/N
11074	0-100, 100-600, 600-1000	N

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11030	31/ 3	39 33.6N	14 37.5W	CTD	0-1700	0927-1040		
# 1		39 33.5N	14 37.5W	MS		DAY	DOWN 1040 - CTD MALFUNCTION	
11031	31/ 3	39 30.4N	14 53.3W	CTD	0-2000	1435-1631		
# 1		39 30.2N	14 53.6W	MS		DAY	DOWN 1532 - WB AT STANDARD DEPTHS	
11032	31/ 3	39 47.0N	14 53.9W	CTD	0-2000	1907-2040		
# 1		39 46.9N	14 53.7W	MS		DAY	DOWN 1947 - WB AT STANDARD DEPTHS	
				TRANSM				
11033	31/ 3	39 33.6N	15 10.7W	CTD	0-2000	2359-0111		
# 1	1/ 4	39 33.6N	15 11.2W	MS		NIGHT	DOWN 0032 - WB AT STANDARD DEPTHS	
				TRANSM				
11034	1/ 4	39 34.1N	14 51.4W	CTD	0-2000	0313-0426		
# 1		39 33.9N	14 52.3W	MS		NIGHT	DOWN 0342 - WB AT STANDARD DEPTHS	
				TRANSM				
11035	1/ 4	39 21.1N	14 52.3W	CTD	0-2000	0615-0729		
# 1		39 20.9N	14 52.5W	MS		DAWN	DOWN 0650 - WB AT STANDARD DEPTHS	
				TRANSM				
11036	1/ 4	39 23.3N	14 56.4W	RMT1M/1	790- 890	1000-1100		
# 1		39 24.7N	14 59.0W	RMT8M/1		DAY	FLOW DIST. 3.87 KM.	
11036	1/ 4	39 24.7N	14 59.0W	RMT1M/2	890- 995	1100-1200		
# 2		39 26.1N	15 1.0W	RMT8M/2		DAY	FLOW DIST. 3.73 KM.	
11036	1/ 4	39 26.1N	15 1.0W	RMT1M/3	990- 1095	1200-1308		
# 3		39 27.9N	15 3.0W	RMT8M/3		DAY	FLOW DIST. 4.17 KM.	
11037	1/ 4	39 35.5N	14 49.4W	CTD	0- 600	2000-2102		
# 1		39 35.2N	14 49.4W	MS		NIGHT	DOWN 2020 - WB AT STANDARD DEPTHS	
				TRANSM				
				UFL				

STN.	DATE 1984	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11038 # 1	1/ 4	39 34.5N 39 33.9N	14 51.7W 14 54.6W	RMT1M/1 RMT8M/1	180 - 280	2213-2313 NIGHT	FLOW DIST. 3.60 KM.	
11038 # 2	1/ 4 2/ 4	39 33.9N 39 33.0N	14 54.6W 14 57.2W	RMT1M/2 RMT8M/2	280 - 385	2313-0015 NIGHT	FLOW DIST. 3.86 KM.	
11038 # 3	2/ 4	39 33.0N 39 32.4N	14 57.2W 15 0.1W	RMT1M/3 RMT8M/3	385 - 470	0015-0115 NIGHT	FLOW DIST. 3.82 KM.	
11039 # 1	2/ 4	39 31.5N 39 30.3N	15 4.7W 15 7.3W	RMT1M/1 RMT8M/1	470 - 565	0248-0347 NIGHT	FLOW DIST. 4.05 KM.	
11039 # 2	2/ 4	39 30.3N 39 30.3N	15 7.3W 15 10.6W	RMT1M/2 RMT8M/2	565 - 660	0347-0446 NIGHT	FLOW DIST. 4.05 KM.	
11039 # 3	2/ 4	39 30.3N 39 29.6N	15 10.6W 15 13.2W	RMT1M/3 RMT8M/3	660 - 775	0446-0544	FLOW DIST. 3.87 KM.	
11040 # 1	2/ 4	39 39.0N 39 39.2N	14 39.7W 14 42.5W	RMT1M/1 RMT8M/1	470 - 565	1034-1134 DAY	FLOW DIST. 3.64 KM.	
11040 # 2	2/ 4	39 39.2N 39 39.1N	14 42.5W 14 45.0W	RMT1M/2 RMT8M/2	565 - 660	1134-1234 DAY	FLOW DIST. 3.46 KM.	
11040 # 3	2/ 4	39 39.1N 39 38.8N	14 45.0W 14 47.5W	RMT1M/3 RMT8M/3	660 - 800	1234-1334 DAY	FLOW DIST. 3.60 KM.	
11041 # 1	2/ 4	39 38.5N 39 38.5N	14 48.6W 14 48.7W	CTD UFL TRANSM LMD	0 - 300	1427-1442 DAY	DOWN 1435	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11042	2/ 4	39 38.6N	14 49.8W	RMT1M/1	180- 280	1508-1608		
# 1		39 38.4N	14 52.7W	RMT8M/1		DAY	FLOW DIST. 3.78 KM.	
11042	2/ 4	39 38.4N	14 52.7W	RMT1M/2	280- 380	1608-1708		
# 2		39 38.2N	14 55.6W	RMT8M/2		DAY	FLOW DIST. 3.37 KM.	
11042	2/ 4	39 38.2N	14 55.6W	RMT1M/3	380- 480	1708-1812		
# 3		39 37.8N	14 58.8W	RMT8M/3		DAY	FLOW DIST. 4.31 KM.	
11043	2/ 4	39 37.6N	15 0.9W	CTD	0- 300	1903-1956		
# 1		39 37.2N	15 1.2W	MS		DUSK	DOWN 1921 - WB AT STANDARD DEPTHS	
				TRANSM				
				UFL				
				LMD				
11044	2/ 4	39 35.3N	14 49.2W	CTD	0- 600	2224-2249		
# 1		39 35.1N	14 49.4W	TRANSM		NIGHT	DOWN 2237	
				UFL				
11045	3/ 4	39 32.0N	14 56.5W	RMT1M/1	- 50	0149-0249		
# 1		39 30.6N	14 58.5W	RMT8M/1		NIGHT	FLOW DIST. 3.78 KM.	
11045	3/ 4	39 30.6N	14 58.5W	RMT1M/2	45- 100	0249-0349		
# 2		39 29.2N	15 0.3W	RMT8M/2		NIGHT	FLOW DIST. 3.87 KM.	
11045	3/ 4	39 29.2N	15 0.3W	RMT1M/3	100- 180	0349-0449		
# 3		39 27.8N	15 2.0W	RMT3M/3		NIGHT	FLOW DIST. 3.82 KM.	
11046	3/ 4	39 36.6N	14 50.9W	CTD	0- 300	0839-0912		
# 1		39 36.6N	14 51.0W	MS		DAY	DOWN 0852 - WB AT STANDARD DEPTHS	
				TRANSM				
				UFL				
				LMD				

