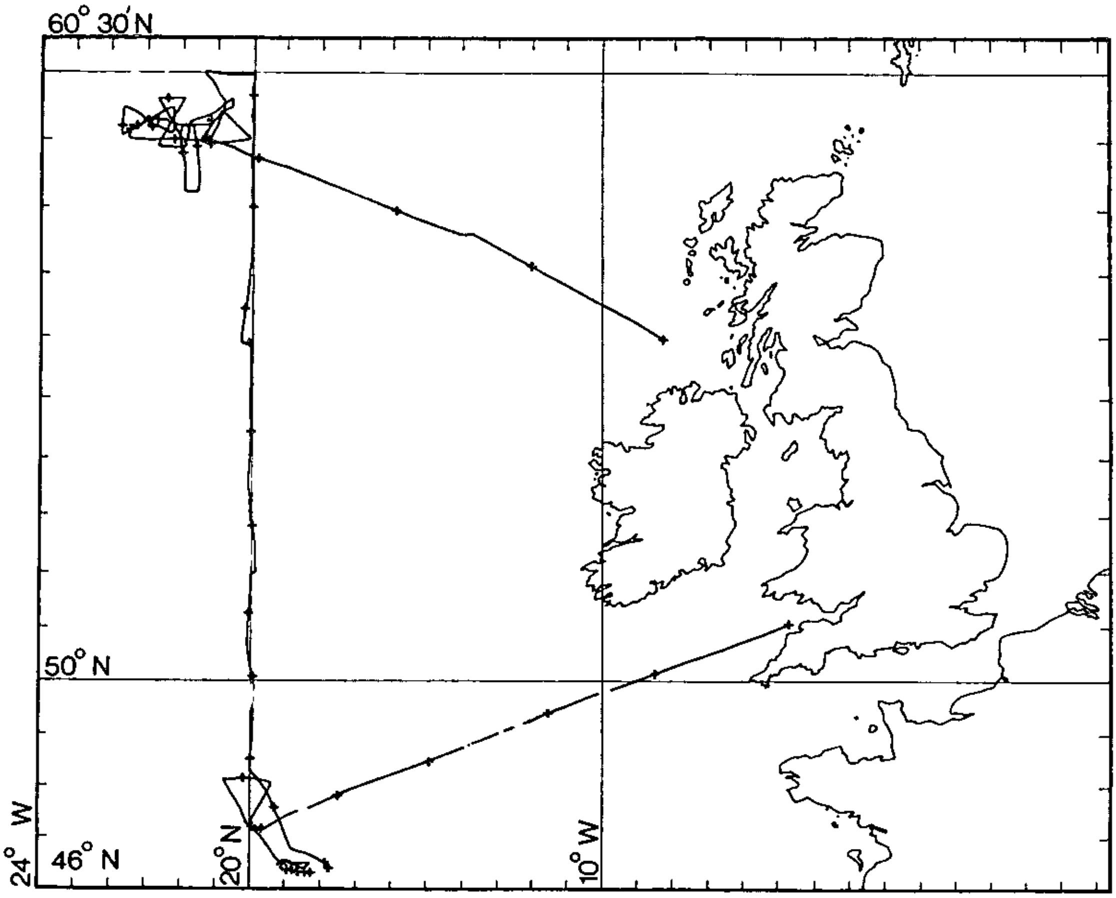
Institute of
Oceanographic Sciences
Deacon Laboratory

RRS Discovery Cruise 182

8 May - 8 Jun 1989

BOFS Cruise Leg 1: Investigations in the region of 47°N, 20°W and 60°N, 20°W

Cruise Report No 213 1990



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CRUISE REPORT NO. 213

RRS DISCOVERY

Cruise 182

8 May - 8 Jun 1989

BOFS Cruise Leg 1:

Investigations in the region of 47°N, 20°W and 60°N, 20°W

Principal Scientist

M.J.R. Fasham

1990

DOCUMENT DATA SHEET

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ABSTRACT

This report describes the scientific activities carried out on *Discovery* Cruise 182, the first cruise of the Biogeochemical Ocean Flux Study (BOFS). The aim of the cruise was to study the role of biological populations in the uptake of carbon dioxide from the atmosphere at two stations, 47°N 20°W and 60°N 20°W. At the southerly station cooperative work and intercalibrations were carried out with American and German research ships.

Key measurements made on the cruise were the partial pressure of carbon dioxide, total carbon dioxide, phytoplankton chlorophyll distribution and primary production, bacterial production, nutrients and hydrographic structure. An important result was the observation of a close correlation between carbon dioxide concentrations and phytoplankton chlorophyll distribution over space scales of few tens of kilometres.

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MOSS, S.	Chief Engineer
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HARRISON, M.	Bosun

ITINERARY

Depart Barry 8 May - Arrive Troon 8 June 1989

OBJECTIVES

a) To undertake semi-synoptic measurements of pO_2 and pCO_2 in surface water.

b) To study the vertical distribution of $T\text{-}CO_2$, $A\text{-}CO_2$ and pCO_2, oxygen and nitrate in order to estimate the flux of these compounds in and out of the euphotic zone.

c) To measure the size distribution of phytoplankton at BOFS study sites and, in conjunction with zooplanktologists, to determine whether the predominant flow of carbon is through the microbial food web (microbial loop) or through the metazoan zooplankton.

d) To determine the production of biomass by phytoplankton cells of different size through the euphotic zone.

e) To study the spatial distribution of biological and chemical properties of the euphotic zone and their relationship with physical structure.

NARRATIVE*

The ship sailed from Barry on 20:00 on the 8th May 1989, two days later than scheduled, the delay being caused by the time required to fit the ship out for the many new scientific requirements of the first BOFS cruise. The departure was filmed by a camera crew from TV-AM which, together with interviews obtained on the previous Friday and a live interview with the PSO direct from the ship, was part of a news feature put out on Tuesday morning. This was the just the beginning of considerable media interest in the cruise and BOFS. During the cruise radio interviews were given to BBC Wales, BBC Science on Four, SKY TV, Radio Ulster, and the Western Morning News.

A course was set for the position of a Bathysnap that had been deployed on cruise 175 (station 11794#115, position: 47°11'N, 19°39'W) with a view to recovering it before commencing the sampling programme.

*There is a list of abbreviations and acronyms used throughout this report on page 43.

On the 9th and 10th of May a number of gear trials were carried out. A successful trial dip of the CTD was made but software problems with the CTD logging into the level A computer were encountered. These problems took some days to resolve but were eventually tracked down and most of the CTD data was recovered satisfactorily. The pipework for supplying seawater to the various sensors (TCO_2, pCO_2, pH, oxygen and chlorophyll fluorescence measured by a Turner Designs Fluorometer) in the biological laboratory was installed and connected to an overside pump fixed to a pole midships on the starboard side, via a reservoir for removing bubbles. A successful test of this system was made on the afternoon of the 10th, but the pole had to be brought in later as it could not take the strains imposed by ship speeds in excess of 11 knots

On the 10th there was the first overflight by the NASA P3 aircraft at 12:00 and the UOR was streamed to provide coincident optical and chlorophyll fluorescence data. Unfortunately a technical fault prevented the UOR from undulating and so it was towed at 10m depth. On this and all subsequent P3 flights surface phycoerythrin and chlorophyll samples were taken by Mike Wyman to provide sea truth for the P3 sensors. Details of all the UOR tows are given in Table 2.

We arrived at the nominal position of the Bathysnap at 07:30 on the 11th and attempted to make acoustic contact. Initially no signal could be detected and so, while further attempts were made, a water sample for a deck incubation experiment was taken. In the meantime contact had been made with the Bathysnap and it was released. It was sighted at the surface at 11:22 and successfully recovered at 11:45. The Bathysnap appeared to be in good working order but unfortunately it was later found that neither the camera nor current meter had functioned properly.

Whilst waiting for the Bathysnap to rise a shallow CTD cast to 300m was carried out to provide water samples for the JGOFS level 1 measurements. In the afternoon a deep CTD cast was made for level 1 samples but the rosette misfired twice and so the samples could not be used. This was the first of a number of deep casts made with the 10l Go-Flos between the 11th and 18th of May. As a result of tests made on the 18th of May it was realised that all these deep Go-Flo samples were suspect and so the sample depths have not been recorded in the station listing (Table 1).

Station 11857 was characterised by a mixed layer depth of about 40m with the highest chlorophyll a values (1.5-2 mg m^{-3}) in the mixed layer. The surface nutrient concentrations were: NO_3 1.7 mMol m^{-3}, PO4 0.7 mMol m^{-3}.

At 20:24 on the 11th May the Seasoar was deployed for a triangular survey. The survey tracks were designed to map part of the 'standard' eddy that had been identified by the Harvard-APL group (A.R. Robinson, D.J. McGillicudie, J. Calman) using Geosat data coupled with a computer model. In order to provide good ground truth data for an update of this model the survey was designed so that legs 1 and 3 coincided with Geosat tracks whose positions had been provided by the Harvard-APL group. Another factor in the choice of survey track was the position of the BOFS mooring laid on cruise 181 (47°58.4'N, 19°33.1'W) which was close to the apex between legs 2 and 3. At 07:56 on the 12th May the Seasoar was recovered to effect repairs to the conductivity sensor. The ship hove-to during this repair and the Seasoar was re-deployed at 10:46. The survey was completed and the Seasoar recovered at 23:37 on the 12th. The data obtained from this survey confirmed the position and extent of the 'standard' eddy, and a summary of the data was sent to Harvard to allow them to update their model.

During the survey, samples were taken at hourly intervals from the ship's non-toxic water supply for determinations of salinity, chlorophyll *a* (by acetone extraction and HPLC methods) and phytoplankton (Lugols). The salinity samples were used to calibrate the Seasoar conductivity cell and Thermosalinograph, while the acetone extracted chlorophyll determination were used to calibrate the Seasoar *in situ* fluorometer and Turner Designs fluorometer. This procedure was carried out for all Seasoar surveys.

During the Seasoar survey a communication was received from the *Meteor* requesting that the JGOFS inter-calibration on the 18th May should be held close to their position, as they did not want to interrupt their drifting experiment which had been running for several days. This was agreed, but it was realised that if we were to rendezvous overnight on the 17th/18th and still be able to carry out a drifting productivity experiment on the 17th, then we would have to site our drifting station closer to the present *Meteor* position. This in turn meant that we could not site our station within the triangular area of the Seasoar survey which had been the original intention. Accordingly after recovering the Seasoar we set course in a southwesterly direction, stopping at 03:30 on the 13th to collect water samples for the *in situ* incubations, and hove-to at station 11859 at 07:53.

The first task was to launch the drifting *in situ* productivity rig. This rig was used throughout most of the cruise and consisted of two mooring buoys which supported a series of metal frames containing bottles for the oxygen and ^{15}N incubations (gear code PRPJW in Table 1) and a toroid which supported the bottles for the ^{14}C incubations (gear code PRSAV). The two rigs were linked together by rope and joined to a Dhan buoy with a radar reflector. The bottle depths are given in the station listing and correspond to the depths at which water samples were taken using the Go-Flo bottles. At the 47°N stations the rig was usually recovered after a 12 hour incubation.

Next, the drifting rig for deploying the sediment traps and Langdon remote oxygen probes was launched (11:58-13:15). Once deployed this rig was used as a Langrangian marker for the duration of station 11859.

The rest of the day was taken up by a CTD, a profile with the Aiken vertical profiler (VPI), zooplankton sampling with the Bongo and Apstein nets, a short test run of the UOR, and recovering the *in situ* productivity rig.

On the 14th of May the *in situ* productivity rig was deployed for the second time. Activities during the day consisted of a CTD for level 1 samples, further CTDs, a VPI and a Bongo net.

During the night of the 14th/15th the stand-alone pumps (SAPs) were deployed once using plastic coated wire off the aft A-frame. The SAP sampling did not finish until 05:28, but as the sea was calm we were able to use the Kevlar winch concurrently and so obtained water samples for the third *in situ* productivity experiment. This was deployed at 07:53 on the 15th and consisted of the ^{14}C rig only. During the morning a heavy swell prevented any over-the-side activity. In the afternoon a deep CTD cast was made and trouble was again experienced with the rosette sampler. The mechanism was given a thorough overhaul and thereafter functioned properly. The productivity rig was brought in at 19:47, and after this the UOR was deployed for a survey along a NW-SE track for about 10 n.m. either side of the drifting sediment trap rig.

The UOR survey was completed at 02:10 on the 16th May and was followed by a Bongo net and then water samples for productivity experiment 4, which was deployed at 06:49. A deep CTD cast was made to 2000m but it was found that some of the Go-Flo bottles had leaked. Between 11:00 and 18:30 a yo-yo series of CTD dips was carried out to investigate the diel cycle of oxygen and chlorophyll in the top 300m of the water column. For this exercise the VPI was bolted to the CTD to give concurrent readings. The productivity rig was recovered at 20:07 and this was followed by a series of SAP samples deployed from the after Schaft davit finishing at 03:20 on the 17th.

Productivity experiment 5 was deployed 07:02 and then the UOR was launched to provide ground truth data for a NASA P3 overflight. A westerly course was followed to bring the ship on to the northwesterly extension of the course being followed by *Atlantis II* on their approach to the 47°N station from the Azores. The plan was that the P3 would overfly this course and thus pass over both ships. However the P3 flight had to be abandoned due to poor visibility, and so the UOR was recovered at 14:02 and a course was made back towards the productivity rig. After a CTD dip the productivity rig was recovered followed by the drifting sediment traps and Langdon remote productivity probes. Unfortunately it was found that a rope had parted resulting in loss of some of Langdon's equipment. All the sediment traps were recovered but there was evidence that the cups had been leaking. The leakage was confirmed by a bench test and was due to the warping of the plastic plate sealing the top of the cups. During station 11859 the rig drifted in a westerly direction between 13th and 14th of May, but thereafter drifted to the north-east (Table 5a).

Station 11859 was characterised by a mixed layer depth of between 25 and 30m, low surface chlorophyll concentrations (0.4-0.6 mg m^{-3}), a deep chlorophyll maximum between 30 and 40m (2-2.5 mg m^{-3} chlorophyll a) and a 1% light level between 40-45m. The surface nutrient concentrations were: NO_3 1.5-1.9 mMol m^{-3}.

At 21:28 course was made for the JGOFS rendezvous position and we came alongside the *Meteor* at 23:01. Drs. Lenz and Stienen from *Meteor* and Professors Ducklow and McCarthy and Dr. Gordon from *Atlantis* came on board *Discovery* to decide the plan for the inter-calibration exercise. A standard series of depths for bottle samples was agreed, and also it was agreed that *Meteor* should distribute some water samples to the other ships for further cross-calibration. These deliberations were aided by the consumption of a few bottles of a rather presumptuous claret.

Due to a backlog of samples for oxygen measurement it was only possible to carry out a ^{14}C *in situ* productivity experiment (number 6) during the inter-calibration (station 11860). As soon as the productivity rig had been deployed a deep CTD cast to 3250m was made to obtain level 1 samples. This was followed by two Bongo nets, a 300m CTD for level 1 samples, and a VPI cast.

In the afternoon the nutrient concentrations of the deep level 1 samples were analysed and it became apparent that at least some of the Go-Flo bottles had leaked on the upwards cast. This was potentially a very serious problem and it was decided that the bottles would be tested by firing off all 12 bottles at 2000m and the measuring their nutrient concentration. This exercise showed that 7 out of 12 of the bottles had leaked. A similar test at 300m showed no sign of leakage. Later tests in the cold temperature laboratory showed that it was the cold temperatures of the deep water that caused the bottles to leak. The implications of these results were that we had to discard all deep samples taken previously, and were unable to use the Go-Flos for future deep casts but had instead to use NIO 7l water bottles of which there were only six on board the ship.

During the inter-calibration exercise there was much to-ing and fro-ing between ships both for scientific and social purposes. Drs. Watson and Robinson and Prof. Williams visited *Atlantis II* to exchange samples for a carbon dioxide inter-calibration. Axel Miller exchanged samples with Drs Yoshimi Suzuki and Ed Peltzer on *Atlantis II* for DOC inter-calibration. The PSO and Drs. McEvoy and Newton paid a visit to *Meteor* and were entertained to dinner in some style. A large party of German scientist were given dinner on *Discovery* in perhaps less style, but by all accounts to the mutual enjoyment of all concerned. Between 13:07 and 13:14 the NASA P3 overflew the area and the PSO gave an impromptu interview with a reporter from, appropriately, SKY TV.