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11046 # 2	3/ 4	39 36.5N 39 36.4N	14 50.9W 14 51.0W	CTD MS TRANSM UFL LMD	0- 100	0949-0959 DAY	DOWN 0955	
11046 # 3	3/ 4	39 36.5N 39 36.4N	14 51.0W 14 51.0W	WB30 PROD	5- 25	0930-1013 DAY	WB AT 5 AND 25M	
11047 # 1	3/ 4	39 36.1N 39 35.7N	14 51.3W 14 53.1W	RMT1M/1 RMT8M/1	0- 50	1043-1117 DAY	FLOW DIST. 2.13 KM.	
11047 # 2	3/ 4	39 35.7N 39 35.1N	14 53.1W 14 55.2W	RMT1M/2 RMT8M/2	50- 105	1117-1209 DAY	DIFFICULTY IN CLOSING NET FLOW DIST. 3.11 KM.	
11047 # 3	3/ 4	39 35.1N 39 33.3N	14 55.2W 14 59.4W	RMT1M/1 RMT8M/1	105- 180	1315-1416 DAY	FLOW DIST. 4.00 KM.	
11048 # 1	4/ 4	39 36.0N 39 35.9N	14 52.0W 14 52.2W	XX	0- 0	1703-1745 DAY	SPAR BUOY RECOVERY	
11049 # 1	7/ 4	45 38.2N 45 38.9N	13 53.4W 13 53.9W	XX	0- 0	0612-0734 DAWN	SPAR BUOY DEPLOYMENT	
11050 # 1	7/ 4	45 41.4N 45 39.8N	14 10.9W 14 3.8W	RMT1M/1 RMT8M/1	500- 600	2120-2221 NIGHT	FLOW DIST. 3.26 KM.	
11050 # 2	7/ 4	45 39.8N 45 38.3N	14 8.8W 14 6.3W	RMT1M/2 RMT8M/2	600- 700	2221-2320 NIGHT	FLOW DIST. 3.55 KM.	
11050 # 3	7/ 4 8/ 4	45 38.3N 45 36.7N	14 6.3W 14 4.8W	RMT1M/3 RMT8M/3	700- 800	2320-0020 NIGHT	FLOW DIST. 3.53 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11051 # 1	8/ 4	45 36.5N 45 35.9N	14 2.5W 14 0.7W	RMT1M/1 RMT8M/1	0- 50	0136-0236 NIGHT	FLOW DIST. 3.69 KM.	
11051 # 2	8/ 4	45 35.9N 45 34.6N	14 0.7W 13 58.4W	RMT1M/2 RMT8M/2	50- 112	0236-0336 NIGHT	UNCERTAIN WHEN NET CLOSED - SEE BIO LOG. FLOW DIST. 3.60 KM.	
11052 # 1	8/ 4	45 37.9N 45 38.1N	13 51.2W 13 50.9W	CTD MS TRANSM UFL LMD	0- 300	0738-0826 DAY	DOWN 0748 - WB AT STANDARD DEPTHS	
11053 # 1	8/ 4	45 35.1N 45 36.0N	13 51.7W 13 45.3W	CTD TRANSM UFL LMD	0- 300	0957-1915 DAY	CTD YO-YO	
11054 # 1	8/ 4 9/ 4	45 33.9N 45 39.9N	13 55.1W 13 43.1W	CTD TRANSM UFL LMD	0- 300	2044-0904 NIGHT	CTD YO-YO	
11055 # 1	10/ 4	45 37.6N 45 39.7N	13 59.9W 13 53.8W	RMT1M/1 RMT8M/1	200- 305	1200-1300 DAY	FLOW DIST. 4.11 KM.	
11055 # 2	10/ 4	45 39.7N 45 41.8N	13 58.8W 13 58.0W	RMT1M/2 RMT8M/2	305- 400	1300-1400 DAY	FLOW DIST. 3.73 KM.	
11055 # 3	10/ 4	45 41.8N 45 43.3N	13 58.0W 13 56.9W	RMT1M/3 RMT8M/3	400- 495	1400-1500 DAY	FLOW DIST. 3.73 KM.	
11056 # 1	10/ 4	45 45.4N 45 46.7N	13 55.7W 13 54.9W	RMT1M/1 RMT8M/1	0- 50	1548-1628 DAY	FLOW DIST. 2.58 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11056 # 2	10/ 4	45 46.7N 45 48.0N	13 54.9W 13 54.1W	RMT1M/2 RMT8M/2	50- 100	1628-1708 DAY	FLOW DIST. 2.51 KM.	
11056 # 3	10/ 4	45 48.0N 45 50.5N	13 54.1W 13 52.4W	RMT1M/3 RMT8M/3	0- 200	1708-1826 DAY	100-200M HAUL BUT NET NOT CLOSED TIL SURFACE FLOW DIST. 5.34 KM.	
11057 # 1	10/ 4	45 33.9N 45 38.0N	13 52.0W 13 48.7W	RMT1M/1 RMT8M/1	200- 300	2134-2234 NIGHT	FLOW DIST. 3.78 KM.	
11057 # 2	10/ 4	45 38.0N 45 37.2N	13 48.7W 13 45.4W	RMT1M/2 RMT8M/2	300- 400	2234-2334 NIGHT	FLOW DIST. 3.37 KM.	
11057 # 3	10/ 4 11/ 4	45 37.2N 45 36.7N	13 45.4W 13 42.6W	RMT1M/3 RMT8M/3	395- 500	2334-0034 NIGHT	FLOW DIST. 3.67 KM.	
11058 # 1	11/ 4	45 36.0N 45 35.4N	13 41.0W 13 38.7W	RMT1M/1 RMT8M/1	0- 50	0134-0234 NIGHT	FLOW DIST. 3.62 KM.	
11058 # 2	11/ 4	45 35.4N 45 34.9N	13 38.7W 13 36.4W	RMT1M/2 RMT8M/2	50- 100	0234-0334 NIGHT	FLOW DIST. 3.57 KM.	
11058 # 3	11/ 4	45 34.9N 45 34.3N	13 36.4W 13 34.1W	RMT1M/3 RMT8M/3	95- 200	0334-0434 NIGHT	FLOW DIST. 3.51 KM.	
11059 # 1	11/ 4	45 40.7N 45 41.0N	13 50.6W 13 50.4W	CTD MS TRANSM UFL LMD	0- 300	0656-0730 DAWN	DOWN 0708 - WB AT STANDARD DEPTHS	
11059 # 2	11/ 4	45 40.7N 45 41.0N	13 50.6W 13 50.4W	WB30 PROD	25- 25	0720-0730 DAWN	2 WB AT 25M	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11060 # 1	11/ 4	45 42.0N 45 42.2N	13 49.0W 13 49.0W	XX	0- 0	0852-0951 DAY	SPAR BUOY RECOVERY	
11061 # 1	11/ 4	45 46.4N 45 47.2N	13 33.2W 13 32.3W	CTD MS TRANSM	0-2000	1950-2139 DUSK	DOWN 2055 - WB AT STANDARD DEPTHS	
11062 # 1	11/ 4 12/ 4	45 54.0N 45 55.0N	13 35.8W 13 36.2W	CTD MS TRANSM	0-2000	2256-0017 NIGHT	DOWN 2333 - WB AT STANDARD DEPTHS	
11063 # 1	12/ 4	45 49.5N 45 50.2N	13 41.4W 13 40.2W	CTD MS TRANSM	0-2000	0145-0312 NIGHT	DOWN 0225 - WB AT STANDARD DEPTHS	
11064 # 1	12/ 4	45 51.0N 45 53.4N	13 39.8W 13 39.4W	RMT1M/1 RMT8M/1	0- 100	0345-0446 NIGHT	FLOW DIST. 3.98 KM.	
11064 # 2	12/ 4	45 53.4N 45 56.7N	13 39.4W 13 38.9W	RMT1M/2 RMT8M/2	100- 700	0446-0606 DAWN	OBLIQUE TOW FLOW DIST. 4.70 KM.	
11064 # 3	12/ 4	45 56.7N 45 58.3N	13 38.9W 13 39.0W	RMT1M/3 RMT8M/3	700-1000	0606-0656 DAWN	OBLIQUE TOW FLOW DIST. 3.14 KM.	
11065 # 1	13/ 4	44 1.2N 44 1.0N	14 9.2W 14 9.3W	CTD MS TRANSM	0-2000	0817-0947 DAY	DOWN 0852 - WB AT STANDARD DEPTHS	
11066 # 1	13/ 4	44 1.1N 43 58.9N	14 8.6W 14 8.6W	RMT1M/1 RMT8M/1	0- 100	1008-1108 DAY	FLOW DIST. 3.64 KM.	
11066 # 2	13/ 4	43 58.9N 43 55.4N	14 8.6W 14 9.3W	RMT1M/2 RMT8M/2	100- 700	1108-1228 DAY	OBLIQUE TOW FLOW DIST. 4.64 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11066 # 3	13/ 4	43 55.4N 43 53.4N	14 9.3W 14 9.5W	RMT1M/3 RMT8M/3	700-1000	1228-1313 DAY	OBLIQUE TOW FLOW DIST. 2.87 KM.	
11067 # 1	13/ 4	43 51.9N 43 52.1N	14 10.3W 14 10.7W	CTD MS TRANSM	0-2000	1415-1543 DAY	DOWN AT 1455 - WB AT STANDARD DEPTHS	
11068 # 1	14/ 4	42 30.3N 42 30.9N	14 30.1W 14 30.9W	CTD MS TRANSM	0-2000	0109-0247 NIGHT	DOWN AT 0144 - WB AT STANDARD DEPTHS	
11069 # 1	14/ 4	42 30.7N 42 29.2N	14 31.5W 14 33.9W	RMT1M/1 RMT8M/1	5- 100	0309-0409 NIGHT	FLOW DIST. 3.73 KM.	
11069 # 2	14/ 4	42 29.2N 42 27.7N	14 33.9W 14 35.3W	RMT1M/2 RMT8M/2	100- 600	0409-0505 NIGHT	OBLIQUE TOW FLOW DIST. 2.99 KM.	
11069 # 3	14/ 4	42 27.7N 42 25.9N	14 35.3W 14 38.8W	RMT1M/3 RMT8M/3	600-1000	0505-0606 NIGHT	OBLIQUE TOW FLOW DIST. 3.91 KM.	
11070 # 1	14/ 4	40 59.5N 40 59.0N	14 51.6W 14 52.5W	CTD MS TRANSM	0-2000	1535-1714 DAY	DOWN 1611 - WB AT STANDARD DEPTHS	
11071 # 1	14/ 4	40 59.2N 40 57.0N	14 52.9W 14 53.1W	RMT1M/1 RMT8M/1	0- 100	1758-1858 DAY	FLOW DIST. 4.05 KM.	
11071 # 2	14/ 4	40 57.0N 40 54.5N	14 53.1W 14 53.0W	RMT1M/2 RMT8M/2	100- 600	1858-2002 DUSK	OBLIQUE TOW FLOW DIST. 3.93 KM.	
11071 # 3	14/ 4	40 54.5N 40 51.9N	14 53.0W 14 52.9W	RMT1M/3 RMT8M/3	600-1000	2002-2110 NIGHT	OBLIQUE TOW FLOW DIST. 4.20 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11072 # 1	15/ 4 14/ 4	40 15.6N 40 15.7N	15 0.3W 15 0.9W	CTD MS TRANSM UFL LMD	0- 300	1429-1515 DAY	DOWN 1444 - WB AT STANDARD DEPTHS	
11073 # 1	15/ 4	39 30.0N 39 30.6N	14 59.2W 14 59.6W	CTD MS TRANSM	0-2000	2133-2326 NIGHT	DOWN 2220 - WB AT STANDARD DEPTHS NET MONITOR TEST	
11074 # 1	15/ 4 15/ 4	39 31.2N 39 32.6N	14 59.2W 14 56.6W	RMT1M/1 RMT8M/1	0- 100	2352-0052 NIGHT	FLOW DIST. 3.75 KM.	
11074 # 2	15/ 4	39 32.6N 39 34.2N	14 56.6W 14 53.9W	RMT1M/2 RMT8M/2	100- 600	0052-0155 NIGHT	OBLIQUE TOW FLOW DIST. 3.41 KM.	
11074 # 3	15/ 4	39 34.2N 39 35.1N	14 54.0W 14 52.6W	RMT1M/3 RMT8M/3	600-1000	0155-0232 NIGHT	OBLIQUE TOW FLOW DIST. 1.79 KM.	
11075 # 1	16/ 4	39 39.3N 39 38.6N	14 43.0W 14 47.9W	CTD MS TRANSM	0-2000	0401-0526 NIGHT	DOWN 0433 - WB AT STANDARD DEPTHS	
11076 # 1	16/ 4	39 27.2N 39 27.4N	14 45.1W 14 45.5W	CTD MS TRANSM	0-2000	0659-0827 DAWN	DOWN 0733 - WB AT STANDARD DEPTHS	
11077 # 1	16/ 4	39 30.5N 39 30.5N	14 57.8W 14 57.9W	XX	0- 0	1116-1226 DAY	SPAR BUOY DEPLOYMENT	
11078 # 1	17/ 4	39 51.3N 39 51.4N	15 3.4W 15 5.4W	RMT1M/1 RMT8M/1	500- 605	2124-2224 NIGHT	FLOW DIST. 3.78 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11078 # 2	17/ 4	39 31.4N 39 31.3N	15 5.4W 15 2.2W	RMT1M/2 RMT8M/2	605- 695	2224-2324 NIGHT	FLOW DIST. 3.48 KM.	
11078 # 3	17/ 4 18/ 4	39 31.3N 39 31.5N	15 2.2W 14 59.5W	RMT1M/3 RMT8M/3	695- 795	2324-0024 NIGHT	FLOW DIST. 3.78 KM.	
11079 # 1	18/ 4	39 31.6N 39 31.9N	14 57.0W 14 54.2W	RMT1M/1 RMT8M/1	200- 300	0133-0233 NIGHT	FLOW DIST. 3.42 KM.	
11079 # 2	18/ 4	39 31.9N 39 32.1N	14 54.2W 14 51.4W	RMT1M/2 RMT8M/2	300- 400	0233-0333 NIGHT	FLOW DIST. 3.57 KM.	
11079 # 3	18/ 4	39 32.1N 39 32.4N	14 51.4W 14 48.4W	RMT1M/3 RMT8M/3	400- 495	0333-0433 NIGHT	FLOW DIST. 3.89 KM.	
11080 # 1	18/ 4	39 34.9N 39 34.9N	14 58.8W 14 58.7W	CTD MS TRANSM UFL LMD	0- 300	0725-0801 DAY	DOWN 0732 - WB AT STANDARD DEPTHS	
11080 # 2	18/ 4	39 34.9N 39 34.9N	14 58.7W 14 58.7W	WB30 PROD	40- 40	0750-0800 DAY	WBS AT 40M	
11081 # 1	18/ 4	39 37.7N 39 39.8N	14 59.0W 14 59.1W	RMT1M/1 RMT8M/1	800- 905	0930-1030 DAY	FLOW DIST. 3.62 KM.	
11081 # 2	18/ 4	39 39.8N 39 42.0N	14 59.1W 14 59.0W	RMT1M/2 RMT8M/2	900-1000	1030-1130 DAY	FLOW DIST. 3.46 KM.	
11081 # 3	18/ 4	39 42.0N 39 44.3N	14 59.0W 14 59.1W	RMT1M/3 RMT8M/3	1000-1100	1130-1230 DAY	FLOW DIST. 3.48 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11082 # 1	18/ 4	39 45.6N 39 45.7N	14 59.5W 14 59.5W	CTD TRANSM UFL LMD	0- 300	1329-1421 DAY	CTD YO-YO	
11083 # 1	18/ 4	39 44.7N 39 42.2N	14 59.8W 15 0.4W	RMT1M/1 RMT8M/1	500- 600	1500-1602 DAY	FLOW DIST. 3.80 KM.	
11083 # 2	18/ 4	39 42.2N 39 40.3N	15 0.4W 15 0.8W	RMT1M/2 RMT8M/2	600- 700	1602-1702 DAY	FLOW DIST. 3.35 KM.	
11083 # 3	18/ 4	39 40.3N 39 38.2N	15 0.8W 15 1.2W	RMT1M/3 RMT8M/3	700- 800	1702-1802 DAY	FLOW DIST. 3.66 KM.	
11084 # 1	18/ 4	39 36.6N 39 36.7N	15 1.2W 15 1.2W	CTD MS TRANSM UFL LMD	0- 300	1916-2004 DUSK	DOWN 1931 - WB AT STANDARD DEPTHS	
11085 # 1	18/ 4	39 39.1N 39 40.9N	15 3.0W 15 4.9W	RMT1M/1 RMT8M/1	800- 900	2118-2218 NIGHT	FLOW DIST. 3.70 KM.	
11085 # 2	18/ 4	39 40.9N 39 42.6N	15 4.9W 15 6.7W	RMT1M/2 RMT8M/2	900-1000	2218-2318 NIGHT	FLOW DIST. 3.60 KM.	
11085 # 3	18/ 4 19/ 4	39 42.6N 39 44.5N	15 6.7W 15 8.6W	RMT1M/3 RMT8M/3	1000-1100	2318-0018 NIGHT	FLOW DIST. 3.50 KM.	
11086 # 1	19/ 4	39 46.3N 39 45.0N	15 10.0W 15 8.4W	RMT1M/1 RMT8M/1	0- 50	0129-0229 NIGHT	FLOW DIST. 3.35 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11086 # 2	19/ 4	39 45.0N 39 43.5N	15 5.4W 15 6.6W	RMT1M/2 RMT8M/2	50- 100	0229-0329 NIGHT	FLOW DIST. 3.87 KM.	
11086 # 3	19/ 4	39 43.5N 39 42.1N	15 6.6W 15 4.9W	RMT1M/3 RMT8M/3	100- 200	0329-0429 NIGHT	FLOW DIST. 3.36 KM.	
11087 # 1	19/ 4	39 41.5N 39 41.6N	15 4.5W 15 4.5W	CTD TRANSM UFL LMD	0- 300	0505-0558 NIGHT	CTD YO-YO	
11088 # 1	19/ 4	39 39.0N 39 40.9N	14 59.0W 14 57.5W	RMT1M/1 RMT8M/1	200- 300	0740-0840 DAY	FLOW DIST. 3.66 KM.	
11088 # 2	19/ 4	39 40.9N 39 42.6N	14 57.5W 14 56.4W	RMT1M/2 RMT8M/2	300- 400	0840-0940 DAY	FLOW DIST. 3.66 KM.	
11088 # 3	19/ 4	39 42.6N 39 44.2N	14 56.4W 14 55.1W	RMT1M/3 RMT8M/3	400- 500	0940-1040 DAY	FLOW DIST. 3.24 KM.	
11089 # 1	19/ 4	39 43.6N 39 43.4N	15 14.0W 15 12.7W	RMT1M/1 RMT8M/1	50- 100	2204-2234 NIGHT	FLOW DIST. 1.78 KM.	
11089 # 2	19/ 4	39 43.9N 39 43.1N	15 12.7W 15 11.5W	RMT1M/2 RMT8M/2	50- 100	2234-2304 NIGHT	FLOW DIST. 1.78 KM.	
11089 # 3	19/ 4	39 43.0N 39 42.7N	15 11.5W 15 10.3W	RMT1M/3 RMT8M/3	50- 100	2304-2334 NIGHT	FLOW DIST. 1.78 KM.	
11090 # 1	20/ 4	39 42.2N 39 41.7N	15 8.6W 15 7.3W	RMT1M/1 RMT8M/1	50- 100	0019-0049 NIGHT	FLOW DIST. 1.93 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11090 # 2	20/ 4	39 41.7N 39 41.3N	15 7.3W 15 6.0W	RMT1M/2 RMT8M/2	50- 100	0049-0120 NIGHT	FLOW DIST. 2.04 KM.	
11090 # 3	20/ 4	39 41.3N 39 40.9N	15 6.0W 15 4.6W	RMT1M/3 RMT8M/3	50- 100	0120-0150 NIGHT	FLOW DIST. 2.00 KM.	
11091 # 1	20/ 4	39 40.7N 39 40.9N	15 4.0W 15 3.8W	CTD MS TRANSM UFL LMD	0- 300	0218-0245 NIGHT	CABLE FAULT - STATION ABANDONED	
11092 # 1	20/ 4	39 40.7N 39 40.3N	15 2.9W 15 1.3W	RMT1M/1 RMT8M/1	50- 100	0333-0403 NIGHT	FLOW DIST. 1.76 KM.	
11092 # 2	20/ 4	39 40.3N 39 39.9N	15 1.3W 15 0.2W	RMT1M/2 RMT8M/2	50- 100	0403-0433 NIGHT	FLOW DIST. 1.84 KM.	
11092 # 3	20/ 4	39 39.9N 39 39.5N	15 0.2W 14 59.1W	RMT1M/3 RMT8M/3	50- 100	0433-0503 NIGHT	FLOW DIST. 1.75 KM.	
11093 # 1	20/ 4	39 42.8N 39 43.2N	15 2.9W 15 2.6W	CTD MS TRANSM UFL LMD	0- 300	0806-0856 DAY	DOWN 0830 - WB AT STANDARD DEPTHS	
11093 # 2	20/ 4	39 43.0N 39 43.1N	15 2.9W 15 2.7W	WB30 PROD	10- 40	0820-0845 DAY	WB AT 10 and 40M.	
11094 # 1	20/ 4	39 43.3N 39 44.9N	15 2.4W 15 2.4W	RMT1M/1 RMT8M/1	0- 50	0915-0945 DAY	FLOW DIST. 1.91 KM.	

STN.	DATE 1984	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS	SOUNDING(M)
11094 # 2	20/ 4	39 44.9N 39 46.1N	15 2.4W 15 2.5W	RMT1M/2 RMT8M/2	50- 100	0945-1015 DAY	FLOW DIST. 1.98 KM.	
11094 # 3	20/ 4	39 46.1N 39 43.3N	15 2.5W 15 3.3W	RMT1M/3 RMT8M/3	100- 200	1015-1115 DAY	FLOW DIST. 3.93 KM.	
11095 # 1	20/ 4	39 46.3N 39 41.9N	15 2.0W 15 1.7W	RMT1M/1 RMT8M/1	1100-1215	1258-1505 DAY	FLOW DIST. 7.35 KM.	
11095 # 2	20/ 4	39 41.9N 39 37.3N	15 1.7W 15 1.4W	RMT1M/2 RMT8M/2	1203-1298	1505-1705 DAY	FLOW DIST. 7.35 KM.	
11095 # 3	20/ 4	39 37.3N 39 33.7N	15 1.4W 15 1.1W	RMT1M/3 RMT8M/3	1298-1403	1705-1905 DAY	FLOW DIST. 7.30 KM.	
11096 # 1	20/ 4 21/ 4	39 47.3N 39 43.8N	14 56.3W 14 51.1W	RMT1M/1 RMT8M/1	1400-1500	2342-0142 NIGHT	FLOW DIST. 7.80 KM.	
11096 # 2	21/ 4	39 48.3N 39 50.6N	14 51.1W 14 45.6W	RMT1M/2 RMT8M/2	1500-1600	0142-0342 NIGHT	FLOW DIST. 7.50 KM.	
11096 # 3	21/ 4	39 50.6N 39 52.4N	14 45.6W 14 39.9W	RMT1M/3 RMT8M/3	1595-1800	0342-0542 NIGHT	FLOW DIST. 8.18 KM.	