During the afternoon Dr. Langdon deployed his probes off the after davit and this test revealed some problems which were cured before subsequent deployments. In the evening a new overside pump was installed to replace the previous one that had developed a short in the power supply cable. The productivity rig was then recovered and a rendezvous made with *Atlantis II* at 22:30 to give them samples from our productivity experiment for trace metal analysis. At 23:30 the Seasoar was deployed for the northwards run to the site of the BOFS mooring.

Station 11860 was characterised by a thermocline at 30m but, unlike station 11859, the surface layer was not well mixed but had a temperature gradient of as much as 0.5°C between 30m and the surface. There was also no sub-surface chlorophyll maximum and surface chlorophyll a concentrations ranged from 1.4-1.6 mg m^{-3}. The 1% light level was between 30-35m and the surface nutrient levels were: NO_3 1.5 mMol m^{-3}, PO_4 0.4 mMol m^{-3}.

At 11:00 on the 19th May it was discovered that the new overside pump had ceased working, but it was decided not to interrupt the Seasoar run to repair it. The ship arrived at the mooring site at 15:50. The pump was recovered and the problem was found to be yet another cable short, presumably caused by vibration of the pole. A new high internal capacity pump for the ship's non-toxic water supply had been installed in Barry and so it was decided to try and use this supply to feed the instruments in the biological laboratory. This proved very effective and was used for the rest of the cruise with no problems being experienced.

The Bathysnap was deployed at 16:14 and reached the bottom (4520m) at 17:52. After a VPI cast the Seasoar was deployed and a course was set for the next BOFS station at 59°N,20°W.

During the morning of the 20th the weather gradually worsened and at 13:20 it was decided to recover the Seasoar and continue northwards at 5-6 knots until the weather ameliorated. However by the time the wind had dropped sufficiently to redeploy Seasoar we were so close to 52°N that it was not considered worthwhile.

The Seasoar track between 47°N and 52°N was designed to cut across the 'small', 'standard', and 'big' eddies as defined by the Harvard-APL group. Seasoar run 2 revealed a complicated sequence of eddy-like structures, the first of which began only 15-20km from the JGOFS station. Seasoar run 3 showed a very pronounced cold-core eddy with its centre at 50°N,20°W which can presumably be identified with the 'big' eddy. However, the two runs did not unequivocally demonstrate the existence of three eddies. A summary of the data was faxed to the Harvard-APL group for the updating of their model.

We arrived at the 52°N station (11862) at 06:12 on the 21st of May and commenced a standard series of level one samples consisting of a 30l water bottle sample to provide water for a deck ^{14}C incubation, a deep CTD, a shallow CTD for level 1 samples, a VPI cast, a hydrocast with 7l NIO water bottles for level 1 samples and, finally a Bongo net.

Station 11862 was characterised by a marginal thermocline at 90m with a temperature gradient of only 0.2°C. However this gradient was sufficient to have allowed the development of surface chlorophyll concentrations as high as 3 mg m^{-3}. The surface nutrient concentrations were: NO_3 5.5 mMol m^{-3}, PO_4 0.7 mMol m^{-3}.

At 17:25 the Seasoar was redeployed for the run to the next BOFS stations at 56°N. Between 18:47 and 20:29 the UOR was deployed off the after Schatt davit and no problems were encountered. The UOR was run jointly with Seasoar on a number of other occasions, although it would not undulate properly because of the low ship's speed.

The Seasoar was run throughout the 21st of May before being recovered at 23:36 on arrival at the 56°N (11863) station. Between the 52°N and 56°N the there was another pronounced cold-core eddy in the region of 52° 40'N with a horizontal scale of c. 100km. North of this there was a second broader less pronounced eddy-like structure after which the deeper temperature structure became similar to that at the start of the run, although the surface temperature was about 2 degrees colder.

A similar set of BOFS level 1 samples were taken at station 11863 as for 11862. The mixed layer depth at this station was 115m with a temperature gradient of only 0.1°C across the thermocline. However, as for station 11862, there was a substantial concentration of chlorophyll in the mixed layer reaching 2.5-3.4 mg m^{-3} above 40m. The surface nutrient concentrations were: NO_3 7.4 mMol m^{-3}, PO_4 0.9 mMol m^{-3}.

After completing station 11863, the Seasoar was deployed and a course was made for 60°N,20°W. On arrival at this position course was altered to run along latitude 60°N until 21°20'W before altering course to the site of the American ML-ML, buoy where the Seasoar was recovered at 00:04 on the 25th May. The Seasoar data for this run showed a warm-core eddy at 56°15'N with a spatial scale of about 50km. Further north there were a number of cold-core eddies, but the general trend of the surface temperature was downwards. At 60°N the temperature gradient in the top 300m was only 0.1°C. The chlorophyll concentration in the top 50m declined from about 2-2.5 mg m^{-3} at 56°N to 0.3-1.2 mg m^{-3} at 60°N.

The first activity at station 11864 was a shallow CTD cast which was intended to provide oxygen data for a calibration of Dr. Langdon's oxygen probes on the ML-ML buoy. This was followed by a hydrocast with 7l water bottles and then some water samples for *in situ* productivity experiment 7 which was deployed at 07:42. The Seasoar was then launched to carry out a triangular survey to the south of the ML-ML buoy with the intention of being back at the ML-ML buoy the following morning to recover the productivity rig. However the Seasoar developed a cable fault and had to be recovered at 18:05, and so only two-thirds of the survey was achieved. The ship then made course back to the ML-ML buoy arriving there at 23:30 on the 25th. The next few hours were spent searching for the productivity rig and it was eventually sighted at 04:00 having drifted south-westwards rather than north-eastwards as had been expected. Whilst waiting for the full 24 hour incubation period the opportunity was taken to deploy the Bathysnap. This was launched at 06:54 and reached the bottom (2870m) at 07:48.

The sampling plan for the 60°N station had envisaged carrying out an extensive 5-day Seasoar sampling programme, after which a drifting buoy would have been launched and followed for the remainder of the time available. Two factors made this plan unworkable. Firstly the Spring stabilisation of the mixed layer had hardly developed; there was less than 0.1°C of temperature gradient in the top 100m of the water column. Chlorophyll concentrations were around 0.5 mg m-3 and there had been no draw-down of CO_2. It was therefore considered that spending such a long time on a survey would be a poor use of ship's time. Secondly, because of the extremely short period of darkness, Prof. Williams and Dr. Savidge decided to carry out 24 hour *in situ* incubations, which meant that they could only be carried out every other day. These considerations eventually led a sampling plan in which alternate days were devoted to *in situ* experiments and Seasoar surveys.

It was decided to start the drifting station at the ML-ML buoy and so the ship returned to that position. During the morning and afternoon of the 26th a standard series of level 1 measurements were made followed by the deployment of the drifting rig with sediment traps and Langdon remote oxygen productivity probes. This rig again acted as the Langrangian marker for station 11864.

SAP sampling was carried out over the night of the 26th/27th followed by deployment of the productivity rig at 05:45. During the 27th, a series of CTD, VPI casts and a Bongo net sample were made. At 16:55 an attentive second officer realised that the two productivity rigs had parted.

During the night of the 27th/28th a further series of SAP samples were carried out from the midships winch and the productivity rig was recovered at 05:14.

The Seasoar was deployed at 07:05 on the 28th May with the intention of carrying out a two-day survey as far south as 57°N along 22°W to investigate the progress of the Spring bloom in that area. However during the day there was a marked reduction in the cloudiness and rise in air temperature compared to the previous few days. The data from the Seasoar showed that this was producing a rapid surface heating and apparent increase in mixed layer chlorophyll concentrations. It was considered probable that if such meteorological conditions were continued they would lead to a rapid development of the spring bloom at station 11864. It was therefore decided to limit the Seasoar survey to just one day and return to the drifting buoy that night in time to deploy the productivity rig the next morning.

The Seasoar was recovered at 01:24 on the 29th and the ship made contact with the drifting rig at 02:08. The productivity rig was deployed at 06:15 (productivity experiment 9). Sampling for the rest of the day consisted of CTD casts to study the diel changes in oxygen and chlorophyll fluorescence, VPI casts, 30l water bottle sample for Dr. Wyman's studies of cell DNA, and some Apstein nets.During these experiments the ship was kept within 1 to 2 cables of the drifting rig. Overnight some more SAP samples were taken. The productivity rig was recovered at 06:23 on the 30th.

At 07:21 the Seasoar was deployed to carry out a north-south 'bow-tie' survey. This revealed that the chlorophyll concentrations ranged from 0.3-2 mg m^{-3}, with the highest values being observed in the southeast corner of the survey associated of an area with higher surface temperatures.

The Seasoar survey was completed at 01:27 on the 31st of May and the productivity rig deployed close to the drifting rig at 06:39 (productivity experiment 10). During the rest of the day a further drifting diel experiment was carried out, and SAP samples were taken overnight. The productivity rig was recovered at 06:19 on the 1st of June.

At 07:01 the Seasoar was deployed to carry out an east-west 'bow-tie' survey. A pronounced frontal feature was observed to the northwest of the drifting rig with temperature at 300m dropping by a degree over a distance of 20km. The chlorophyll concentration also declined by a factor of three on crossing the front. However, throughout most of the rest of the survey area the chlorophyll values were fairly uniform.

The Seasoar was recovered at 01:01 on the 2nd of June and was followed by a shallow CTD dip. The ship then returned to the position of the drifting rig at 03:10 and the productivity rig was launched at 06:04 (productivity experiment 11). Dr. Langdon had obtained some data from his probes via the Argos buoy satellite link and this had indicated a fault in one of the probes. And so at 07:04 the drifting rig was grappled and partially recovered so that Dr.Langdon could effect a repair.

During the rest of the day a further series of CTD casts and water bottle samples was made. At 23:00 a start was made at recovering the drifting sediment traps and Langdon probes, and all was in board by 00:36 on the 3rd. The fixes obtained from the Argos buoy showed that the drifting rig had initially drifted in a southwesterly direction, then westerly and then southwesterly again (Table 5b). The ship then hove-to until 05:24 when the productivity rig Dhan buoy was recovered. Unfortunately it was found that the snap link connecting the two toroid buoys had parted and the toroid buoys were not to be seen. Productivity experiment 11 was therefore an almost complete write-off.

During the occupation of station 11864 the surface temperature increased from 8.5 to 9°C, with the resulting thermocline being at about 30m. There was a concurrent development of the surface phytoplankton with chlorophyll *a* values increasing from 1 to 2.5 mg m^{-3}. The surface nutrient concentrations during the station were: NO_3 9-11 mMol m^{-3}, PO_4 1.0 mMol m^{-3}.

At 07:05 the Seasoar was launched for the last time. The intention of this survey was to try and re-locate the area of high chlorophyll observed at the southeast of the 'bow-tie' survey made on the 30th of May. The initial course was therefore in a westerly direction along latitude 59°N. No areas of markedly high chlorophyll had been found by the time of the overflight by the NASA P3. Discussions with the crew of the P3 resulted in the information that surface chlorophyll concentrations were much higher just to the north of the ML-ML buoy. It was therefore decided to turn north and then north-west on a track up to the ML-ML buoy, encircle it and return to approximately 59°N,21°30'W for the last drifting station. This survey confirmed the high chlorophyll values northeast of the buoy observed by the P3 aircraft. The Seasoar was recovered at 00:10 on the 4th of June.

The Argos buoy with the Langdon probes was deployed at 00:55. Despite having lost both *in situ* productivity rigs, it was to found possible to construct a make-shift replacement and this was deployed at 05:24 (productivity experiment 12). During the remainder of the day the usual series of CTDs, VPIs, 30l water bottles plus some Bongo nets were carried out. Overnight SAP samples were taken finishing at 03:24 on the 5th. The productivity rig was recovered successfully at 04:35. A course was then set for the proposed site of the BOFS mooring at 59°N,22°W and we arrived there at 07:30. We commenced laying the mooring from the poop deck at 07:30 and the operation was completed by 10:50.

A course was then made back to the Argos buoy arriving there at 15:00 having towed the UOR for the whole period. A series of CTD casts and a deep hydrocast with 7l NIO water bottles completed the sampling at station 11865, and the Argos drifting buoy and Langdon probes were recovered at 20:03. A course was then set for Troon and the UOR was deployed at 20:23. It had been intended to tow the UOR until the shelf edge had been crossed. However a message was received from the Admiralty requesting us not to tow the UOR east of 14°W. The UOR was therefore recovered at 17:07 on the 6th June.

The Discovery docked at Troon in the early morning of the 8th of June.

MJRF

SCIENTIFIC REPORTS

CTD profiling

An RVS Neil Brown Systems CTD with rosette sample with 12 10l Go-Flo bottles was used for vertical profiling throughout the cruise. A Seatek 25cm transmissometer (No. 116D), a Beckman oxygen sensor and a Langdon pulsed oxygen sensor were also attached to the CTD frame. Other sensors which were used on shallow dips were an Aiken downwards irradiance meter and two Chelsea Instruments *in situ* fluorometers (see Table 1 for details of their deployment).

At the start of the cruise considerable difficulties were experienced with the level A computer sampling of the CTD system. Some of these problems were due to a faulty program, and some due to the fact that, in this particular CTD deck unit, unused higher order bits took the value 1 rather than the more usual 0. However, after this problem had been fixed the CTD system worked very well. Unfortunately this could not be said for the rosette samples and 10l Go-Flo bottles. The initial problem with the intermittent firing of the rosette sampler was cured in the first few days. It was then found that some of the Go-Flo bottles were not closing properly and it was eventually found necessary to start a dip with the valves open rather than closed. As reported in the narrative, it was realised during the JGOFS inter-calibration exercise that most of the Go-Flo bottles leaked when used for deep sampling at cold water temperatures. For the remainder of the cruise the Go-Flos were only used for shallow samples and deep samples had to be obtained using 7 litre NIO bottles on the electric hydrographic winch.

The CTD temperature sensor was calibrated against digital reversing thermometers at various times throughout the cruise and yielded the calibration,

$$T_{corr} = 0.99614 * T_{obs} - 0.036151$$

The standard error of the difference between the corrected and calibration temperature readings was 0.0019°C.

Water samples were taken for most CTD dips to calibrate the CTD conductivity sensor. The mean conductivity ratio for the whole cruise was 1.000929±0.000299 (n=28).

The calibration for the downwards irradiance meter was provided by Jim Aiken and was,

$$\log(I) = 1.1463 - 2.23 * V,$$

where I is the irradiance in Watts m^{-2} and V is the meter output in volts.

MJRF

Seasoar Surveys

The IOSDL Seasoar fitted with a Neil Brown CTD, and the RVS Chelsea Instruments *in situ* fluorometer (No. SA 240) was used for all Seasoar surveys (see Table 3 details). Only two problems were experienced with the system during the cruise. A noisy connector to the conductivity sensor on run 1 resulted in a small stoppage for repairs, and a cable problem on run 6 resulted in this run being abandoned so that a full repair could be carried out.

During runs regular water samples were taken from the non-toxic supply for the calibration of the fluorometer and conductivity sensor and samples were also taken for phytoplankton enumeration.

The Seasoar data were sampled by the ship computer system and then transferred at four hourly intervals to the Sun system devoted to the P-EXEC software, where further data reduction and coloured Uniras contouring was carried out.

MJRF

Continuous seawater sampling

Throughout the cruise non-toxic seawater was pumped from a few metres below the water surface into the biological and chemical laboratories. The water into the biological laboratory was initially obtained from a Flygt pump on a pole attached to the starboard side of the ship just aft of the midships winch. However, the pole vibrated at high speeds and eventually caused the pump's electrical connections to break. After this had happened twice it was decided to use the ship's non-toxic pump which takes water from an inlet in the side of the ship. This pump had been recently replaced and was found to be more than adequate to supply our requirements and was found to be a most satisfactory arrangement.

The pumped water was first passed through a tank on deck to remove bubbles and then passed into the biological laboratory from whence feeder lines were taken to supply the instruments measuring TCO_2, CO_2, pH, Oxygen, nutrients and chlorophyll fluorescence.

Water from another shipboard pump was used to supply the Thermosalinograph and a Seatek transmissometer contained in a plastic water bath. The latter system was found to give very noisy readings in rough weather. Salinity samples were taken from the pumped seawater during the Seasoar surveys and these were used to calibrate the thermosalinograph. The resulting calibration was,

$$Scal = 0.095127*Tobs - 0.01840*Sobs + 35.00851,$$

where Tobs and Sobs are the thermosalinograph temperature and salinity reading respectively.