Figure 1. Track plot for Discovery Cruise 146.

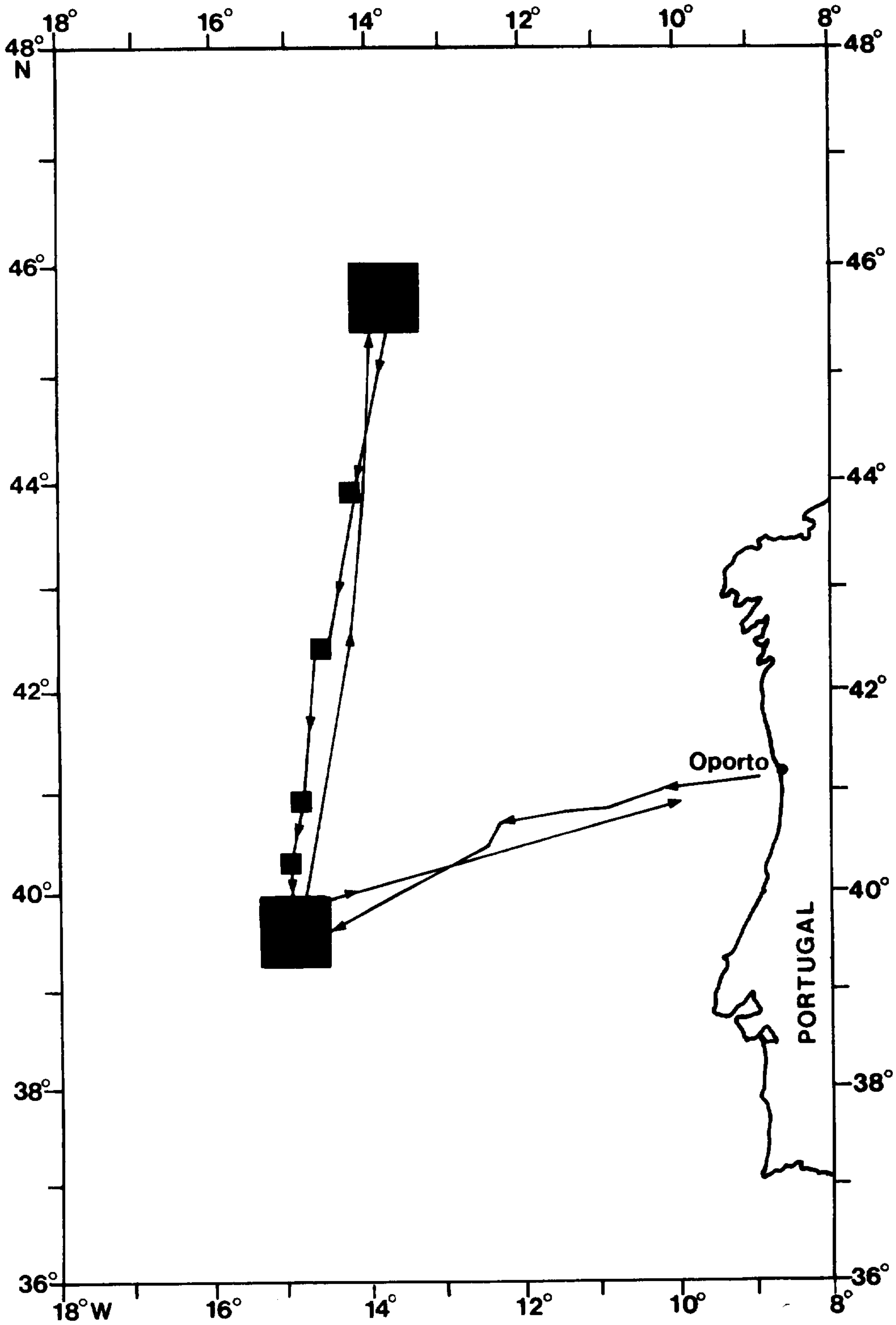

18°
16°
14°
12°
10°
8°
48°
N
46°
44°
42°
40°
38°
36°
Oporto
PORTUGAL
18° W

Figure 2a. Plan of SeaSoar surveys 1 and 2 at southern site.

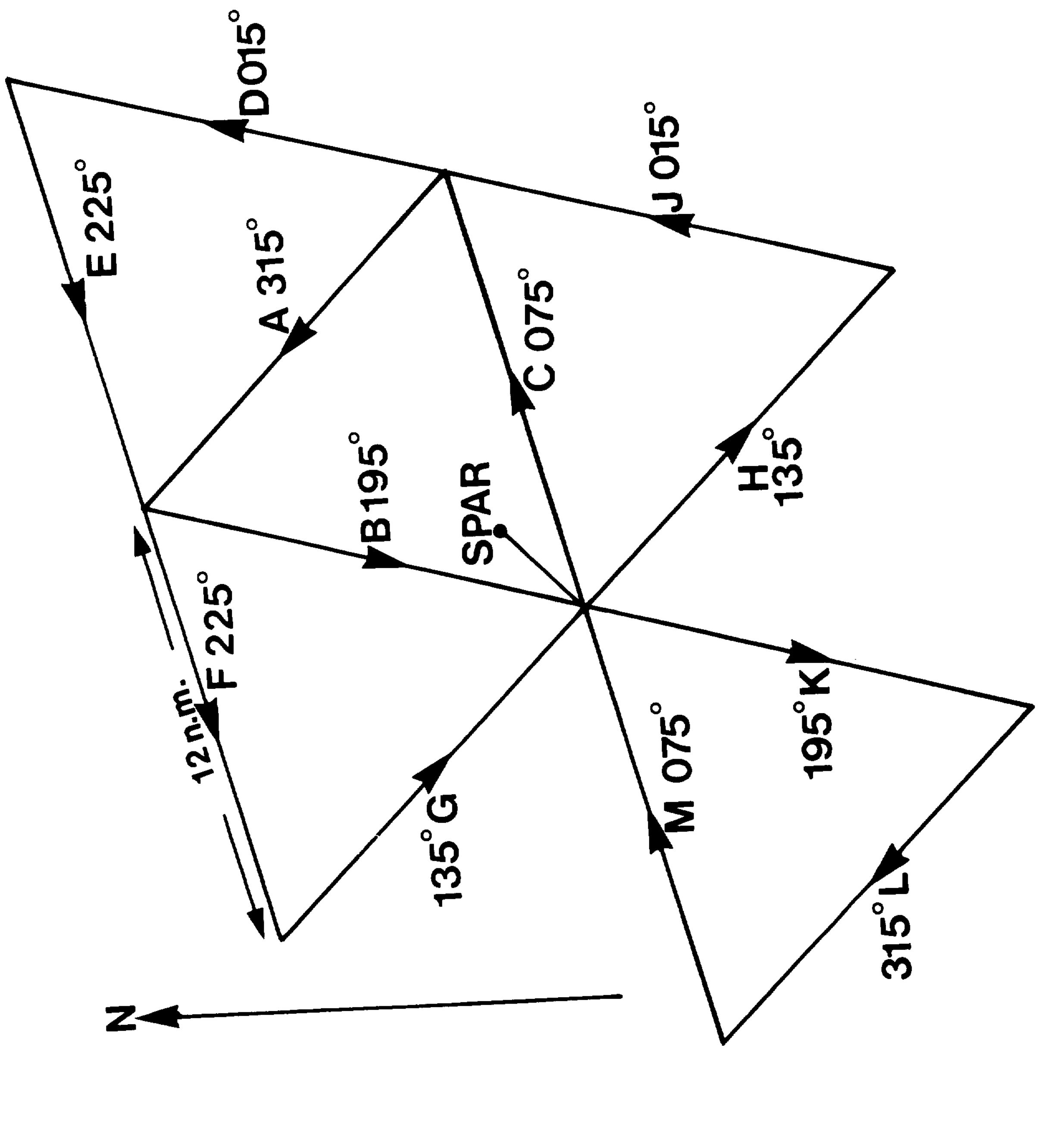

D015°
E 225°
J 015°
A 315°
C 075°
B195°
SPAR
H
135°
F 225°
12 n.m.
135° G
M 075°
195° K
315° L
N

Figure 2b. Track plot of SeaSoar surveys at northern site.

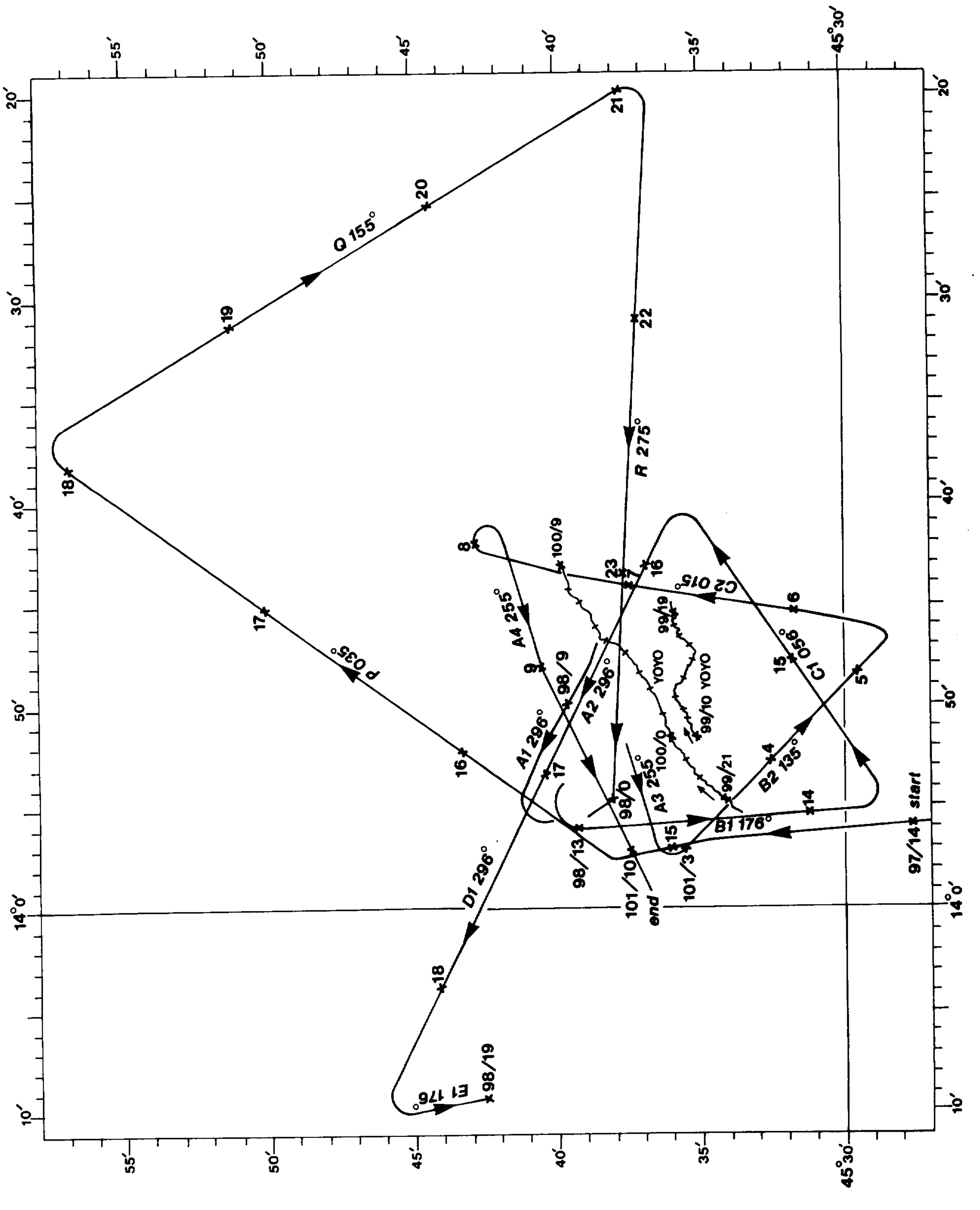

Q 155°
R 275°
P 035°
A1 296°
A2 296°
A3 255°
A4 255°
B1 176°
B2 135°
C1 056°
C2 015°
D1 296°
E1 176°
YOYO
start
end
97/14
98/13
98/9
98/0
98/19
100/9
100/0
99/19
99/10
99/21
101/10
101/3
14°0'
45°30'

Figure 2c. Plan of SeaSoar surveys 3 and 4 at southern site.