MJRF

pH Measurements and Carbon dioxide intercalibrations

pH was measured by glass electrode potentiometry in a continuous flow system with a free diffusion liquid junction. The electrode was calibrated against 0.005M tris seawater buffer in accordance with the recommendations of the 1987 report of the Joint Panel on Oceanographic Tables and Standards: the resulting pH values are on the pH(SWS) scale.

Samples from CTD and bottle casts.

Water bottle samples were taken using 50ml all glass syringes flushed once to remove all air: the syringes were then connected directly to the flow pH system. Samples were analysed from all full bottles at the following stations:

Date	Stations	Date	Stations
11/5/89	11857#2	18/5/89	11860#3, 11860#6
15/5/89	11859#24	23/5/89	11863#1, 11863#3
16/5/89	11859#29	26/5/89	11864#6, 11864#10
17/5/89	11859#34	5/6/89	11865#20

Intercalibration between the three CO_2 measurements made on board was achieved by calculating carbonate alkalinity from (i) pH and total CO_2, and (ii) pCO_2 and total CO_2. From the known precision of the thermodynamic constants used, and from the estimated accuracies of our measurements, the calculated alkalinities should agree to within 0.5% (1 standard deviation). The results from stations at 47°N are given below, and indicate satisfactory agreement between the three measurements. To our knowledge this is the first such intercalibration at sea.

Station	% difference in calc. alkalinity (mean ± 1 standard deviation)
11857#2	1.08±0.34
11859#34	0.34±0.29

Underway measurements.

For these measurements the pH flow system was connected to the seawater pumping system via a bypass line. These measurements were much less satisfactory than those on the discrete samples. The major problem was the variable hydrostatic pressure on the inlet to the flow system, which caused unpredictable changes at the flowing liquid junction. This problem was partly overcome by alterations to the flow system, but the results were strongly dependent on the state of the peristaltic pump tubing. Good agreement with pCO_2 and total CO_2 measurements, comparable to that reported above for discrete samples, could be obtained for several hours after replacement of the pump tubing, following which significant drift was often observed. In order to construct a reliable system for accurate underway pH measurements it will be necessary to draw the sample from an overflowing container at bench level with a short residence time. This will require a low-level drain from the laboratory.

DT

Determinations of partial pressure of Carbon dioxide (pCO_2)

pCO_2 was determined by equilibrating gas with seawater, followed by measurement of gaseous CO_2 using a gas chromatograph. Detection was by catalytic conversion of CO_2 to methane and flame ionisation. Discrete samples were analysed after bringing to fixed temperature in a water bath. In on-line mode, surface water was continuously equilibrated with air at near-ambient temperature in a shower-type equilibrator, with samples of the gas being taken every 5 or 10 minutes. CO_2 in the atmosphere was also sampled every 10 minutes in on-line mode. Dissolved methane also shows up in the chromatograms and could be quantified from the data set.

Four types of observation were made:

a) Profiles of pCO_2 with depth, using discrete samples from water bottles.

b) Productivity experiments, in which the pCO_2 in "zero", 12 or 24 hour *in situ* incubations and 12 or 24 hour dark on-deck incubations were compared.

c) On-line measurements of surface water accompanying Seasoar surveys

d) 24-hour time-series of on-line measurements at a drifting station

The discrete sample mode, used for a) and b) above, requires some improvement to achieve full accuracy and precision. The on-line measurements went extremely well; during surveys we were able to obtain good correlations between pCO_2 and other water properties, particularly TCO_2 and fluorescence. The correspondence with fluorescence indicates that at this time of the year, local production is the controlling influence on pCO_2 in the water. A further indication of this is that at 47°N, where a diatom bloom had just occurred, the pCO_2 values were of order 280 ppm whereas at 60°N where productivity was lower, pCO_2 was in the region 330-340 at the beginning of the study period, declining somewhat during the study. The latitudinal distribution of pCO_2 (declining as one goes south) is the opposite to that seen in most previous data (which is in any case extremely sparse).

In data taken in on-line mode while drifting on station a diel signal was always seen. The surface increase in temperature during the daylight hours tended to cause pCO_2 to increase. This effect can be accurately accounted for and once this is done all the diel curves show a decrease of the order 1% in pCO_2 during the daylight hours, which we interpret as being due to biological uptake of carbon. If constant alkalinity is assumed then the curves can be converted to uptake of total carbon, giving values which are of the right order to be consistent with the other measures of productivity made from the ship. This kind of observation has not previously been reported in the open ocean.

Sample Details

a) Discrete Samples

DATE	STN #SERIES	TYPE	DEPTHS (m)
11/5/89	11857#2	CAST	2,10,20,30,40,50,75,100,125
13/5/89	11859#1	PRODUCTIVITY	10
14/5/89	11859#14	"	10
15/5/89	11859#24	CAST	900,2250,3862
16/5/89	11859#28	PRODUCTIVITY	10
16/5/89	11859#29	CAST	500,1000,1500,2000
7/5/89	11859#30	CAST	2,10,20,30,40,50,75,100,150 300
8/5/89	ATLANTIS		
	GOFS3/STN25	CAST4	400,600,750,1000,1500,2000,3250
25/5/89	11864#4	PRODUCTIVITY	5
25/5/89	11864#6	CAST	2,10,20,40,50,75,100,150,200,300
27/5/89	11864#8	PRODUCTIVITY	5

b) On-line determinations

DATE		DATA RATE
11/5/89-12/5/89	24HR SURVEY	1 SAMPLE/10 MIN
19/5/89-24/5/89	TRANSECT	"
25/5/89	24HR SURVEY	"
28/5/89	24HR SURVEY	1 SAMPLE/5 MIN
29/5/89	24HR ON STATION	"
30/5/89	24HR SURVEY	"
31/5/89	24HR ON STATION	"
01/6/89	24HR SURVEY	"
02/6/89	24HR ON STATION	"
03/6/89	18HR SURVEY	"

AW

Plankton production rates and total Carbon dioxide measurements

During the cruise, production measurements were undertaken at 5 locations, a total of 13 experiments were made, 9 were *in situ* incubations and 4 were deck incubations. Four different forms of measurement were made to determine a number of aspects of planktonic production: gross and net community production and respiration were determined using both oxygen and total carbon dioxide (T-CO_2) light bottle techniques, unambiguous measurements of gross production were made using 18-O_2 production from 18-O_2 labelled water, and the assimilation of ammonia and nitrate was followed using 15-N tracer techniques. The 18-O_2 rate determinations were undertaken in conjunction with Prof. Michael Bender of the University of Rhode Island.

The oxygen and the T-CO_2 measurements were made on board, the 15-N measurements will be undertaken at the PML, the 18-O_2 measurements will be made at the University of Rhode Island.

The following is a summary of observations:

Date	Station	Rate measured	Sample depths
13/05/89	11858#1	O_2, T-CO_2, 15-NH_3 & 15-NO_3	2, 10, 15, 20, 25 & 30m
14/05/89	11858#13	O_2, T-CO_2, 15-NH_3 & 15-NO_3	2, 10, 15, 20, 25 & 30m
16/05/90	11859#27	O_2, T-CO_2, 15-NH_3, 15-NO_3 & 18-O_2	2, 10, 15, 20, 25 & 30m
21/05/89	11862#1	O_2, 15-NO_3 & 15-NH_3	10m
23/05/89	11863#4	O_2, 15-NO_3 & 15-NH_3	10m
24/05/89	underway	O_2, 15-NO_3 & 15-NH_3	Surface
25/05/89	11864#3	O_2, T-CO_2, 15-NO_3 & 15-NH_3	5, 15, 30, 45, 60, & 80m
27/05/89	11864#17	O_2, T-CO_2, 18-O_2, 15-NO_3 & 15-NH_3	5, 10, 15, 25, 35, & 50m
29/05/89	11864#27	O_2, T-CO_2, 18-O_2, 15-NO_3 & 15-NH_3	5, 10, 15, 20, 25, & 35m
31/05/89	11864#43	O_2, T-CO_2, 18-O_2, 15-NO_3 & 15-NH_3	5, 10, 15, 20, 25, & 35m
02/06/89	11864#58	O_2, T-CO_2, respiration only	5, 10, 15, 20, 25, & 35m
04/06/89	11865#2	O_2, 18-O_2	5, 10, 15, & 25m
05/06/89	11865#21	O_2, respiration only	40, 80, 120, & 160m

The oxygen data show some interesting features. At 47°N there was an increase in the production and photosynthetic rates over the 3 days we sampled: gross production rates increased from 4 to 9.5 µmoles/kg.day, respiration rates from 2.5 to 6.9 µmoles/kg.day. Gross production and respiration maxima were obtained at 10m, the observed compensation depth was in the region of 25m. The upper 25m of the water column was left with a positive balance of 150 m moles O_2/m^2.day, equivalent to 100 mgC/m^2.day.

At 60°N the productivity profiles were initially linear with depth, without any obvious intermediate maximum or evidence for light limitation or inhibition. Over the first three days the rates increased gradually from 3.5 to 6.5 μmoles/L.day in the case of gross production at 5m; net production rates at the same depth from 2.5 to 5 μmoles/kg.day. Respiration rates were more or less constant in the top 35m at 1 μmole/kg.day. The compensation depth was in the vicinity of 35m, the net productivity of this upper part of the water column was of the order of 100m-moles O_2/m^2.day (1 gmC/m^2.day). The profile at the end of the study at 60°N showed the more classical log decrease with depth, suggestive of light limitation.

A preliminary examination of the ^{14}C and O_2 data suggest that the two methods are showing the same trends; an interesting feature in the comparison is that the ratio of the two molar rates (O_2/CO_2) decreases with depth approaching unity at the compensation depth: one interpretation of this would be the rates measured by the ^{14}C method approach gross production at low light intensities.

Total inorganic carbon was measured coulometrically. One system, titrated water samples from hydrocasts and 11 of the productivity stations. The second instrument analysed over 2750 samples from the underway pumping system. At a sampling frequency of one analysis every 8 minutes, and an average ship's speed of 8 knots, the mapping resolution was 1 km.

T-CO_2 was determined during all mapping surveys. Preliminary observations of correlations with other determined features (chlorophyll, fluorescence, pCO_2, beam attenuation, nutrients and oxygen), especially with chlorophyll fluorescence were very encouraging.

Analysis of T-CO_2 at JGOFS level 1 stations from 2m to 1400m was also undertaken. These results were used to test the correspondence of the three carbonate system measurements made on board. Alkalinity calculated from pCO_2 and T-CO_2 compared with alkalinity obtained from T-CO_2 and pH measurements gave correspondence as good as or better than that expected when errors in the equilibrium constants were taken into account.

The presence of *Atlantis II* on station at 47°N afforded the unique opportunity to intercalibrate T-CO_2 coulometric measurements. Samples were collected in Niskin bottles from seven depths between 600m and 3250m on *Atlantis II* and returned to *Discovery*. Results of the intercalibration show excellent agreement, and are listed below.

Water samples for alkalinity determination have been taken at 4 JGOFS level 1 stations, and at two hourly intervals during the transect 60°N to Troon. In this way we can over-describe the carbonate system and further verify the accuracy of the instruments used here to measure T-CO_2, pCO_2 and pH.

JGOFS 47°N INTERCALIBRATION T-CO_2

Depth(m)	U.K (umol/kg)	U.S.A. (umol/kg)	Δ (%)
600	2127.9	2126.2	+0.08
750	2147.2	2144.2	-0.13
900	2162.6	2157.3	+0.24
1000	2166.2.	2166.3	-0.005
1500	2149.1	2149.2	-0.005
2000	2142.7	2141.2	+0.07
3250	2174.6	2176.3	-0.08

CR, EW, PW

Remote oxygen productivity probes and pulsed oxygen sensors

Three systems were employed for monitoring net community production from changes in oxygen concentrations. These were five autonomous productivity chambers deployed from a drifter, an ENDECO 1133 oxygen sensor modified for fast response time (time constant 2 sec) and fast sampling rate (every 10 sec) which was connected to the Neil Brown CTD for vertical profiling, and second ENDECO oxygen sensor set for a sampling rate of every 2 min which was fitted to a flow cell and connected to the underway pumping system. A large number of discrete oxygen samples were collected and analyzed by Peter Williams'group for the purposes of calibration of the underway and CTD oxygen sensors. The underway sensor worked particularly well, recording diel oxygen changes which agreed well with the near surface bottle incubation measurements. Preliminary analysis indicates good agreement also with the pCO_2 measurements made by Andy Watson during the days the ship stayed with the drifter. During the survey north from 47°N to 59°N the underway oxygen sensor recorded a decrease in oxygen concentrations from 108% supersaturation at 47°N to 99-100% saturation at 59°N. The supersaturation can be taken as a signature of the bloom. Percent saturation at 59°N increased from 99% when we first arrived to 103% by June 5. Surveys showed that patches of water with higher saturation were located to the north and south of us. Some of the supersaturation is due the warming of the surface waters but, given undersaturated water below the surface and generally high wind speeds, the supersaturation could only sustain itself, as we observed with the CTD O_2 profiles, by significant net production of the phytoplankton.

The autonomous productivity chambers were less successful. These instruments have been developed over the last two years. This was only the second cruise on which they were employed at sea, though a prototype was tested successfully in estuarine waters. Prior to this cruise I had less than two weeks actual experience with the instruments at sea. They still have a number of electrical and software bugs, particularly in the circuit which operates the sampling valve. A number of modifications were made during the cruise and a 100% data return was achieved on the last 36 hour deployment. In total three deployments, listed below, were made. Five instruments were deployed on the first deployment at 47°N. Sometime during the seven day deployment the line parted and three of the instruments were lost. The topmost instrument failed shortly after deployment and returned no data. Based on experience gained during this deployment the remaining three instruments were modified and data return during the second deployment at 59°N was significantly greater. A complete record of PAR and temperature at 5 and 15 meters was obtained. A problem with the oxygen measuring circuit was detected from data telemetered back from the drifter via Argos. Based on this information the ship visited the drifter and corrected the problem. As a result good oxygen measurements were obtained on the final day of the deployment. Oxygen production of 6 uM/day was measured at 5m on June 2. The instruments at 15 and 25 m failed after 6 and 2 days respectively for different reasons. All these problems were corrected and on the final 36 hour deployments all three units performed perfectly. Only very preliminary analysis of the data has been completed, however, the data though scanty looks very exciting.

Autonomous Productivity Drifter Deployments

No. 1 Launch May 13, 1989, JD 133, 46° 23.30'N 18° 52.19'W
Recovery May 17, 1989, JD 137, 46° 34.24'N 18° 12.09'W

Depths	Sensors
2	Oxygen, PAR, Temperature
10	" " " , Upwelling radiance at 683
15	" " " "
25	" " "

2 Launch May 26, 1989, JD 146, 59° 28.3'N 20° 53.60'W
Recovery June 2, 1989, JD 154, 59° 08.21'N 23° 28.66'W

Depths	Sensors
5	Oxygen, PAR, Temperature
15	" " "
30	" " "

3 Launch June 4, 1989, JD 155, 59° 0.21'N 21° 21.90'W
Recovery June 5, 1989, JD 156, 59° 2.01'N 21° 02.48'W

Depths	Sensors
5	Oxygen, PAR, Temperature
15	" " "
30	" " "

List of Stations and depths where discrete oxygen analyses were made

Station	Depths
11857#2	2,10,20,30,40,50,75,100,125,150,200,300
11859#5	2,10,15,25
11859#16	2,300
11859#17	2,300
11859#19	2,300
11859#20	2,300
11859#29	500,1000,1500,2000
11859#34	2,10,20,30,40,50,75,100,150,200,300
11860#3	400,750,900,1000,1500,2255,2750,3250
11860#6	5,10,15,20,25,30,45,60,80,100,150,200
11862#3	2,10,20,30,40,50,75,100,150,200,300
11862#6	400,750,900,1000,1500,3250
11863#3	400,600,750,900,1050,1400
11864#1	2,10,20,40,60,80,100,120,160,200,240
11864#6	2,10,20,30,40,50,75,100,150,200,300
11864#10	400,600,750,900,1000,1500
11864#20	2,30
11864#23	2
11864#29	2,10,20,30,40,50,75,100,150,200,300
11864#37	2,20,40,75,150,300
11864#46	2,30,50,150
11864#47	2,20,40,300
11864#51	2,30,50,150
11864#52	2,20,40,300
11864#53	2,10,20,30
11864#57	2,20,150,300
11864#61	2,10,150,300
11864#62	1000
11864#64	2,10,200,300
11864#65	2,100
11864#67	10,100
11864#68	2,40,150
11865#4	2,10,20,30
11865#7	2,5,10,15,25
11865#8	5,15
11865#10	5,15,25
11865#12	5,15,25
11865#13	5,15,25
11865#18	5,10

Discrete underway pump samples collected for calibration O2 sensor

Date	Time	Date	Time	Date	Time
12/5	13:10	22/5	17:03	29/5	10:00
"	14:03	"	23:20	"	13:50
18/5	23:52	23/5	01:20	"	18:00
19/5	01:02	"	02:44	30/5	09:41
"	02:59	"	03:08	"	13:11
"	04:56	"	03:16	"	15:56
"	07:07	"	05:15	"	17:25
"	09:58	"	08:33	"	20:30
"	23:12	"	11:44	1/6	09:56
20/5	01:00	"	12:10	"	14:42
"	03:01	"	22:25	2/6	01:53
"	04:53	"	23:45	2/6	11:17
"	07:05	24/5	04:12	2/6	15:10
"	13:00	"	06:18	"	16:39
"	15:04	25/5	02:10	"	20:53
"	17:00	"	20:31	4/6	09:54
"	19:02	26/5	11:52	"	11:57
21/5	09:25	"	14:26	"	01:40
"	10:24	"	20:01	"	03:23
"	11:50	27/5	13:20	"	16:01
"	12:30	28/5	09:30		
"	14:52	"	12:52		
"	16:34	"	19:29		
22/5	16:06	"	23:20		

CL

Dissolved organic carbon determinations

Introduction

The intention for DOC measurement was to sample surface waters during mapping exercises and vertical profiles whilst on station. Determination of DOC was to be performed by high temperature catalytic oxidation,using a Shimadzu TOC-500 Total Carbon Analyser.