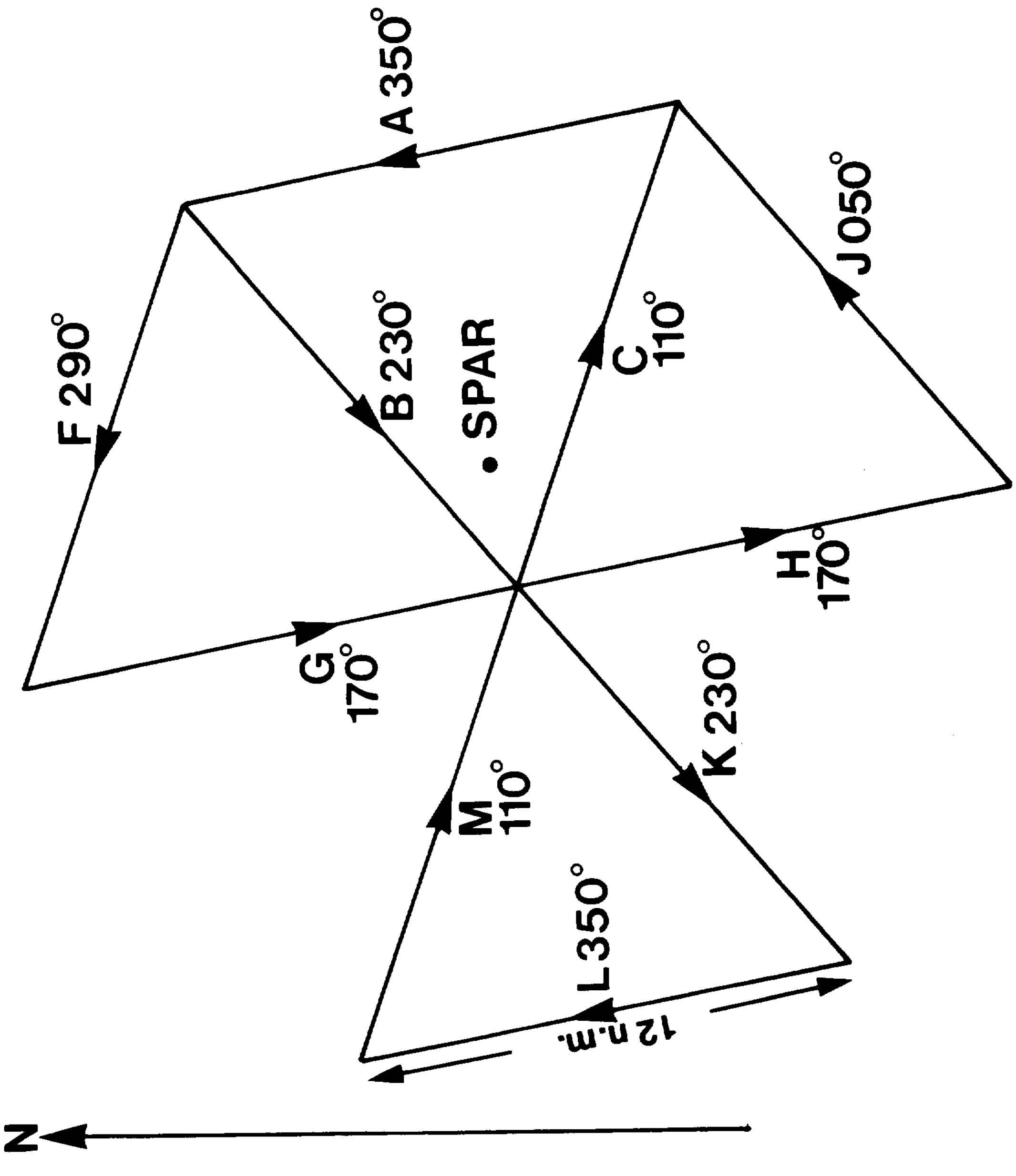

A 350°
F 290°
B 230°
SPAR
C 110°
J 050°
G 170°
H 170°
K 230°
M 110°
L 350°
12 n.m.
N

Figure 2d. Track plot of SeaSoar Survey 5 at southern site.

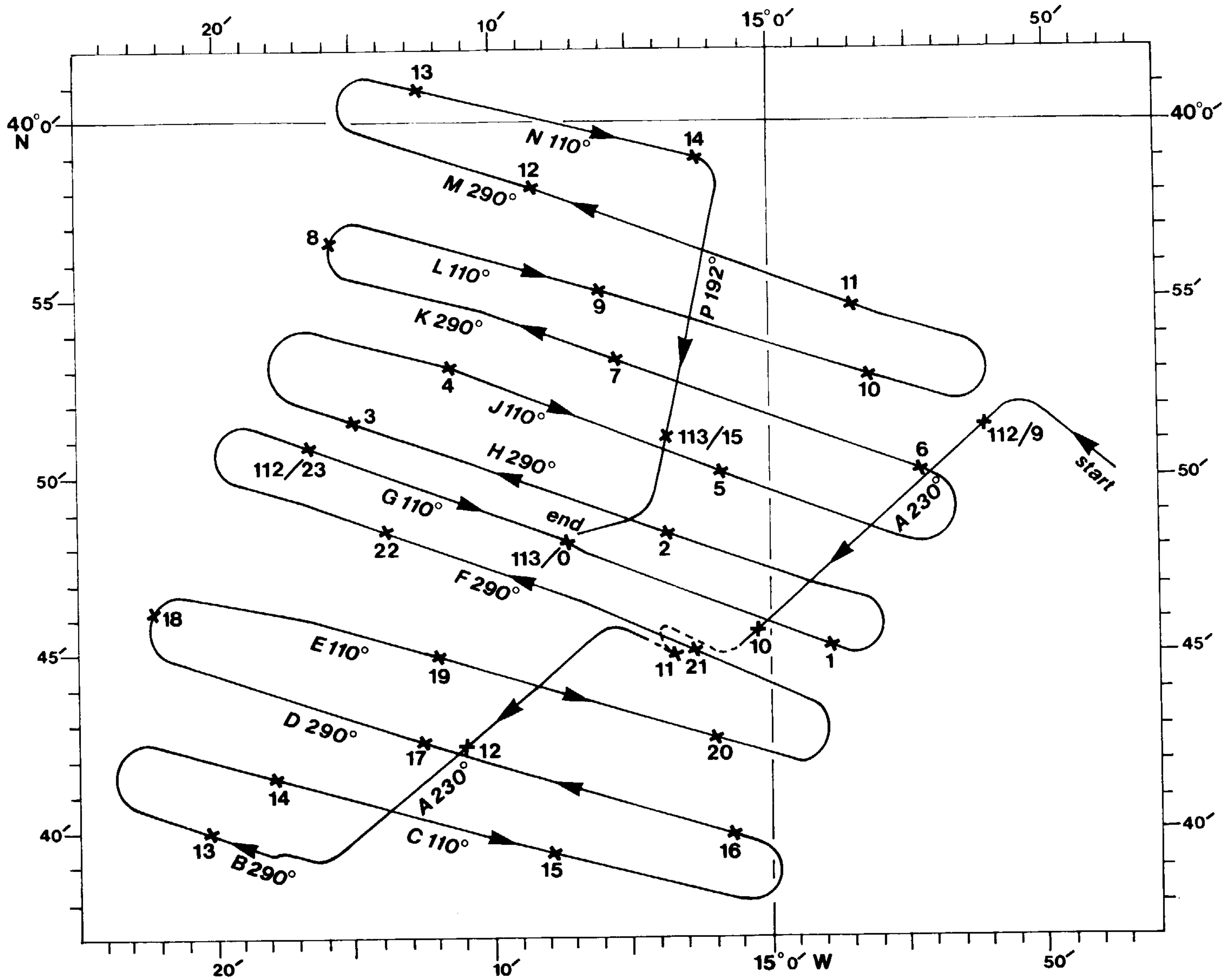
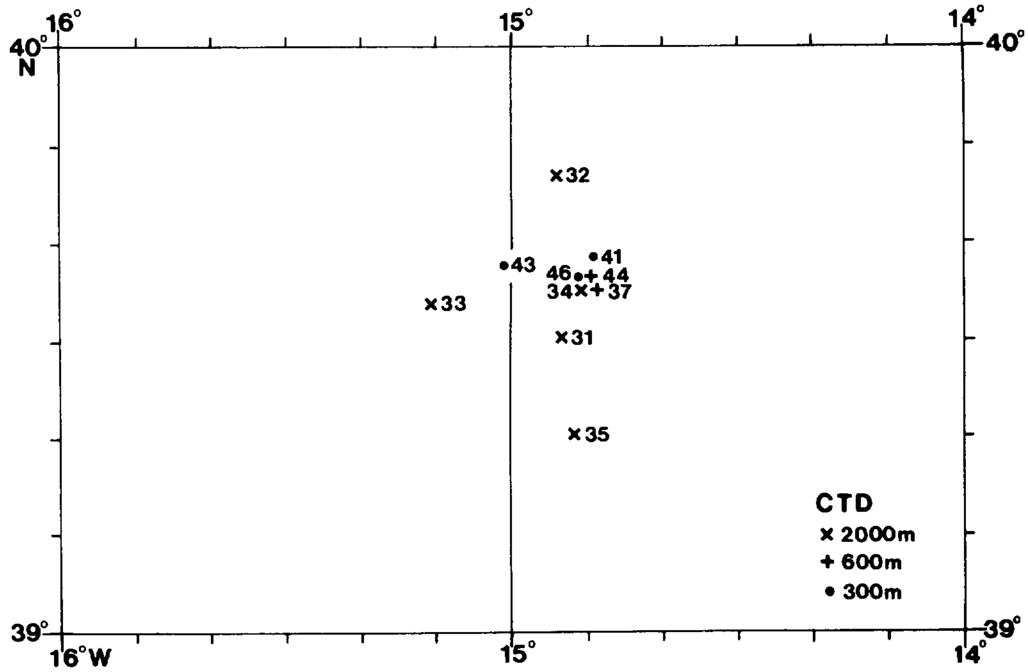
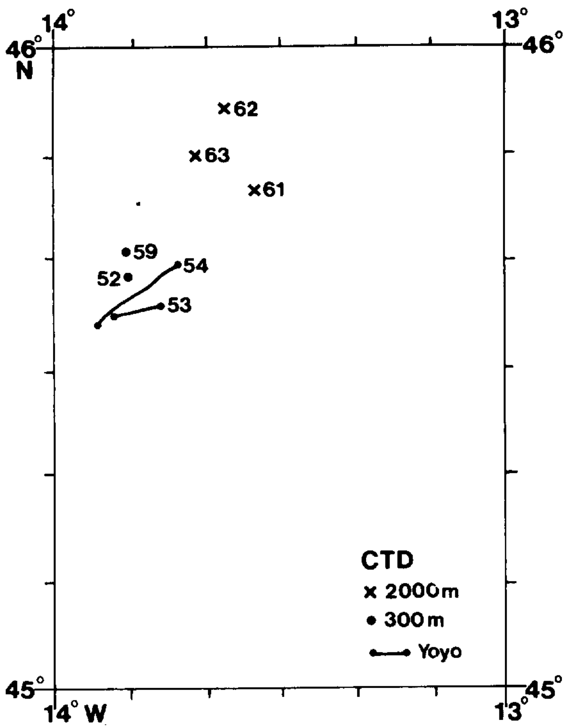

start
112/9
A 230°
6
10
1
11
21
113/15
5
2
end
113/0
112/23
3
4
7
8
9
12
13
14
N 110°
M 290°
L 110°
K 290°
J 110°
H 290°
G 110°
F 290°
E 110°
D 290°
C 110°
B 290°
P 192°
22
18
19
20
17
16
15
40°0′
N
55′
50′
45′
40′
20′
10′
15°0′
15°0′ W

Figure 3. CTD positions at southern site first visit (top), northern site (lower left), and southern site second visit (lower right).


16°
15°
14°
40° N
40°
×32
•43
•41
46•+44
34×+37
×33
×31
×35
CTD
× 2000m
+ 600m
• 300m
39°
16°W
15°
14°
39°


14°
13°
46° N
46°
×62
×63
×61
•59
52•
54
53
CTD
× 2000m
• 300m
Yoyo
45°
14° W
13°
45°

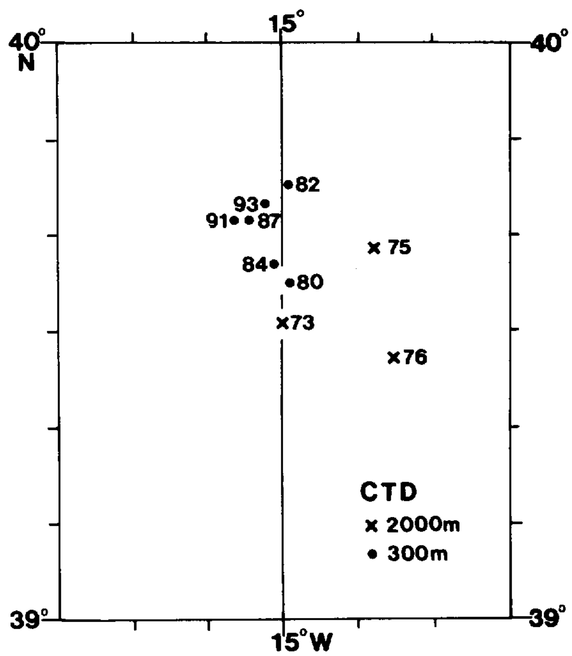

15°
40° N
40°
•82
93•
91• •87
× 75
84•
•80
×73
×76
CTD
× 2000m
• 300m
39°
15°W
39°

Figure 4. Time series of unedited surface meteorological data.

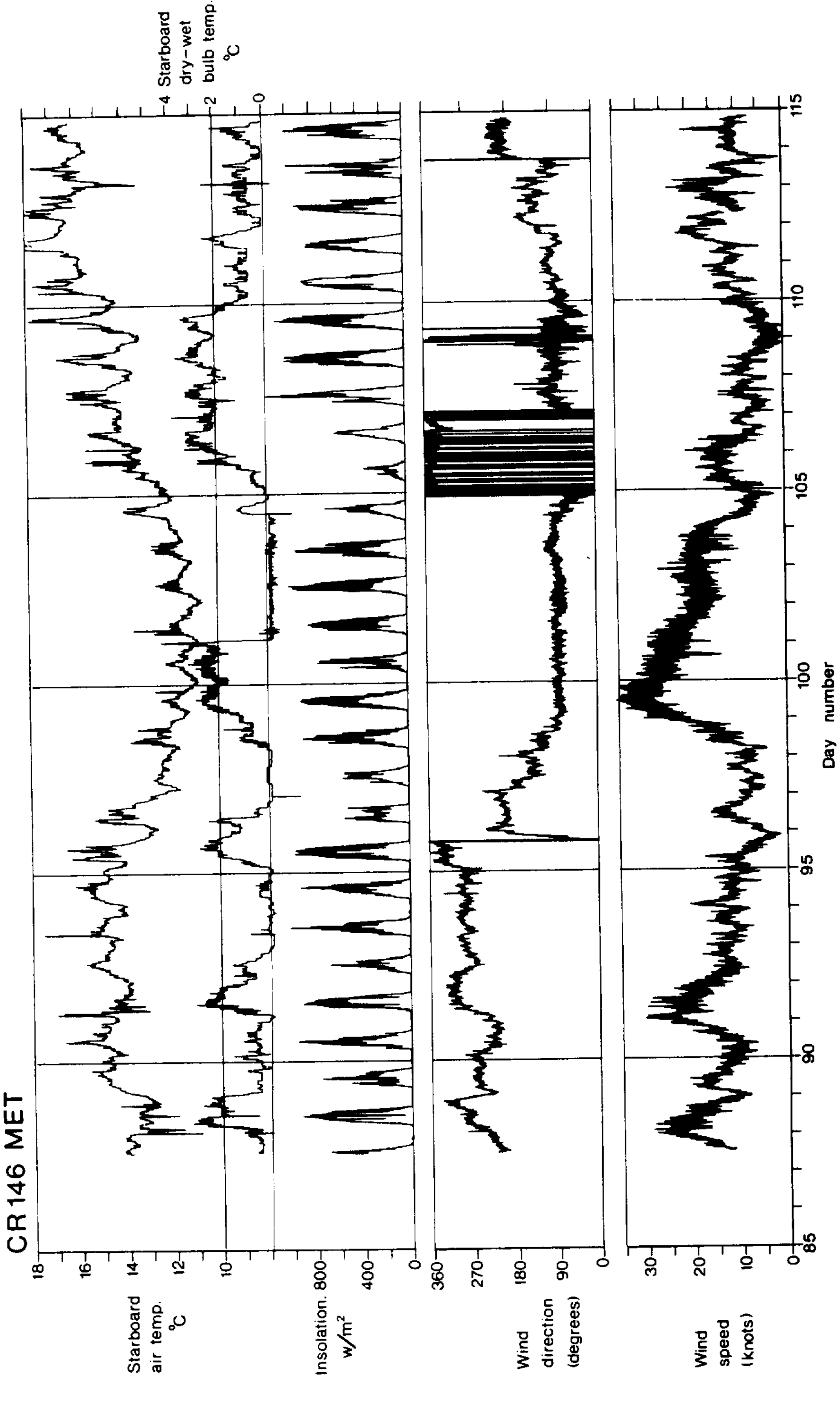
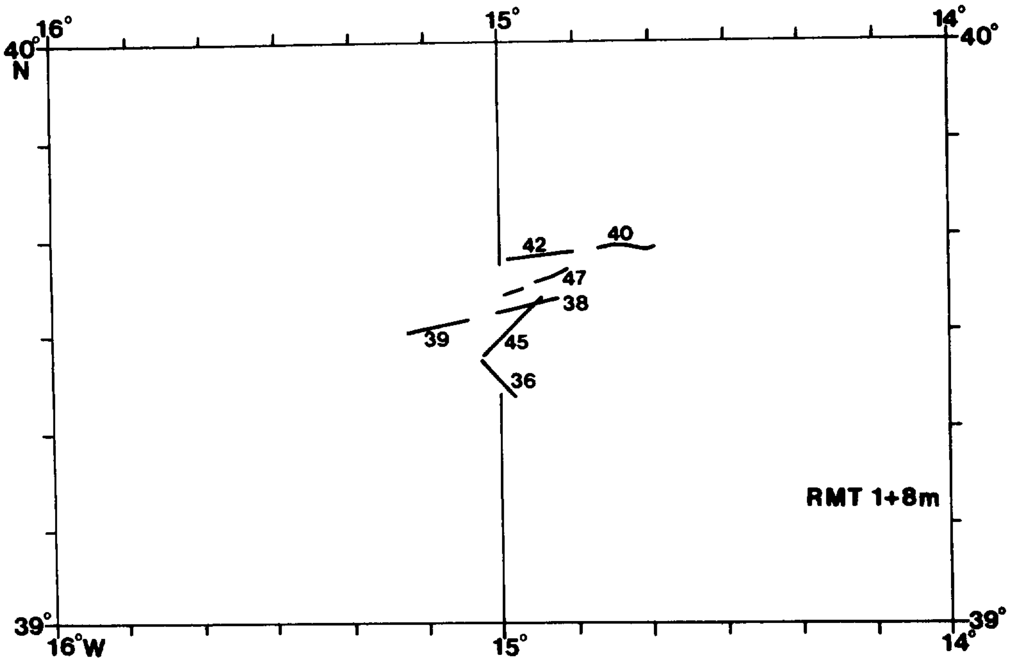

CR146 MET
Starboard air temp. °C
Starboard dry-wet bulb temp. °C
Insolation. w/m²
Wind direction (degrees)
Wind speed (Knots)
Day number
18
16
14
12
10
4
2
0
800
400
0
360
270
180
90
0
30
20
10
0
85
90
95
100
105
110
115

Figure 5a. Station positions for RMT1+8M trawls at southern site first visit (top) and northern site (lower).