Sampling

Surface water samples were taken at hourly intervals during the mapping exercise around 47°N and at two-hourly intervals during all subsequent Seasoar surveys.

Vertical profiles were obtained by sampling at all depths for the following stations:-

11857#02	11859#24	11859#29	11859#34
11860#03	11860#06	11862#03	11862#06
11863#01	11863#03	11864#06	11864#10
11865#18	11865#20		

In addition, DOC samples were taken in line with some productivity experiments performed by the UCNW team. Samples were obtained from the *in situ* rigs at 47°N and 60°N.

Further, at 47°N an intercalibration exercise was performed in collaboration with Ed Peltzer and Yoshimi Suzuki from RV *Atlantis II* on 18/5/89. Samples from their deep hydrocast were taken to allow intercomparison of DOC analysis techniques.

Instrument Performance

On previous cruises workers had encountered severe problems with the Shimadzu TOC-500,due to vibration from the ship's engines. As a result,the instrument here had been arranged on rubber mountings to baffle background noise. Subsequently,the instrument performed well on mid-range sensitivity; both on station and when cruising on one engine. Reproducibility was generally below 5%. However, when a second engine was running the background vibration severely affected the baseline,rendering measurement possible only on the low-range setting; at which the repeatability of replicate injections was shifted to generally between 5 and 10%.

AM

Undulating oceanographic recorder (UOR)

The UOR is an automatic, servo-controlled, depth-profiling sampler (0 to 70 m at a speed of 5 to 6 $m.s^{-1}$) with sensors for depth, conductivity, temperature, chlorophyll fluorescence, water transmission (at 660 nm) and eleven light sensors (PAR, plus downwelling and upwelling pairs at 412, 450, 490, 520 and 550 nm). Data are recorded *in situ* in a solid state data logger (SSDL) and down-loaded after each tow into an IBM PS2/70 micro-computer for processing, plotting and contouring.

The UOR was towed 18 times (see tow lists Table 2) covering a total distance of 1405 km (~ 760 miles). For 6 tows (8, 9, 10, 11, 12 and 14) the UOR was towed concurrently with Seasoar at a fixed depth (5, 10 or 15 m) or undulating near surface (2 to 12 m or 2 to 18 m acquiring optical measurements simultaneously with CTD and chlorophyll fluorescence. The instrument failed to undulate on tow 3 (software hang-up in new I-processor servo) and on tows 7 and 8 (electronic fault NMFS Mark 2B servo) and undulated intermittently at slow speed (< 4 $m.s^{-1}$) on some Seasoar tows.

In addition the sensors and instrumentation packages from the UOR were deployed on station (single casts, yo-yos and oblique profiles), acquiring vertical profiles of irradiance (VPI) simultaneously with profiles of temperature, chlorophyll fluorescence and PAR (See VPI lists, Table 1).

Optical measurements were acquired concurrently with all over-flights of the NASA aircraft; on UOR tows 2 and 3 (10 May) and tow 15 (3 June) and VPIs on 18, 21 and 29 June.

organisms past history and therefore offer the possibility of relating biological activity to the physical nature of the environment with a degree of temporal and spatial resolution which has been unobtainable hitherto. The experiments described in the following paragraphs have the overall aims of introducing the power of molecular biology to the field of biological oceanography.

Aims

1) To isolate DNA/RNA from natural phytoplankton populations to:

a) examine the impact of variability in physico-chemical conditions on transcriptional activity of selected organisms and relationships to physiological state.

b) examine the development of different populations within the water column during stratification using the precision of molecular techniques

c) provide material for cloning from non-culturable organisms e.g. Prochlorophytes

d) make comparisons between the genetic variability of natural populations and representatives held in culture collections.

2) To estimate phycoerythrin concentrations in Synechococcus populations to:

a) provide ground-truth data for NASA P3 underflights

b) examine the diel and longer scale variability in PE content and type.

Techniques

1) DNA/RNA isolation

Isolation of DNA for RFLP Analysis and 'Shotgun Cloning'

4-5 litre samples were filter-fractionated through 5, 2, 0.6 and 0.2μm Nuclepore filters and the retentate of each filter resuspended in isotonic sucrose isolation buffer prior to storage at -20^{o}C. High molecular weight DNA isolated by standard protocols from the Synechococcus-rich 0.6-2.0μm fraction will be subjected to RFLP analysis using the restriction endonucleases Eco RI; HInd III; BamHI; PST 1; Sal I, and XHO I and heterologous DNA probes for the genes cpeB; cpcA; apcAB; glnA; psbA, and rrn. Synechococcus and Prochlorophyte DNA present in the 0.6-2.0μm and 0.2-0.6μm fractions will be cut and ligated into suitable vectors prior to the isolation of rDNA and clones encoding elements of the photosynthetic apparatus.

The UOR measurements of chlorophyll biomass and temperature structure were in close agreement with the observations by the Seasoar and shipboard instrumentation for pumped surface water (Turner Designs fluorometer). Of particular note, all sensors detected the "spiky" fluorescence signature associated with large diatoms at 47°N, 52°N and 56°N. The "spiky" signature was significantly absent at 59/60°N, except for patches detected in the Seasoar/UOR surveys around the study site.

Generally, optical measurements were as anticipated for spring bloom conditions; low reflectance values at all wavelengths (< 5%) and high values of the diffuse attenuation coefficients (K412, K450, K490 and KPAR) where chlorophyll concentrations were elevated. Reflectance increased in patches to ca 10% on the final UOR tows (17 and 18) from 21°W to Rockall (14°W) indicating a possible increase in coccolithophore concentrations. These were still well below "bloom" conditions where reflectances can reach 20-30%. The measurements on this section were the best examples from the UOR data of the meso-scale variability which characterises the area. Vertical sections of Temperature and Chlorophyll concentration for tow 17 showed highly variable temperature structure (fronts/ eddy boundaries) with high chlorophyll biomass (2-4 $mg.m^{-3}$) in the warmer waters and high values of transmission associated with the low chlorophyll concentrations in the colder waters.

In support of the UOR, Seasoar and shipboard pigment and optical measurements, 576 water samples were preserved in Lugols and buffered formaldehyde for laboratory analysis of phytoplankton species composition; coincidentally water was filtered for the determination of chlorophyll concentration or other pigments (by HPLC).

JA

Phytoplankton cell properties and phycoerythrin determinations

Introduction

Fundamental questions regarding the magnitude of oceanic primary productivity and its influence on the flux of materials throughout the worlds oceans are currently being addressed using a combination of remote and shipboard observations. Remote measurements have the potential to tell us much about the marine physico-chemical environment and how this influences the development of phytoplankton populations on a basin-wide or global scale. However, if we are to formulate models which describe in a realistic way the biological activity of the oceans we need to derive fundamental concepts about how phytoplankton regulate their physiology and growth. Given the variability of the oceanic environment, traditional observational studies have limited potential to provide other than phenomenological or anecdotal solutions. This is because the rate of any physiological process is a largely unknown integration of the organisms current environmental experience and its past history. Understanding how phytoplankton respond to variability in the physico-chemical nature of their environment, therefore requires us to look at cell processes which are more sensitive to environmental change. In recent years it has become possible to look at the primary events involved in the expression of an organism genome. Such techniques have the attraction of being relatively insensitive to the

Sediment traps

Parflux Mark 7G-13 Time Series sediment Trap deployments:

1. Drifting Mooring (Table 5a), 13-17/5/89, 11859#3

   4 traps at 20, 40, 100 and 300m, carousels 544, 501, 545, 504 respectively. 4 x 24 hour sampling periods.

2. Drifting Mooring (Table 5b), 26/5/89-3/6/89, 11864#13.

   2 traps at 64 and 309m, carousels 541, 542 respectively. 7 x 24 hour sampling periods.

3. Fixed Mooring, 5/6/89-6/8/89 11866#1 59°00.7'N, 21°59.6'W

   4 traps at 277, 968, 1973 and 2769m, carousels 541, 542, 545 and 501 respectively.

   Sampling periods:

6/6/89,	00:01	-	11/6/89,	12:00
11/6/89,	12:00	-	14/6/89,	12:00
14/6/69,	12:00	-	18/6/89,	12:00
18/6/89,	12:00	-	21/6/89,	12:00
21/6/89,	12:00	-	25/6/89,	12:00
25/6/89,	12:00	-	2/7/89,	12:00
2/7/89,	12:00	-	9/7/89,	12:00
9/7/89,	12:00	-	16/7/89,	12:00
16/7/89,	12:00	-	23/7/89,	12:00
23/7/89,	12:00	-	30/7/89,	12:00
30/7/89,	12:00	-	6/8/89,	12:00

Trap solutions were prepared from seawater collected from the same water body as the trap deployment depth, with enhanced salinity 2ò relative to that of seawater (using NaCl) and 2% formaldehyde as preservative. Manipulation of trap solutions was carried out under clean conditions, to reduce contamination.

The fixed plates of sediment trap carousels (519, 550, 551, 504, 545, 501, 544) were found to be warped, thus causing leakage of trap solutions during deployment. The effectiveness of salinity enhancement/preservative was therefore unknown during the first drifting mooring, but the presence of live "swimmers" suggests that leakage seriously compromised the sample collection. Only trap carousels 541, 542 were found not to leak, and were consequently deployed on the second drifting mooring. These carousels were used on the fixed mooring, along with the two faulty carousels (501, 545) found to leak the

Isolation of mRNA from Synechococcus populations

1-5 litre samples were filter-fractionated to obtain the 0.6-2.0µm fraction and total RNA extracted into isolation buffer prior to storage at -20°C. Process time from collection to storage for each sample was maintained to a maximum of 15 minutes. Processed samples will be analysed by Northern dot blots. Utilising the reprobing facility of Zeta-probe, transcriptional activity of up to six different genes will be quantified by either densitometry or scintillation counting.

Isolation of mRNA for cDNA cloning

4-5 litre samples were processed as described and stored in RNA isolation buffer at -20°C. mRNA from eukaryotes will be purified on oligo-dT columns using standard protocols. Cyanobacterial and Prochlorophyte samples taken during the day and at night will be enriched in light-regulated transcripts using subtraction cDNA cloning techniques.

2) Phycoerythrin

Cyanobacterial (Synechococcus) specific estimates of PE were determined by spectrofluorometry (Wyman 1989 Limnol. Oceanogr. in press). 1-2 litre samples were concentrated by differential filtration through 2.0 and 0.6µm Nuclepore filters and the 0.6-2.0µm fraction (>90% Synechococcus) resuspended in 50% aq. glycerol. Uncoupled PE fluor emission was excited at 520nm and scanned from 520-700nm. Excitation spectra for emission at 580nm (PE) were scanned from 400-580nm.

Preliminary conclusions

Considerable onshore analysis is require before commenting on the success of the DNA/RNA isolations. It can be expected that at a minimum sufficient material will be available for cloning and RFLP analysis. Preliminary analysis suggests that the integrity of the prokaryote mRNA samples has been maintained: no apparent degradation of the 23S, 16S and 5S ribosomal subunits was observed when representative samples were run on formaldehyde gels.

PE determinations provided considerable insight into the nature and development of Synechococcus populations. In contrast to the populations present in surface waters, the development of a distinct pigment type was observed in deeper waters at the 59°N 20°W station. It remains to be resolved whether alterations in pigment type may be attributed to photoadaptation or whether distinct species with differing PE types became established at different depths in the water column. RFLP analysis will provide a definitive and unequivocal answer to this problem.

MW

least. Trap solutions of faulty carousels were spiked with KNO_3 to assess extent of leakage during deployments.

Drifting mooring samples were refrigerated at approximately 2°C in the dark, after sub-sampling and freezing several cc of supernatant.

PN

Stand-Alone Pumps (SAPS)

Precombusted GF/F filters were subsampled for analysis of pigments, lignins, organic carbon (all stored frozen), lipids (stored in chloroform/methanol), and the remainder frozen for archive. 0.4µm Nuclepore filters were frozen for analysis of inorganic and mineral components. All filter-assembly manipulators were conducted under a laminar flow hood, and assemblies sheathed in polythene until submersion in water.

Deployment of SAPS was from nylon-coated wire from the aft-davit/aft A-frame (multiple SAP dips, <1000m), or single dips from the midships winch (>1000m). Principal problems encountered were filter breakage due to escape of air through filter on submersion, and loss/redistribution of collected particles during recovery. Initial deployments were used to investigate the circumnavigation of these problems.

Filter breakage was only avoidable by corking the flowmeter outlet and filling the SAP with seawater prior to deployment. The cork was removed by rope from deck when the SAP was submerged. Damage to flowmeters caused by this procedure was prevented by securing meters with plastic brackets and adapting the flowmeter from the horizontal to the vertical outlet.

Loss/redistribution of particles on filters was caused by the head of water overlaying the filter during SAP recovery. This was found to be minimised by allowing SAP to drain its cartridges on the wire for several minutes. For this to be successful, filters must not be clogged; pumping periods were consequently selected to avoid clogging.

For reliable quantitative sampling, redesign of SAPS will be required in the two aspects discussed. Excellent performance of SAPS when used in cartridge-filter mode can be anticipated.

Stand alone pumps were deployed as shown

Station	Depth (m)	Filter	Vol. water filtered (litres)
11859#21	520	GF/F	1793
"	500	GF/F	1764
"	480	GF/F	1588
"	460	GF/F	1562
"	440	GF/F	1831
"	420	GF/F	1821
"	220	GF/F	
"	20	GF/F	318
11859#31	1000	Nuclepore	890
"	496	GF/F	0
"	320	Nuclepore	0
"	300	Nuclepore	663
"	100	Nuclepore	
"	60	GF/F	685
"	50	Nuclepore	168
"	20	Nuclepore	430
11864#15	30	GF/F	336
"	50	Nuclepore	446
"	60	GF/F	345
"	90	GF/F	371
"	100	Nuclepore	
"	150	GF/F x 2	
"	200	Nuclepore	127
11864#24	1000	Nuclepore	554
11864#25	2000	Nuclepore	56
11864#39	2000	Nuclepore	574
11864#40	1000	Nuclepore	539
11864#54	1500	Nuclepore	556
11864#55	300	Nuclepore	455
11864#56	1000	Nuclepore	0
11865#15	1000	GF/F	860
11865#16	300	Nuclepore	442
11865#17	50	Nuclepore	153

PN

Volatile organic compounds

Samples were collected for volatile analysis by purging 500ml seawater with helium and trapping on a tenax-filled column. The samples were collected at four stations from a depth range of 2 to 300m, except at station 11859 when deep water samples were purged (500-2000m). It was intended to screen the samples by gas chromatographic analysis to determine which samples should be duplicated for laboratory analysis by gas chromatography/mass spectrometry. Unfortunately, the cryogenic cooling system did not work, so samples were routinely collected for GC/MS analysis only.