16°
15°
14°
40°
N
40°
42
40
47
38
39
45
36
RMT 1+8m
39°
16°W
15°
14°
39°

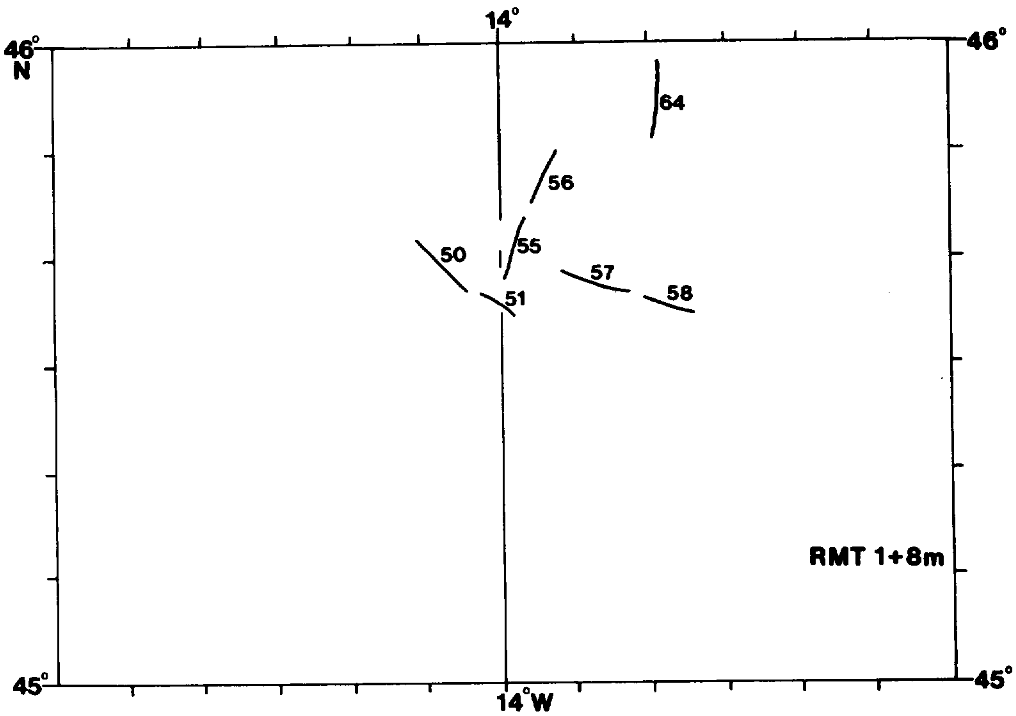
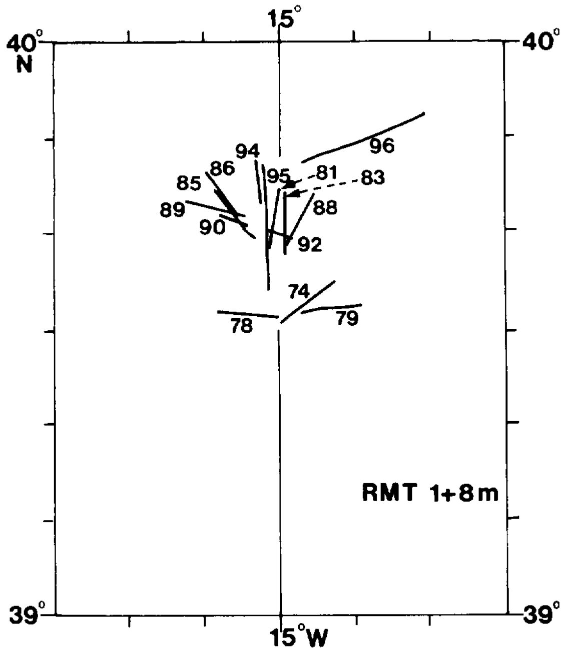
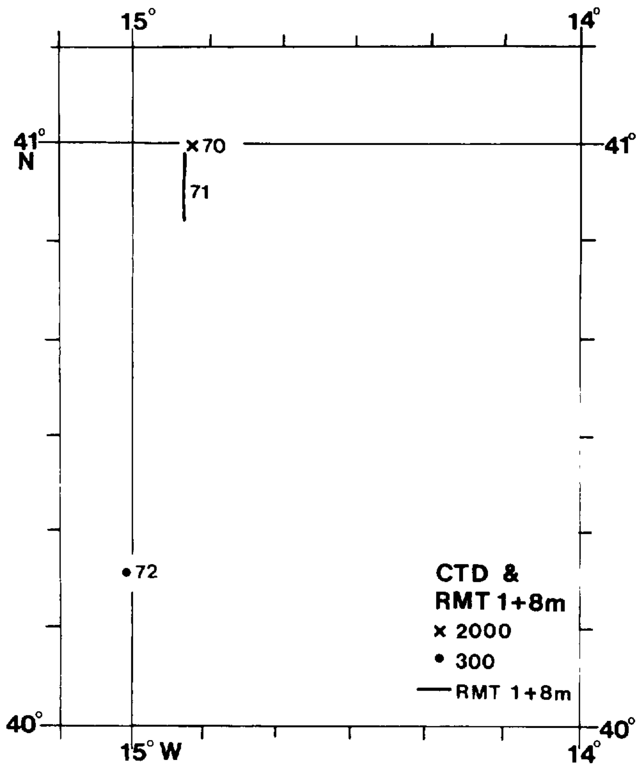
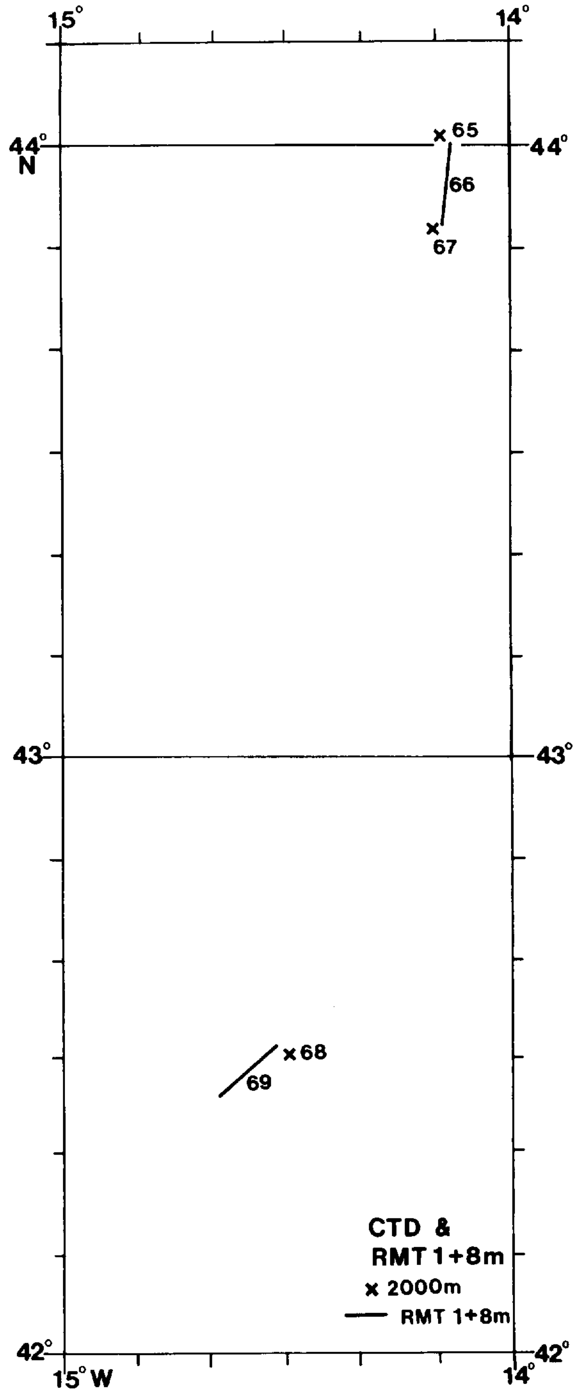

14°
46°
N
46°
64
56
50
55
57
51
58
RMT 1+8m
45°
14°W
45°

Figure 5b. Station positions for RMT1+8M trawls at southern site second visit (top left) and for CTD's and RMT1+8M on the north-south leg northern section (right), and southern section (lower left).


15°
40°
N
40°
94
96
86
95
81
83
85
89
88
90
92
74
78
79
RMT 1+8m
39°
39°
15°W


15°
14°
41°
N
×70
41°
71
•72
CTD &
RMT 1+8m
× 2000
• 300
RMT 1+8m
40°
40°
15° W
14°


15°
14°
44°
N
×65
44°
66
×
67
43°
43°
×68
69
CTD &
RMT 1+8m
× 2000m
RMT 1+8m
42°
42°
15° W
14°