Sea water was filtered (10-15 l) for organic analysis of the particulate material during a Seasoar (1) survey over 16h, and from two stations at depths from 2m to 300m.

Zooplankton was collected for organic analysis at two stations using the Bongo nets.

Volatile samples

Station 11857#2

8 samples were collected. 500ml from 30, 40, 50, 75, 100, 125, 150 and 300m.

Station 11859#29

4 samples were collected. 500ml from each of 500, 1000, 1500 and 2000m.

Station 11864#51

9 samples were taken. 500ml from each of 2, 20, 30, 40, 50, 75, 150 and 300m.

Station 11864#57

8 samples were collected. 500ml from each of 2, 10, 20, 30 & 40 combined, 50, 75, 100 and 300m.

Station 11865#10

6 samples were taken. 500ml from each of 2, 15, 25, 50, 75 and 300m.

Filtered samples (10-15 l) taken at:-

1) Seasoar survey 1, surface water at 7 locations over 16hr period.

2) From CTD stations 11859#16, 17, 19, 20 at depths 2, 10, 20, 30, 40, 50, 60 and 300m.

3) CTD (Yo-Yo) station 11864#32 at depths 2, 10, 20, 30, 40, 50, 70 and 100m.

4) Bongo net - zooplankton collected at station 11864#16 (nighttime) 100m - surface.

5) Bongo net - zooplankton collected at station 11865#6 (0-30m).

JMcE

Nutrient analysis

Routine nutrient analyses were performed using the PML Auto-Analyser (AA) as set up for the determination of NO_3-N, Si, PO_4-P, NO_2-N and NH_4-N. The system was used extensively in continuous mode during survey legs and in discrete mode for vertical profile samples, being of particular value in establishing the occurrence of severe leakage problems in the Go-Flo water sampling bottles when used at depths in excess of 300m.

The NO_3, NO_2, and Si channels of the AA performed well, although the Si values were found to be consistently higher than the American or German values at the inter-calibration station. In the early part of the cruise the PO_4 output became unstable and resulted in the loss of data for 4-5 days. No one cause of the problem was resolved but close attention to the functional detail improved stability satisfactorily. The NH_4 channel failed early in the cruise due to colorimeter optical filter and PCB problems. The PCB in the Si colorimeter also failed later on but was replaced with a spare and no Si data were lost. However no further spares were available to correct the NH_4 colorimeter and NH_4 data were not obtained after 21/5/89.

Cleaned data sets were derived before the end of the cruise for the limited number of station casts. A start was also made on digitising the large volume of on-line data but it is expected that this process will take considerable time to complete. Although a semi-automated digitiser was available shipboard, it is clear that an integral real-time AA system data analyser is essential for a multidisciplinary cruise of the present nature. Lack of this facility means that primary diagnostic data necessary for making short term cruise planning decisions during the course of the cruise is unavailable; this problem is particularly serious in areas of high biological and chemical variability such as encountered in the present survey.

Initial results suggest that the most variable and interesting data sets were obtained from the main northward transect and from spatial surveys in the vicinity of 60°N 20°W.

The NOx analyser was not used as extensively as planned, as greater than expected NO_3 concentrations were encountered, especially at 47°N 20°W. However, several calibration runs were carried out in parallel with the AA and in addition three preliminary NO_3 time course uptake experiments were run together with two experiments to assess the influence of irradiance on phytoplankton NO_3 uptake rates.

GS,PB

^{14}C productivity experiments

Three modes of ^{14}C uptake experiment were carried out during the cruise in order to derive production estimates. These included *in situ* incubations using samples from six depths, deck incubations using a range of size irradiances,and P:I determinations employing an artificial light incubator. Particular care was taken to use clean techniques throughout and avoid light shock as far as possible with all samples being collected from Go-Flo bottles mounted on Kevlar line. The link-up with *Atlantis II* was of great value in allowing transfer of water samples for the later determination at the Moss Landing Laboratory of trace metal content, and also for allowing parallel US-UK *in situ* ^{14}C uptake intercalibration experiments to be carried out.

Six *in situ* ^{14}C productivity estimates were performed at each of the two main stations at 47°N and 60°N. Three concurrent deck incubations were also carried out together with three further similar experiments when 24hr station keeping was not possible for *in situ* incubations. At 47°N a suite of six P:I curves was established using samples from each of the standard sampling depths of 2, 10, 15, 20, 25, and 30/35m. At 60°N two further P:I relationships were obtained from both 2 and 30/35m to assess differences in the P:I characteristics as related to vertical stability. The value of these data was considerably enhanced by having available concurrent ambient irradiance and light profile data. All ^{14}C uptake experiments involved size fractionating the phytoplankton into the 0.2-1.0, 1.0-5.0 and greater than 5.0µm size classes.

Considerable benefit was gained from having access to a shipboard liquid scintillation counter. This allowed ready comparison of ^{14}C and O_2 evolution estimates of production, assay of tracer additions and checks on the consistency of the ^{14}C experimental procedure. Opportunity was also taken during the JGOFS intercalibration exercise to compare US and UK 14C tracer activity.

The ^{14}C uptake programme was particularly successful with the exception of the loss of an *in situ* incubation rig on 2/6/89 at 60°N. Initial results indicate a high degree of correlation between parallel ^{14}C uptake and O_2 evolution estimates of primary production.

GS,PB

Chlorophyll a determinations

Size-fractionated extracted chlorophyll a determinations were carried out using fluorometric techniques on all productivity phytoplankton samples. The size categories conformed to those used in the 14C experiments. Total fraction chlorophyll a samples were also processed for calibration of the on-line fluorometer.

GS,PB

Microbial loop studies

Objectives

There were four main objectives:

1) To compare bacterial populations, in terms both of numbers and growth rates at each of the 4 BOFS sites, 47°N, 52°N, 56°N and 60°N; and to monitor their response to the onset of the spring bloom. Bacterial growth rates were measured by the incorporation of radiolabelled thymidine (^{3}H.Tdr) and the results are expressed in picomoles of thymidine incorporated per litre, per hour (pmol $L^{-1}hr^{-1}$).

2) To compare cynanobacterial populations, in terms of numbers, at each of the 4 BOFS sites, from depth profiles of cell counts.

3) To conduct grazing experiments determining the grazing pressure experience by the bacterial populations.

4) Intercalibration of the methodology used in the BOFS/JGOFS programmes with American and German scientists aboard the *Atlantis II* and the *Meteor* during the rendezvous at 47°N.

Cruise report

1) In order to observe the changes in bacterial activity, regular depth profiles were assayed for the uptake rate of tritiated thymidine (^{3}H Tdr). In all, 12 shallow depth profiles were done and 5 deep profiles. Due to gear problems (Go-Flo bottles) the integrity of the water samples from the first two deep casts (the only two at 47°N) is questionable. For all the remaining deep casts, at 52°N, 56°N and 60°N, NIO bottles were used for water collection. These gave reliable samples.

Initial results give net population growth rates. Specific growth rates will be obtained with the cell counts. At all BOFS sites the maximum activity was low: 47°N, 2.00; 56°N, 2.30; 60°N, 1.40 all units as pmol $l^{-1}hr^{-1}$. However at the rendezvous site, (stn. 11860) the activity was much higher: 5.20, and at the final station at 60°N, a region of high chlorophyll identified from the Seasoar surveys, (stn 11865) maximum activity reached 6.8 pmol l^{-1} hr^{-1}. Some samples assayed for bacterial activity were coordinated with primary productivity sampling. The enables an estimation of the proportion of primary production channelled into bacterial growth. Early estimates suggest, that in these low productivity areas, this may be as little as 1%.

2) Profiles of cyanobacterial cell numbers were obtained for all the BOFS sites, with additional profiles for stations 11860#6, 11864#3, 11864#43, 11865#2 and 11865#18.

3) Five grazing experiments were carried out using the dilution technique of Landry and Hassett; two at 47°N, and three at 60°N two of those done at 60°N will yield information on the grazing pressure on different phytoplankton communities. This data obtained by observing changes in fractionated chlorophyll levels as well as changes in bacterial populations. Since sampling for these experiments was coordinated

with the primary productivity sampling, the results will give the proportion of primary productivity passing to Protozoa as a direct result of herbivory as well as the proportion which passes through the bacteria.

4) Intercalibrations of the techniques used by all three ships for determining bacterial and cyanobacterial cell numbers/biomass and of bacterial growth rates measured by ^{3}H Tdr were carried out on water samples exchanged between the ships, and by comparison of profiles sampled independently. Agreement between *Meteor* and *Discovery* was excellent for ^{3}H Tdr uptake. Detailed results from the *Atlantis II* are not yet available, nor are cell numbers and biomass data.

In addition to meeting the primary objectives of the cruise some opportunistic measurements were made;

a) A survey of the changes in bacterial numbers along the transect of longitude at 20°W, from 47°N to 60°N. These data will be matched with physical and chemical measurements made simultaneously with the Seasoar and from the pumped non toxic water.

b) Two diel experiments were carried out while the ship followed a drogue buoy to investigate the diurnal cycle of bacterial activity. The results suggest some periodicity with possibly a 30% difference between the peak activity at early pm and an apparent trough of net ^{3}H Tdr uptake in the evenings. These trends will be more fully investigated during the Langrangian experiments of the BOFS cruises next year.

MWS

Table 1 List of stations carried out on Cruise 182

Abbreviations

Gear Codes

APSTEIN	Apstein opening-closing zooplankton net
BONGO	Twin WPB2 zooplankton net. $0.25m^2$ mouth area, 200µm mesh net.
CFLUOR1	Chelsea *in situ* fluorometer No. SA226 (300m pressure case).
CFLUOR2	Chelsea *in situ* fluorometer No. SA240 (6000m pressure case).
CTD	Neil Brown Sytems CTD with added Beckman Oxygen sensor, Seatek 0.25m Transmissometer (No. SN116D), Langdon pulsed oxygen sensor, and rosette sampler with 12 10 l Go-Flo bottles.
DIRR	Aiken Irradiometer measuring downwelling PAR.
GOFLO/KEVLAR	10 l or 30 l Go-Flo bottle deployed on Kevlar winch.
PRLANG	Langdon remotely controlled oxygen incubators on a drifting rig.
PRPJW	Drifting rig for *in situ* oxygen and ^{15}N incubations
PRSAV	Drifting rig for *in situ* ^{14}C incubations.
SAP	Stand-alone pump.
SED.FLOAT	Drifting rig with Parflux sediment traps.
SED.TRAP	Sediment traps on fixed mooring.
UOL	Plymouth Marine Laboratory Undulating Oceanographic Recorder
VPI	Aiken vertical profiler measuring chlorophyll and downwelling and upwelling irradiance.
VPI/UOR	UOR used in vertical profiling mode.

Sample Codes

BG	Bacterial grazing experiment.
BN	Bacterial counts by epifluorescent microscopy.
BP	Bacterial production by tritiated thymidine uptake.
CH	Chlorophyll by acetone extraction.
CY	Cyanobacteria counts by epifluorescent microscopy.
DC	Dissolved Organic Carbon.
DN	Cell DNA
NU	Nutrients (nitrate, nitrite, silicate, phosphate and ammonium).
O2	Oxygen.

PC	Particulate Organic Carbon.
PE	Phycoerythrin
PG	Pigments by HPLC.
PH	pH
PN	Particulate Organic Nitrogen.
PO	CO_2 partial pressure.
RN	Cell messenger RNA.
TC	Total CO_2.
VO	Volatile organic compounds.

NB The presence of one of the above codes in the station list does not mean that such samples were taken at ALL sample depths.

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound-ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11857#01	11/05/89	08:05	0		GOFLO/KEVLAR	47 9.99N	19 38.65W	2,10,15,20,25,30	Water for deck incubation
	11/05/89	09:31	30			47 8.95N	19 39.01W		CB,BN,BP
11857#2	11/05/89	10:04	0		CTD,DIRR,CFLUOR1	47 10.87N	19 38.78W	2,10,20,30,40,50,75	Level 1 Samples
	11/05/89	11:20	300			47 10.17N	19 39.21W	100,125,150,200,300	
11857#3	11/05/89	12:21	0		VPI	47 10.30N	19 38.87W		Instrument malfunction
	11/05/89	12:34	85			47 10.22N	19 38.94W		
11857#4	11/05/89	14:45	0	4677	CTD	47 8.90N	19 40.08W		Rosette misfired, samples
	11/05/89	17:13	4628			47 7.92N	19 40.99W		not used.
11857#5	11/05/89	16:30	0		PRLANG	47 8.15N	19 40.48W		Test Run off stern of
	11/05/89	19:30	85			47 7.71N	19 41.36W		ship.
11857#6	11/05/89	18:01	0		VPI	47 7.79N	19 41.28W		
	11/05/89	18:12	85			47 7.81N	19 41.36W		
11858#1	13/05/89	03:30	0		VPI	46 40.28N	19 18.45W		
	13/05/89	03:51	125			46 40.21N	19 18.37W		
11858#2	13/05/89	04:00	0		GOFLO/KEVLAR	46 40.20N	19 18.28W	2,10,15,20,25,30	Water for productivity rig
	13/05/89	05:51	30			46 38.96N	19 17.99W		PO
BOFS 47N STATION									
11859#1	13/05/89	08:16	0		PRSAV,PRPJW	46 23.71N	18 53.63W	2,10,15,20,25,30	Productivity expt. 1
	13/05/89	21:15	30			46 19.97N	18 45.22W		
11859#2	13/05/89	12:20	0		PRLANG	46 22.66N	18 52.09W	2,10,15,25	Langrangian marker for station
	17/05/89	18:49	25			46 36.87N	18 10.52W		Three O2 probes lost.
11859#3	13/05/89	13:15	0		SED.FLOAT	46 22.26N	18 52.26W	15,40,100,300	Leakage observed in trap cups.
	17/05/89	21:11	300			46 35.52N	18 11.10W		
11859#4	13/05/89	14:09	0		VPI	46 21.90N	18 51.06W		
	13/05/89	14:19	110			46 21.83N	18 50.95W		
11859#5	13/05/89	14:40	0		CTD,DIRR,CFLUOR2	46 21.77N	18 50.72W	2,10,15,20,25,30,40	BG,O2,CH
	13/05/89	15:10	300			46 21.71N	18 50.24W	50,100	
11859#6	13/05/89	15:33	0		BONGO	46 21.69N	18 49.89		
	13/05/89	15:50	100			46 21.62N	18 49.60W		
11859#7	13/05/89	16:30	0		BONGO	46 21.49N	18 49.73W		
	13/05/89	16:35	25			46 21.43N	18 49.69W		
11859#8	13/05/89	17:06	0		APSTEIN	46 21.21N	18 48.90W		
	13/05/89	17:10	40			46 21.16N	18 48.79W		
11859#9	13/05/89	17:18	40		APSTEIN	46 21.09N	18 48.63W		
	13/05/89	17:28	100			46 20.93N	18 48.56W		

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound-ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11859#10	13/05/89	17:37	100		APSTEIN	46 20.80N	18 48.51W		
	13/05/89	18:32	500			46 20.67N	18 48.02W		
11859#11	13/05/89	21:40	0		BONGO	46 19.68N	18 44.88W		
	13/05/89	21:54	100			46 19.53N	18 44.65W		
11859#12	13/05/89	22:07	0		BONGO	46 19.38N	18 44.42W		
	13/05/89	22:20	25			46 19.25N	18 44.27W		
11859#13	14/05/89	03:23	0		GOFLO/KEVLAR	46 21.27N	18 40.60W	2,10,15,20,25,30	Water for productivity rig
	14/05/89	05:15	30			46 21.12N	18 39.31W		PO
11859#14	14/05/89	07:41	0		PRSAV,PRPJW	46 18.92N	18 40.17W	2,10,15,20,25,30	Productivity expt. 2
	14/05/89	20:03	30			46 19.08N	18 32.51W		
11859#15	14/05/89	08:00	0		VPI	46 18.49N	18 40.42W		
	14/05/89	08:12	110			46 18.33N	18 40.45W		
11859#16	14/05/89	09:28	0		CTD,DIRR,CFLUOR2	46 18.37N	18 39.22W	2,10,20,30,40,50,60	JGOFS Level 1 samples.
	14/05/89	10:25	300			46 18.04N	18 38.42W	75,100,150,200,300	OG
11859#17	14/05/89	12:42	0		CTD,DIRR,CFLUOR2	46 18.17N	18 36.28W	2,10,20,30,40,50,60	O2,OG,NU
	14/05/89	13:25	300			46 18.35N	18 35.58W	75,100,150,200,300	
11859#17a	14/05/89	13:38	0		VPI	46 18.37N	18 35.45W		
	14/05/89	13:55	185			46 18.34N	18 35.31W		
11859#18	14/05/89	14:40	0		BONGO	46 18.27N	18 34.85W		Sample for M.Conte
	14/05/89	14:45	100			46 18.26N	18 34.71W		OG
11859#19	14/05/89	15:21	0		CTD,DIRR,CFLUOR2	46 18.43N	18 34.30W	2,10,20,30,40,50,60	O2,OG,NU
	14/05/89	16:05	300			46 18.50N	18 34.15W	75,100,150,200,300	
11859#20	14/05/89	18:15	0		CTD,DIRR,CFLUOR2	46 18.15N	18 33.82W	2,10,20,30,40,50,60	O2,OG
	14/05/89	18:46	300			46 18.24N	18 33.30W	75,100,150,200,300	
11859#21	14/05/89	23:06	0		SAP	46 17.26N	18 28.87W	20,220,420,440,460	Deployed off A frame
	15/05/89	05:28	520			46 15.39N	18 25.67W	480,500,520	Filtered for 2 hrs.
11859#22	15/05/89	03:30	0		GOFLO/KEVLAR	46 15.86N	18 26.46W	2,10,15,20,25,30	Water for productivity rig.
	15/05/89	04:00	30			46 15.84N	18 26.21W		
11859#23	15/05/89	07:53	0		PRSAV	46 18.65N	18 26.61W	2,10,15,20,25,30	Productivity expt. 3
	15/05/89	19:47	30			46 20.53N	18 22.29W		
11859#24	15/05/89	14:27	0	3874	CTD	46 18.49N	18 22.32W		Attempted level 1 deep cast.
	15/05/89	16:54	3750			46 19.00N	18 23.49W		Rosette malfunction.
11859#25	15/05/89	20:54			UOR	46 21.60N	18 23.89		Incorrectly assigned station
	16/05/89	02:10				46 21.68N	18 21.77W		number.
11859#26	16/05/89	02:30	0		BONGO	46 21.82N	18 21.29W		Sample for M.Conte
	16/05/89	02:43	100			46 21.82N	18 21.25W		OG

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sounding m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11859#27	16/05/89	03:23	0		GOFLO/KEVLAR	46 21.73N	18 21.25W	2,10,15,20,25,30	Water for productivity rigs.
	16/05/89	04:28	30			46 21.51N	18 21.93W		PO
11859#28	16/05/89	06:49	0		PRSAV,PRPJW	46 21.48N	18 20.43W	2,10,15,20,25,30	Productivity expt.4
	16/05/89	20:07	30			46 25.04N	18 16.75W		
11859#29	16/05/89	08:41	0		CTD,CFLUOR2	46 21.53N	18 21.06W		Rosette OK, but bottles
	16/05/89	09:58	2000			46 21.69N	18 21.25W		leaked.
11859#30	16/05/89	10:55	0		CTD,DIRR,CFLUOR2,	46 22.15N	18 20.98W		Yo-Yo experiment.
	16/05/89	18:38	300		VPI	46 24.24N	18 15.13W		PO?
11859#31	16/05/89	21:15	0		SAP	46 25.59N	18 16.99W	20,50,60,100,300	Deployed from aft davit
	17/05/89	03:20	1000			46 26.39N	18 15.48W	320,496,1000	
11859#32	17/05/89	04:11	0		GOFLO/KEVLAR	46 27.73N	18 14.71W	2,10,15,20,25,30	Water for productivity rigs
	17/05/89	04:47	30			46 27.80N	18 14.37W		BG
11859#33	17/05/89	07:02	0		PRSAV,PRPJW	46 29.63N	18 13.07W		Productivity expt. 5
	17/05/89	18:49	30			46 36.87N	18 10.52W		
11859#34	17/05/89	16:50	0		CTD,DIRR,CFLUOR2	46 33.78N	18 11.84W	2,10,20,30,40,50,75	TC,O2,DC,PH,NU,PG,CH
	17/05/89	18:02	300			46 34.32N	18 11.60W	100,150,200,300	
JGOFS 47N STATION									
11860#1	18/05/89	03:30	0		GOFLOS/KEVLAR	46 27.64N	17 45.59W	2,10,20,25,30,45,60	Water for productivity rigs
	18/05/89	05:51	60			46 27.45N	17 44.99W		
11860#2	18/05/89	05:51	0		PRSAV	46 27.45N	17 44.99W	2,10,20,25,30,45,60	Productivity expt. 6
	18/05/89	21:25	60			46 24.95N	17 44.05W		
11860#3	18/05/89	06:11	0	4218	CTD	46 27.35N	17 45.33W		Attempted deep level 1.
	18/05/89	08:11	3250			46 27.02N	17 44.84W		Bottles leaked
11860#4	18/05/89	08:42	0		BONGO	46 26.84N	17 44.64W		
	18/05/89	08:50	25			46 26.92N	17 44.56W		
11860#5	18/05/89	09:40	0		BONGO	46 27.13N	17 44.07W		
	18/05/89	09:50	100			46 27.19N	17 43.86W		
11860#6	18/05/89	10:52	0		CTD,DIRR,CFLUOR2	46 26.24N	17 43.76W	5,10,15,20,25,30,45	Level 1 samples.
	18/05/89	11:50	300			46 25.97N	17 43.09W	60,80,100,150,200	
11860#7	18/05/89	12:50	0		VPI	46 25.88N	17 42.49W		P3 overflight at 12:00
	18/05/89	13:30	150			46 25.67N	17 42.13W		
11860#8	18/05/89	13:40			PRLANG	46 25.67N	17 41.95W		Test deployment from aft davit
	18/05/89	19:45				46 25.04N	17 39.80W		
11860#9	18/05/89	15:10	0		CTD	46 25.25N	17 41.00W	3250 (12 samples)	Leakage test for 101 GOFLOS.
	18/05/89	16:53	3250			46 25.00N	17 40.86W		7 out Of 12 bottles leaked.

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound-ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11860#10	18/05/89	17:48	0		GOFLO/KEVLAR	46 24.95N	17 40.52W	10	BP
	18/05/89	17:50	10			46 24.96N	17 40.51W		
11860#11	18/05/89	19:24	0		CTD,DIRR,CFLUOR2	46 25.10N	17 39.85W	300 (12 samples)	Shallow leakage test.
	18/05/89	20:00	300			?	?		
11861#1	19/05/89	16:14	4520	4520	BATHYSNAP	48 1.05N	19 35.09W		Bathysnap on bottom at 17:52
11861#2	19/05/89	16:38	0		VPI	48 1.05N	19 34.84W		
	19/05/89	19:24	105			48 1.75N	19 35.47W		
BOFS 52N STATION									
11862#1	21/05/89	06:24	0		GOFLO/KEVLAR	52 0.09N	19 59.51W	2,10,15,20,25,30	Water for deck incubation
	21/05/89	07:31	30			52 0.43N	19 59.34W		
11862#2	21/05/89	08:00	0	3752	CTD	52 0.47N	19 58.87W		Bottles leaked
	21/05/89	10:29	3500			52 0.59N	19 56.81W		
11862#3	21/05/89	10:58	0		CTD,DIRR	52 0.65N	19 56.23W	2,10,20,30,40,50	Level 1 samples
	21/05/89	11:56	300			52 0.64N	19 55.18W	75,100,150,200,300	
11862#4	21/05/89	11:28	0		VPI	52 0.69N	19 55.68W		2 dips to 50m
	21/05/89	11:45	50			52 0.68N	19 55.36W		
11862#5	21/05/89	12:17	0		VPI	52 0.66N	19 54.85W		2 Dips to 50m, 1 to 100m.
	21/05/89	12:43	100			52 0.68N	19 54.40W		
11862#6	21/05/89	13:15	0		71 NIO BOTTLES	52 0.68N	19 53.79W	400,750,900,1000	Level 1 Samples
	21/05/89	16:42	3250			51 59.89N	19 50.63W	1500,3250	
11862#7	21/05/89	16:48	0		BONGO	51 59.90N	19 50.55W		Samples for Biomass and
	21/05/89	16:55	100			51 59.87N	19 50.44W		M.Conte (OG)
BOFS 56N STATION									
11863#1	23/05/89	00:05	0		CTD	55 55.02N	20 4.82W	2,10,20,30,40,50	Level 1 Samples
	23/05/89	01:10	300			55 54.46N	20 5.44W	75,100,150,200,300	PE
11863#2	23/05/89	01:24	0	1567	CTD	55 54.40N	20 5.49W		
	23/05/89	02:50	1400			55 54.08N	20 6.16W		
11863#3	23/05/89	03:03	0		71 NIO BOTTLES	55 54.08N	20 6.25W	400,600,750,900	Level 1 Samples
	23/05/89	04:33	1400			55 53.46N	20 6.93W	1050,1400	
11863#4	23/05/89	04:35	0		GOFLO/WIRE	55 53.47N	20 6.91W	2,10,15,20,25,30	Water for deck incubation
	23/05/89	04:49	30			55 53.40N	20 7.12W		
11863#5	23/05/89	04:52	0		GOFLO/KEVLAR	55 53.39N	20 7.20W	2,10,15,20,25,30	Water for deck incubation
	23/05/89	05:44	30			55 53.17N	20 8.05W		

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound- ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11863#6	23/05/89	05:36	0		BONGO	55 53.25N	20 7.83W		
	23/05/89	05:57	100			55 53.10N	20 8.46W		
BOFS 60N STATION									
11864#1	25/05/89	00:54	0		CTD,VPI	59 31.36N	20 45.38W	2,10,20,40,60,80	O2
	25/05/89	02:15	300			59 30.66N	20 45.44W	100,120,160,200,240	
11864#2	25/05/89	02:40	0		71 NIO BOTTLES	59 30.55N	20 45.49W	1000	Water for sediment traps,
	25/05/89	03:28	1000			59 30.19N	20 45.36W		sample contaminated
11864#3	25/05/89	03:39	0		GOFLO/KEVLAR	59 30.09N	20 45.40W	2,10,15,20,25,30	Water for productivity rigs.
	25/05/89	05:44	30			59 28.67N	20 45.53W		CY,BN,BP,BG,PO
11864#4	25/05/89	07:42	0		PRSAV,PRPJW	59 27.91N	20 47.77W	2,10,15,20,25,30	Productivity expt. 7
	26/05/89	07:35	30			59 16.93N	21 2.90W		
11864#5	26/05/89	06:54	2870	2870	BATHYSNAP	59 17.17N	21 2.34W		Reached bottom at 07:48
11864#6	26/05/89	10:31	0		CTD,DIRR,CFLUOR1	59 31.38N	20 48.18W	2,10,20,30,40,50	Level 1 samples.
	26/05/89	11:48	300			59 31.16N	20 49.08W	75,100,150,200,300	
11864#7	26/05/89	11:41	0		GOFLO/KEVLAR	59 31.17N	20 48.95W	?	Reason for sample unknown
	26/05/89	11:48	?			59 31.16N	20 49.08W		
11864#8	26/05/89	12:39	0	2871	CTD	59 30.86N	20 49.93W		
	26/05/89	15:05	2846			59 30.10N	20 52.10W		
11864#9	26/05/89	15:02	0		VPI	59 30.10N	20 52.07W		1 dip to 150m, 1 to 100m
	26/05/89	15:22	150			59 30.04N	20 52.30W		
11864#10	26/05/89	15:17	0		71 NIO BOTTLES	59 30.06N	20 52.24W	400,600,750,900	Level 1 samples
	26/05/89	16:52	1500			59 29.68N	20 53.10W	1000,1500	
11864#11	26/05/89	17:03	0		BONGO	59 29.68N	20 53.14W		
	26/05/89	17:14	100			59 29.59N	20 53.25W		
11864#12	26/05/89	17:09	0		VPI	59 29.63N	20 53.18W		
	26/05/89	17:22	100			59 29.53N	20 53.38W		
11864#13	26/05/89	20:25	0		SED.FLOAT	59 28.00N	20 53.97W	64,300	Langrangian marker for station
	03/06/89	00:36	300		PRLANG	59 7.69N	23 29.77W	5,15,25	
11864#14	26/05/89	21:42	0		CTD,DIRR,CFLUOR1	59 27.48N	20 52.45W		
	26/05/89	22:22	300			59 27.04N	20 52.49W		
11864#15	26/05/89	22:49	30		SAP	59 26.87N	20 53.59W	30,50,60,90,100	Deployed from aft davit
	27/05/89	02:45	200			59 24.55N	20 54.76W	150,200	
11864#16	27/05/89	00:29	0		BONGO	59 25.89N	20 54.16W		Biomass Sample,OG
	27/05/89	00:45	100			59 25.69N	20 54.23W		

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound-ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11864#17	27/05/89	03:15	0		GOFLO/KEVLAR	59 24.37N	20 55.89	2,10,15,20,25,35	Water for productivity rigs.
	27/05/89	05:00	35			59 23.35N	20 57.66W		BG,PO
11864#18	27/05/89	05:45	0		PRSAV,PRPJW	59 23.85N	21 0.01W	2,10,15,20,25,35	Productivity expt. 8
	28/05/89	05:14	35			59 13.94N	21 19.17W		
11864#19	27/05/89	08:42	0		CTD,DIRR,CFLUOR1	59 21.13N	21 3.16W		
	27/05/89	09:30	300			59 20.53N	21 4.05W		
11864#20	27/05/89	12:16	0		CTD,DIRR,CFLUOR1	59 19.40N	21 3.57W	2,30	O2
	27/05/89	13:08	300			59 18.89N	21 4.31W		
11864#21	27/05/89	13:40	0		BONGO	59 18.71N	21 4.34W		Grazing experiment
	27/05/89	13:55	100			59 18.55N	21 4.62W		
11864#22	27/05/89	14:24	0		VPI	59 18.39N	21 5.02W		
	27/05/89	14:40	100			59 18.32N	21 5.19W		
11864#23	27/05/89	18:29	0		CTD,DIRR,CFLOUR1	59 17.45N	21 8.65W	2,10,20,30,40,50,75	O2,CY,PE,NU,CH
	27/05/89	19:05	300			59 17.22N	21 8.86W	100,150,200,300	
11864#24	27/05/89	21:45	1000		SAP	59 17.38N	21 11.85W	1000	Deployed from midships winch
	28/05/89	00:30	1000			59 16.98N	21 14.70W		
11864#25	28/05/89	01:15	2000		SAP	59 16.65N	21 15.74W	2000	Deployed from midships winch
	28/05/89	03:42	2000			59 16.07N	21 18.04W		
11864#26	28/05/89	06:08	0		VPI	59 13.78N	21 19.70W		
	28/05/89	06:26	100			59 13.68N	21 20.09W		
11864#27	29/05/89	02:30	0		GOFLO/KEVLAR	59 13.80N	21 43.22W	2,10,15,20,25,35	Water for productivity rigs.
	29/05/89	04:01	35			59 13.98N	21 44.96W		
11864#28	29/05/89	06:15	0		PRSAV,PRPJW	59 13.90N	21 45.43W	2,10,15,20,25,35	Productivity expt. 9
	30/05/89	06:23	35			59 15.44N	22 16.62W		
11864#29	29/05/89	08:54	0		CTD,DIRR,CFLUOR1	59 12.27N	21 48.85W	2,10,20,30,40,50,75	O2,NU
	29/05/89	10:08	300			59 12.17N	21 50.41W	100,150,200,300	
11864#30	29/05/89	10:22	0		VPI	59 12.24N	21 50.72W		2 dips.
	29/05/89	10:53	100			59 12.42N	21 51.57W		
11864#31	29/05/89	11:04	0		CTD,DIRR,CFLUOR1	59 12.47N	21 51.76W		
	29/05/89	11:42	300			59 12.62N	21 52.73W		
11864#32	29/05/89	13:05	0		CTD,DIRR,CFLUOR1	59 12.82N	21 54.64W		Yo-Yo experiment
	29/05/89	16:02	300			59 13.29N	21 59.87W		
11864#33	29/05/89	13:11	0		VPI	59 12.85N	21 54.84W		4 dips to 50m, 1 to 100m,
	29/05/89	14:02	100			59 13.00N	21 56.37W		and 1 to 60m.
11864#34	29/05/89	13:30	0		GOFLO/KEVLAR	59 12.87N	21 55.43W	2,10,20,35,50	Samples for DNA
	29/05/89	15:00	50			59 13.14N	21 57.92W		PE,RN

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sounding m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11864#35	29/05/89	17:09	0		CTD,DIRR,CFLUOR1	59 13.34N	22 1.13W	2,10,20,30,40,50,75	
	29/05/89	17:36	300			59 13.56N	22 1.67W	100,150,300	
11864#36	29/05/89	18:25	0		VPI	59 14.29N	22 2.23W		1 dip to 50m, 1 to 100m.
	29/05/89	19:04	100			59 13.67N	22 3.60W		
11864#37	29/05/89	19:26	0		CTD,DIRR,CFLUOR1	59 13.60N	22 4.14W	2,10,20,30,40,50,75	O2,NU,CH
	29/05/89	20:01	300			59 13.78N	22 4.49W	100,150,200,300	
11864#38	29/05/89	20:52	0		APSTEIN	59 13.83N	22 5.29W	500-100,100-50	
	29/05/89	22:25	500			59 13.78N	22 7.14W	50-0	
11864#39	29/05/89	23:10	2000		SAP	59 13.84N	22 6.75W	2000	Deployed from midships winch
	30/05/89	01:37	2000			59 14.50N	22 8.92W		
11864#40	30/05/89	02:10	1000		SAP	59 14.64N	22 9.45W	1000	Deployed from midships winch
	30/05/89	03:58	1000			59 15.03N	22 10.91W		
11864#41	30/05/89	04:07	0		GOFLO/KEVLAR	59 15.06N	22 10.99W	2,10,15,20,25,35	Water for deck incubation
	30/05/89	04:42	35			59 15.18N	22 11.39W		BP
11864#42	30/05/89	06:27	0		VPI	59 15.41N	22 16.76W		
	30/05/89	06:42	120			59 15.31N	22 17.22W		
11864#43	31/05/89	03:00	0		GOFLO/KEVLAR	59 17.97N	22 35.89	2,10,15,20,25,30	Water for productivity rigs
	31/05/89	04:05	30			59 17.83N	22 36.91W		CY,BN,BP
11864#44	31/05/89	06:29	0		PRSAV,PRPJW	59 18.48N	22 39.20W	2,10,15,20,25,30	Productivity expt. 10
	01/06/89	06:19	30			59 17.61N	22 58.03W		
11864#45	31/05/89	09:33	0		VPI/UOR	59 18.53N	22 41.17W		
	31/05/89	09:57	100			59 18.94N	22 41.79W		
11864#46	31/05/89	10:20	0		CTD,DIRR,CFLUOR1	59 18.47N	22 41.34W	2,10,20,30,40,50,75	Start of diel experiment
	31/05/89	11:15	300			59 18.51N	22 42.43W	100,150,200,300	BP,O2,NU
11864#47	31/05/89	12:20	0		CTD,DIRR,CFLUOR1	59 18.30N	22 43.90W	2,10,20,30,40,50,75	BP,O2,NU,CH
	31/05/89	13:16	300			59 18.57N	22 44.25W	100,150,200,300	
11864#48	31/05/89	13:00	0		VPI/UOR	59 18.53N	22 44.15W		1 dip to 50m, 1 to 100m.
	31/05/89	13:16	100			59 18.57N	22 44.25W		
11864#49	31/05/89	13:25	0		VPI/UOR	59 18.63N	22 44.37W		
	31/05/89	13:36	100			59 18.65N	22 44.44W		
11864#50	31/05/89	13:28			GOFLO/KEVLAR	59 18.64N	22 44.40W	2,10,20,35,50	Samples for DNA/RNA analysis
	31/05/89	15:05	0			59 19.06N	22 45.82W		PE,RN
11864#51	31/05/89	14:19	50		CTD,DIRR,CFLUOR1	59 18.78N	22 45.13W	2,10,20,30,40,50,75	BP,O2,VO,NU
	31/05/89	15:40	300			59 19.26N	22 46.24W	100,150,200,300	
11864#52	31/05/89	18:10	0		CTD,DIRR,CFLUOR1	59 17.43N	22 51.72W	2,10,20,30,40,50,75	O2,NU
	31/05/89	18:52	300			59 17.32N	22 52.10W	100,150,200,300	

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sound-ing m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11864#53	31/05/89	20:04	0		CTD,DIRR,CFLUOR1	59 17.27N	22 53.20W	2,10,20,30,40,50,75	O2,NU,CH
	31/05/89	20:42	300			59 17.17N	22 53.61W	100,150,200,300	
11864#54	31/05/89	21:27	1500		SAP	59 17.04N	22 54.43W	1500	Deployed from midships winch
	01/06/89	00:09	1500			59 17.02N	22 56.87W		
11864#55	01/06/89	00:23	300		SAP	59 17.05N	22 56.93W	300	Deployed from midships winch
	01/06/89	02:25	300			59 16.98N	22 57.73W		
11864#56	01/06/89	02:35	1000		SAP	59 16.94N	22 57.76W	1000	Deployed from midships winch
	01/06/89	04:23	1000			59 16.52N	22 59.21W		
11864#57	02/06/89	01:17	0		CTD,DIRR,CFLUOR1			2,10,20,30,40,50,75	O2,VO,NU
	02/06/89	01:56	300			59 18.85N	23 2.62W	100,150,200,300	
11864#58	02/06/89	03:30	0		GOFLO/KEVLAR	59 14.56N	23 12.67W	2,10,15,20,25,30,40	Water for productivity rig
	02/06/89	04:31	45			59 13.94N	23 13.28W		BP
11864#59	02/06/89	06:04	0		PRSAV,PRPJW	59 13.48N	23 14.88W	2,10,15,20,25,30,40	Productivity expt. 11. Snap
	02/06/89	----	45						shackle failed, toroids lost.
11864#60	02/06/89	08:07	0		VPI/UOR	59 14.47N	23 15.47W		
	02/06/89	08:23	100			59 14.25N	23 14.19W		
11864#61	02/06/89	10:09	0		CTD,DIRR,CFLUOR1	59 14.46N	23 17.57W	2,10,20,30,40,50,75	BP,O2,NU,CH
	02/06/89	11:03	300			59 14.24N	23 17.71W	100,150,200,300	
11864#62	02/06/89	12:20	0		CTD,DIRR,CFLUOR1	59 13.13N	23 18.39W	1000 (4), 300(3)	O2,NU
	02/06/89	13:26	1000			59 12.58N	23 19.82W		
11864#63	02/06/89	12:45	0		GOFLO/KEVLAR	59 12.57N	23 19.78W	2,10,20,35,50	Samples for RNA/DNA analysis
	02/06/89	15:30	50			59 12.00N	23 20.76W		PE,RN,CY
11864#64	02/06/89	14:14	0		CTD,DIRR,CFLUOR1	59 12.19N	23 20.33W	2,10,20,30,40,50,75	O2,NU
	02/06/89	15:30	300			59 11.68N	23 21.84W	100,150,200,300	
11864#65	02/06/89	16:02	0		CTD,DIRR,CFLUOR1	59 11.52N	23 22.47W	2,10,20,30,40,50,75	O2,NU
	02/06/89	16:45	300			59 11.61N	23 23.36W	100,150,200,300	
11864#66	02/06/89	16:53	0		VPI/UOR	59 11.69N	23 23.89W		
	02/06/89	17:14	100			59 11.99N	23 25.39W		
11864#67	02/06/89	18:17	0		CTD,DIRR,CFLUOR1	59 11.87N	23 26.71W	2,10,20,30,40,50,75	O2,NU
	02/06/89	18:54	300			59 11.76N	23 27.01W	100,150,200,300	
11864#68	02/06/89	20:03	0		CTD,DIRR,CFLUOR1	59 9.05N	23 25.60W	2,10,20,30,40,50,75	O2,NU
	02/06/89	20:43	300			59 8.74N	23 26.63W	100,150,200,300	

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sounding m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11865#1	04/06/89	00:55	0		PRLANG	59 0.25N	21 22.18W	5,15,25	
	05/06/89	20:03	25			59 1.94N	21 7.40W		
11865#2	04/06/89	03:06	0		GOFLO/KEVLAR	59 0.26N	21 20.81W	5,10,15,20,25,30,40	Water for productivity rig
	04/06/89	03:30	40			59 0.28N	21 20.75W		CY,BN,BP,BG
11865#3	04/06/89	05:24	0		PRSAV,PRPJW	59 0.83N	21 19.83W	5,10,15,20,25,30,40	Productivity expt. 12
	05/06/89	04:35	40			58 59.31N	21 8.57W		Replacement rig
11865#4	04/06/89	08:28	0		CTD,DIRR,CFLUOR1	59 0.70N	21 18.32W	2,10,20,30,40,50,75	TC,O2,NU,CH
	04/06/89	09:57	300			59 0.59N	21 18.35W	100,150,200,300	
11865#5	04/06/89	10:03	0		VPI/UOR	59 0.63N	21 18.34W		
	04/06/89	19:17	100			59 0.65N	21 13.59W		
11865#6	04/06/89	10:10	0		BONGO	59 0.71N	21 18.31W		Grazing experiment
	04/06/89	10:20	30			59 0.68N	21 18.31W		
11865#7	04/06/89	11:14	0		CTD,DIRR,CFLUOR1	59 0.67N	21 17.82W	2,5,10,15,25,50,75	BP,TC,O2,NU
	04/06/89	12:03	300			59 0.62N	21 17.63W	100,150,200,300	
11865#8	04/06/89	13:00	0		CTD,DIRR,CFLUOR1	59 0.37N	21 16.19W	2,5,10,15,20,25,50	O2,NU
	04/06/89	13:55	300			59 0.37N	21 15.82W	75,100,200,300	
11865#9	04/06/89	13:10	0		GOFLO/KEVLAR	59 0.43N	21 16.12W	2,10,20,30,40	Samples for DNA/RNA analysis
	04/06/89	14:56	40			59 0.32N	21 15.47W		BP,PE,CY,RN
11865#10	04/06/89	15:03	0		CTD,DIRR,CFLUOR1	59 0.32N	21 15.42W	2,5,10,15,20,25,50	VO,NU,O2
	04/06/89	15:52	300			59 0.39N	21 15.49W	75,100,200,300	
11865#11	04/06/89	15:08	0		VPI/UOR	59 0.30N	21 15.43W		
	04/06/89	15:52	100			59 0.39N	21 15.49W		
11865#12	04/06/89	16:57	0		CTD,DIRR,CFLUOR1	59 0.44N	21 14.67W	2,5,10,15,20,25,50	BP,TC,O2,NU
	04/06/89	18:00	300			59 0.73N	21 14.14W	75,100,200,300	
11865#13	04/06/89	19:12	0		CTD,DIRR,CFLUOR1	59 0.61N	21 13.57W	2,5,10,15,20,25,50	BP,O2,TC,NU
	04/06/89	19:50	300			59 0.87N	21 13.37W	75,100,200,300	
11865#14	04/06/89	20:18	0		BONGO	59 0.90N	21 13.20W		Samples for M.Conte
	04/06/89	21:00	100			59 1.00N	21 12.96W		
11865#15	04/06/89	21:35	1000		SAP	59 1.05N	21 12.90W	1000	Deployed from midships winch
	04/06/89	23:31	1000			59 1.04N	21 12.44W		
11865#16	04/06/89	23:46	300		SAP	59 1.05N	21 12.25W	300	Deployed from midships winch
	05/06/89	01:49	300			59 0.66N	21 11.99W		
11865#17	05/06/89	02:13	50		SAP	59 0.61N	21 12.06W	50	Deployed from midships winch
	05/06/89	03:24	50			59 0.45N	21 12.01W		
11865#18	05/06/89	15:01	0		CTD,DIRR,CFLUOR1	59 1.27N	21 8.81W	2,5,10,15,20,25,50	CY,BN,BP,O2,TC,DC,NU,CH
	05/06/89	15:40	300			59 1.34N	21 8.85W	75,100,200,300	

Station	Start/end Date	Start/End Time	Min/Max Depth m	Sounding m	Gear	Latitude	Longitude	Sample Bottle Depths (m)	Comments
11865#19	05/06/89	16:04	0		CTD	59 1.40N	21 8.83W		
	05/06/89	17:21	2000			59 1.77N	21 9.25W		
11865#20	05/06/89	17:28	0		71 NIO BOTTLES	59 1.78N	21 9.22W	400,600,900,1000	TC,O2,AL,DC,PH,NU
	05/06/89	18:31	1400			59 1.97N	21 8.97W	1200,1400	
11865#21	05/06/89	18:49	0		CTD	59 2.02N	21 8.92W	2,10,20,40(2),80(2)	Deep respiration experiment
	05/06/89	19:33	300			59 2.25N	21 8.78W	120(2),160(2)	
11866	05/06/89	10:49	300		SED.TRAP	59 0.66N	21 59.56W	278,968,1974,2769	BOFS 59N mooring
			2799						

Table 2: Details of Undulating Oceanographic Recorder Tows

UOR Tow No.	Start/End Date	Start/End Time	Latitude	Longitude
D58901	9/5/89	09:29	50 19.2N	7 50.1W
		11:38	50 10.5N	8 23.8W
D58902	10/5/89	07:11	48 48.2N	13 44.3W
		10:03	48 36.5N	14 27.1W
D58903	10/5/89	10:44	48 34.0N	14 37.1W
		14:15	48 20.5N	15 26.6W
D58904	13/5/89	19:01	46 21.1N	18 48.6W
		20:08	46 20.6N	18 49.9W
D58905	15/5/89	20:28	46 20.0N	18 22.1W
	16/5/89	02:10	46 21.7N	18 21.4W
D58906	17/5/89	07:57	46 29.4N	18 12.5W
		09:27	46 30.1N	18 29.5W
D58907	17/5/89	10:04	40 29.6N	18 38.6W
		14:02	46 26.8N	18 40.5W
D58908	21/5/89	18:47	52 08.4N	19 49.0W
		18:55	52 09.5N	19 49.5W
D58909	21/5/89	19:19	52 18.2N	19 50.3W
		20:29	52 22.1N	19 50.8W
D58910	22/5/89	13:19	54 39.2N	19 58.5W
		17:57	55 15.6N	20 01.1W
D58911	23/5/89	11:01	56 21.5N	20 12.2W
		16:06	56 59.8N	20 04.0W
D58912	25/5/89	15:46	58 59.8N	20 36.6W
		18:06	58 59.3N	21 13.5W
D58913	25/5/89	20:39	59 06.9N	21 19.5W
		23:38	59 30.5N	20 47.7W
D58914	30/5/89	08:41	59 27.4N	22 06.7W
		19:17	58 55.1N	22 02.2W
D58915	3/6/89	08:20	59 01.4N	23 14.7W
		19:02	59 32.5N	20 46.1W
D58916	5/6/89	11:20	59 00.9N	21 56.9N
		14:43	59 01.5N	21 10.1W
D58917	5/6/89	20:24	59 01.4N	21 01.3W
	6/6/89	07:16	58 17.5N	17 24.4W
D58918	6/6/89	08:07	58 13.0N	17 05.0W
		17:07	57 38.3N	14 12.8W

Table 3: Details of Seasoar runs

Seasoar Run No	Start/End Date	Start/End Time	Latitude	Longitude	Comments
1a	11/5/89	20:24	47 08.1N	19 42.8W	First part of
	12/5/89	07:56	48 08.2N	20 23.8N	triangular survey
1b	12/5/89	10:46	48 08.7N	20 22.4W	Second part of
		23:37	47 14.8N	19 57.9W	triangular survey
2	18/5/89	23:39	46 26.8N	17 45.8W	Transect from JGOFS
	19/5/89	15:10	47 58.9N	19 34.0W	station to UK mooring
3	19/5/89	19:24	48 01.8N	19 35.5W	Transect to 52N
	20/5/89	13:20	50 16.0N	19 54.7W	Station
4	21/5/89	18:05	52 02.7N	19 49.5W	Transect to 56N
	22/5/89	23:36	55 55.3N	20 3.44W	Station
5	23/5/89	07:23	55 53.8N	20 16.5W	Transect to ML-ML
	25/5/89	00:04	59 32N	20 45W	buoy
6	25/5/89	08:26	59 27.7N	20 51.3W	Triangular survey
		18:25	58 58.3N	21 18.6W	south of ML-ML buoy
7	28/5/89	07:08	59 14.0N	21 44.3W	Box survey south of
	29/5/89	00:53	59 05.8N	21 38.8W	drifting rig
8	30/5/89	07:05	59 16.8N	22 17.9W	N-S 'bow-tie' survey
	31/5/89	01:00	59 19.0N	22 26.1W	
9	1/6/89	07:01	59 18.8N	23 02.2W	E-W 'bow-tie' survey
	2/6/89	00:40	59 18.4N	23 00.7W	
10	3/6/89	07:28	59 02.0N	23 27.5W	Transect to ML-ML buoy
		23:45	59 02.9N	21 17.0W	

Table 4: Date, time and position of XBT launches

XBT No.	Date	Time	Latitude	Longitude
1	10/5/89	18:00	48 16.5N	15 53.3W
2	11/5/89	00:00	47 50.5N	17 29.2W
4	11/5/89	06:30	47 15.3N	19 21.5W
7	11/5/89	12:15	47 10.4N	19 39.0W
8	11/5/89	18:16	47 07.5N	19 41.2W
9	12/5/89	09:05	48 08.1N	20 23.2W
10	13/5/89	04:30	46 40.1N	19 18.2W
11	13/5/89	12:00	46 23.2N	18 52.1W
12	13/5/89	17:55	46 21.1N	18 48.4W
13	14/5/89	06:05	46 19.5N	18 42.2W
16	14/5/89	18:10	46 17.6N	18 33.6W
17	15/5/89	18:05	46 19.0N	18 23.2W
18	16/5/89	00:24	46 17.2N	18 09.1W
19	16/5/89	03:30	46 21.5N	18 21.1W
20	16/5/89	08:50	46 21.1N	18 20.4W
21	16/5/89	13:55	46 23.5N	18 18.2W
22	16/5/89	19:00	46 24.2N	18 17.4W
23	17/5/89	03:32	46 26.2N	18 15.5W
24	17/5/89	18:10	46 34.3N	18 11.8W
25	18/5/89	15:50	46 25.0N	17 40.9W
26	21/5/89	17:18	52 0N	19 51W
27	23/5/89	02:52	55 54N	20 06W
28	26/5/89	11:40	59 31.0N	20 48.8W
29	26/5/89	18:30	59 29.1N	20 54.0W
30	27/6/89	08:10	59 21.5N	21 02.7W
31	27/5/89	19:45	59 17.2N	21 09.0W
32	27/5/89	19:55	59 17.2N	21 09.0W
33	28/5/89	06:00	59 13.9N	21 19.6W
35	29/5/89	09:45	59 12.0N	21 49.9W
36	29/5/89	09:50	59 12.0N	21 49.9W
37	29/5/89	16:05	59 13.3N	21 59.7W
38	2/6/89	15:11	59 11.8N	23 21.0W
39	5/6/89	13:03	59 01.3N	21 20.6W

Table 5a: Argos fixes for drifting rig for

Station 11859

Date	Time	Latitude			Longitude		
13/05/89	12:56	46	22.44	N	18	52.56	W
13/05/89	14:35	46	22.2	N	18	50.46	W
13/05/89	16:16	46	21.12	N	18	49.86	W
13/05/89	18:44	46	21.48	N	18	48.48	W
13/05/89	20:23	46	20.94	N	18	47.88	W
13/05/89	22:04	46	20.34	N	18	47.4	W
14/05/89	02:55	46	19.26	N	18	43.5	W
14/05/89	04:35	46	19.2	N	18	42.06	W
14/05/89	06:14	46	18.6	N	18	44.94	W
14/05/89	08:37	46	18.48	N	18	39.78	W
14/05/89	10:17	46	18.06	N	18	37.92	W
14/05/89	11:56	46	17.94	N	18	37.38	W
14/05/89	12:45	46	17.7	N	18	35.04	W
14/05/89	16:06	46	18.18	N	18	35.16	W
14/05/89	18:22	46	18	N	18	33.78	W
14/05/89	20:01	46	17.76	N	18	33.3	W
14/05/89	21:43	46	18.06	N	18	31.62	W
15/05/89	02:45	46	17.64	N	18	27.96	W
15/05/89	04:25	46	18	N	18	28.32	W
15/05/89	06:04	46	18.48	N	18	28.68	W
15/05/89	08:15	46	18.96	N	18	25.98	W
15/05/89	09:55	46	19.14	N	18	23.94	W
15/05/89	11:34	46	19.32	N	18	25.92	W
15/05/89	15:55	46	18.66	N	18	23.16	W
15/05/89	19:39	46	20.16	N	18	23.46	W
15/05/89	21:18	46	20.82	N	18	22.5	W
16/05/89	02:36	46	21.72	N	18	20.46	W
16/05/89	04:15	46	22.14	N	18	20.34	W
17/05/89	02:24	46	27.96	N	18	14.94	W
17/05/89	04:05	46	28.5	N	18	14.52	W
17/05/89	05:44	46	29.46	N	18	14.64	W
17/05/89	07:29	46	29.94	N	18	14.1	W
17/05/89	09:09	46	30.48	N	18	14.04	W
17/05/89	10:50	46	31.14	N	18	13.38	W
17/05/89	13:54	46	32.22	N	18	13.74	W
17/05/89	15:34	46	33.24	N	18	12	W
17/05/89	18:57	46	34.5	N	18	12.3	W

Table 5b: Argos fixes for drifting rig for

Station 11864

Date	Time	Latitude			Longitude		
26/05/89	20:38	59	27.9	N	20	53.82	W
26/05/89	22:20	59	27.9	N	20	55.02	W
27/05/89	05:36	59	23.88	N	20	58.44	W
27/05/89	07:04	59	26.28	N	21	1.44	W
27/05/89	07:19	59	23.1	N	21	0.42	W
27/05/89	08:44	59	22.74	N	21	2.52	W
27/05/89	08:59	59	23.4	N	21	3.12	W
27/05/89	10:26	59	22.14	N	21	3.66	W
27/05/89	10:38	59	22.98	N	21	0.54	W
27/05/89	12:06	59	21.24	N	21	5.28	W
27/05/89	12:14	59	20.94	N	21	4.56	W
27/05/89	13:43	59	20.82	N	21	7.8	W
27/05/89	13:53	59	20.40	N	21	5.94	W
27/05/89	15:20	59	19.32	N	21	7.44	W
27/05/89	15:34	59	19.62	N	21	8.16	W
27/05/89	16:57	59	19.02	N	21	9.3	W
27/05/89	18:34	59	18.48	N	21	11.64	W
27/05/89	20:15	59	17.46	N	21	13.62	W
27/05/89	21:56	59	16.74	N	21	14.28	W
28/05/89	02:07	59	15.36	N	21	18.9	W
28/05/89	03:51	59	15.3	N	21	20.34	W
28/05/89	05:30	59	14.82	N	21	22.14	W
28/05/89	07:08	59	14.34	N	21	23.34	W
28/05/89	08:23	59	13.98	N	21	25.98	W
28/05/89	11:42	59	13.68	N	21	29.04	W
28/05/89	13:21	59	13.62	N	21	30.66	W
28/05/89	13:44	59	13.92	N	21	31.08	W
28/05/89	14:59	59	13.74	N	21	30.72	W
28/05/89	15:25	59	13.56	N	21	32.46	W
28/05/89	16:36	59	13.38	N	21	33.78	W
28/05/89	18:14	59	13.2	N	21	35.16	W
28/05/89	21:34	59	13.02	N	21	39.12	W
29/05/89	01:57	59	13.08	N	21	43.38	W
29/05/89	03:38	59	13.38	N	21	44.46	W
29/05/89	05:19	59	13.5	N	21	46.68	W
29/05/89	06:59	59	12.78	N	21	48.12	W
29/05/89	08:01	59	13.14	N	21	49.2	W
29/05/89	08:38	59	13.14	N	21	51.6	W
29/05/89	09:42	59	13.26	N	21	51.3	W
29/05/89	11:23	59	13.26	N	21	53.16	W
29/05/89	12:59	59	13.74	N	21	55.68	W
29/05/89	13:33	59	13.44	N	21	57.24	W
29/05/89	14:38	59	13.62	N	22	0	W
29/05/89	15:14	59	14.1	N	21	58.44	W
29/05/89	16:15	59	14.16	N	22	0.3	W
29/05/89	16:59	59	14.22	N	22	0.6	W
29/05/89	17:53	59	14.34	N	22	2.46	W
29/05/89	19:31	59	14.52	N	22	3.84	W
29/05/89	21:10	59	14.64	N	22	6.06	W
29/05/89	22:55	59	15.3	N	22	8.04	W
30/05/89	01:46	59	15.42	N	22	11.58	W
30/05/89	03:30	59	15.96	N	22	13.62	W
30/05/89	05:10	59	16.08	N	22	15.54	W
30/05/89	06:49	59	15.6	N	22	17.1	W
30/05/89	07:38	59	16.44	N	22	19.32	W

Date	Time		Latitude			Longitude	
30/05/89	08:27	59	16.38	N	22	19.86	W
30/05/89	09:19	59	16.5	N	22	19.8	W
30/05/89	11:01	59	16.8	N	22	21.78	W
30/05/89	11:48	59	16.8	N	22	22.98	W
30/05/89	12:37	59	17.04	N	22	23.94	W
30/05/89	13:23	59	16.98	N	22	25.02	W
30/05/89	15:04	59	17.28	N	22	26.22	W
30/05/89	15:54	59	17.46	N	22	28.56	W
30/05/89	16:48	59	18	N	22	28.14	W
30/05/89	17:29	59	17.4	N	22	27.96	W
30/05/89	19:10	59	17.64	N	22	29.88	W
30/05/89	20:49	59	17.76	N	22	31.38	W
30/05/89	22:29	59	17.22	N	22	32.58	W
31/05/89	03:18	59	18	N	22	37.56	W
31/05/89	04:59	59	17.76	N	22	38.16	W
31/05/89	06:41	59	18	N	22	39.54	W
31/05/89	07:14	59	16.14	N	22	37.02	W
31/05/89	08:18	59	17.64	N	22	41.7	W
31/05/89	08:58	59	17.58	N	22	41.64	W
31/05/89	10:37	59	17.22	N	22	43.02	W
31/05/89	11:33	59	17.4	N	22	43.74	W
31/05/89	12:18	59	16.74	N	22	45.3	W
31/05/89	13:14	59	17.46	N	22	45.9	W
31/05/89	13:54	59	17.52	N	22	47.88	W
31/05/89	14:55	59	17.7	N	22	47.16	W
31/05/89	15:32	59	18.24	N	22	49.2	W
31/05/89	17:08	59	18	N	22	49.02	W
31/05/89	18:50	59	17.76	N	22	50.46	W
31/05/89	20:26	59	17.46	N	22	52.32	W
31/05/89	22:07	59	17.16	N	22	52.92	W
01/06/89	03:09	59	17.7	N	22	57.66	W
01/06/89	04:48	59	17.7	N	22	58.44	W
01/06/89	06:29	59	17.64	N	22	59.04	W
01/06/89	08:08	59	18.12	N	22	58.98	W
01/06/89	08:34	59	17.58	N	23	0.3	W
01/06/89	11:56	59	17.22	N	23	2.4	W
01/06/89	13:03	59	17.04	N	23	3.06	W
01/06/89	13:32	59	16.98	N	23	3.84	W
01/06/89	14:42	59	16.86	N	23	3.84	W
01/06/89	16:24	59	16.38	N	23	6.66	W
01/06/89	18:24	59	16.02	N	23	7.56	W
01/06/89	21:46	59	15.66	N	23	9.84	W
02/06/89	02:57	59	14.82	N	23	13.38	W
02/06/89	04:40	59	14.28	N	23	12.48	W
02/06/89	06:20	59	14.58	N	23	14.88	W
02/06/89	08:12	59	13.8	N	23	16.98	W
02/06/89	11:15	59	13.62	N	23	18.54	W
02/06/89	11:33	59	13.08	N	23	18.06	W
02/06/89	13:10	59	11.94	N	23	20.64	W
02/06/89	14:30	59	11.7	N	23	19.08	W
02/06/89	16:26	59	10.92	N	23	22.68	W
02/06/89	18:03	59	10.26	N	23	24.54	W
02/06/89	19:43	59	9.9	N	23	26.16	W
02/06/89	21:23	59	9.06	N	23	26.76	W

Table 6: Daily Integrated PAR in Watt-hours/m^2

Date	PAR
10/05/89	1791.3
11/05/89	1424.3
12/05/89	956.6
13/05/89	1494
14/05/89	1590.7
15/05/89	795.4
16/05/89	854.2
17/05/89	1371
18/05/89	1171.2
19/05/89	2109.7
20/05/89	590.4
21/05/89	2202.8
22/05/89	1393.6
23/05/89	1742.3
24/05/89	1759.3
25/05/89	805.1
26/05/89	791.9
27/05/89	695.1
28/05/89	1315.3
29/05/89	1695.3
30/05/89	1598.1
31/05/89	990.4
1/06/89	1037.3
2/06/89	919.2
3/06/89	866.1
4/06/89	964.7
5/06/89	1754.7
6/05/89	1755.1

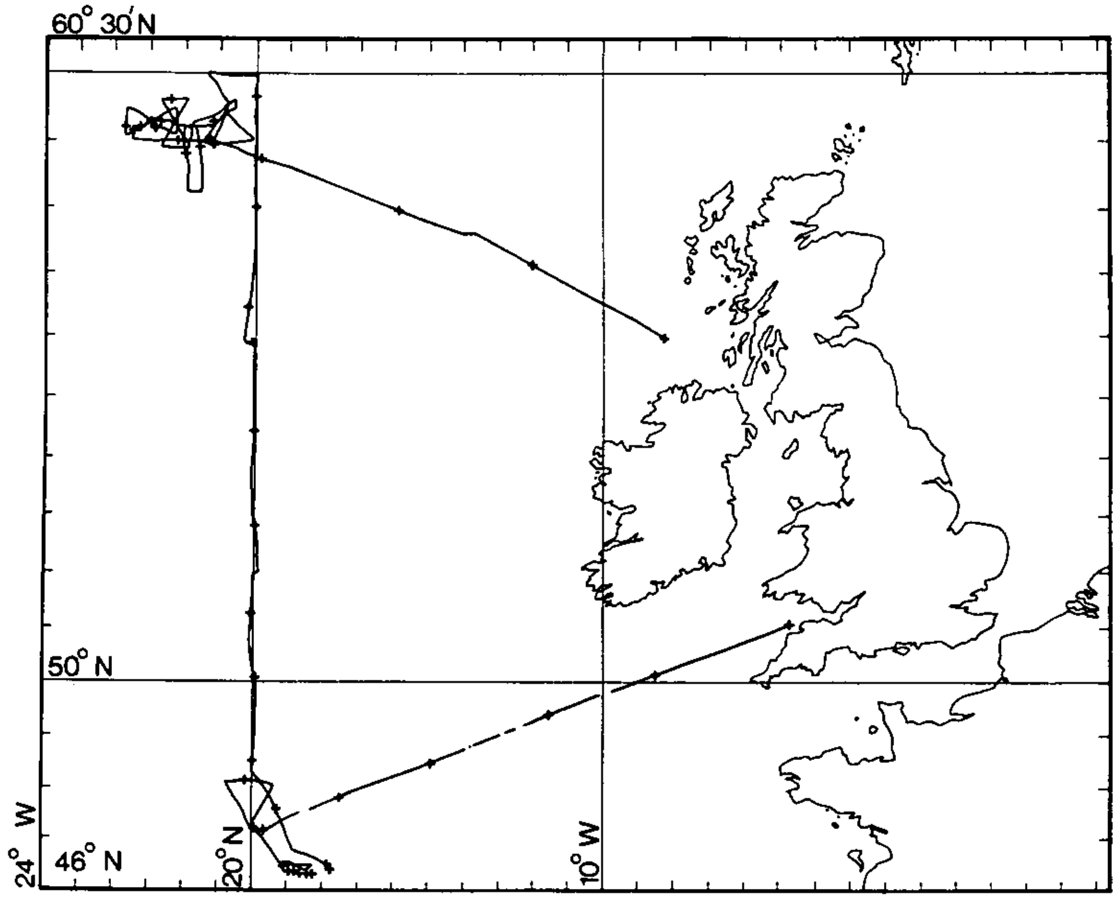

Figure 1. Track chart of RRS *Discovery* cruise 182