CONTENTS

	CONTENTS	PAGE
1.	SUMMARY OF OBJECTIVES AND ACHIEVEMENTS	1
2.	NARRATIVE	
3.	INDIVIDUAL PROJECT REPORTS	16
	3.1 Background Hydrographic and Meteorological Observations	16
	3.2 Pigments and Biomarkers	18
	3.3 ^{14}C Size-fractionated Primary Production and High Resolution Nitrate Uptake Estimates	21
	3.4 Primary Productivity and Community Respiration by O_2 and TCO_2 Changes	24
	3.5 ^{15}New and Regenerated Productivity	25
	3.6 Size-fractionated Multiple Nutrient Uptake Experiments	28
	3.7 Mesozooplankton Biomass and Grazing	30
	3.8 Microzooplankton Trophodynamics	32
	3.9 Trophic Role of Planktonic Ciliates	34
	3.10 Plankton Taxonomic Observations	36
	3.11 Microbiology	39
	3.12 Determination of Non-Volatile Dissolved Organic Carbon	42
	3.13 Stand Alone Pumps	45
	3.14 Stable Isotope Sampling	46
	3.15 Radionuclide Sampling	46
	3.16 Level I POC/PON	46
4.	RVS SUPPORT	47
5.	COMMUNICATIONS	48
6.	ACKNOWLEDGEMENTS	48
7.	FIGURES	
8.	TABLES	
9.	APPENDIX I: LIST OF SCIENTIFIC PERSONNEL	
10.	APPENDIX II: LIST OF CREW MEMBERS	

1. SUMMARY OF OBJECTIVES AND ACHIEVEMENTS

Cruise 46/90 of RRS Charles Darwin was carried out as a component of the 1990 BOFS programme investigating the detailed development of the spring bloom in the north-east Atlantic Ocean.

The specific objectives of the cruise (referred to as BOFS B1 cruise) were to monitor intensively the changes in a wide range of physical, chemical and, especially, biological parameters and processes in the water column over the expected course of the spring bloom of phytoplankton at a location adjacent to a Lagrangian drogue. The marker drogue, set at 20m, had been deployed previously by RRS Discovery at the centre of an array of drogues and rigs strategically located in relation to a mesoscale eddy. The locations of the drogues were monitored continuously via satellite link over the duration of the cruise in order to describe the evolution of the eddy system. Over the course of the experiment, the marker buoy was essentially confined to an area bounded by 48°30'N-50°N, 17°W-19°W.

The observational and experimental components of the cruise programme were maintained continuously for 19 out of the 20 working days of the cruise, with the extra day being taken up in the recovery of the BERTHA rig and also a drogue which had divorced themselves from the main drogue cluster. Weather conditions throughout were excellent and this, together with the absence of any major equipment failures, resulted in no significant working time being lost.

The observational programme was centred on 6-hourly CTD/Rosette sampler dips to 300m to monitor the basic physical, chemical and biological parameters relevant to the overall objectives. Extra dips were taken as required to cover more intensive water sampling periods and to collect samples for stable isotope and natural radioisotope abundance and to provide back-up samples for the macrozooplankton programme. Six full depth Level I hydrographic casts were also carried out to fulfil obligations to the overall JGOFS programme. In all, a total of 105 CTD casts, including one trials cast, were undertaken during the cruise.

The experimental programme considered many of the important biological rate processes associated with carbon and nitrogen flow in the planktonic ecosystem. These included primary production, plankton community respiration, inorganic nitrogen uptake and regeneration, DOC production, bacterial production, macro- and microzooplankton grazing rates and rates of bacterial grazing. In certain instances, more than one approach was attempted for the same measurement, thus allowing comparison of techniques. All rate measurement experiments were backed up with appropriate observational data.

The components of the experimental programme were carried out at varying intervals over the cruise as detailed by logistical requirements with a core programme of in situ size-

fractionated primary production determinations being carried out on a daily basis. Incubations for other rate processes were performed either in situ or deckboard as appropriate. Four diel experiments were carried out in which samples were taken at approximately 4-hourly intervals over a day to monitor diel changes in selected rate processes. These samples were supported by approprate observational data also collected on a 4-hourly basis.

Rendezvous was also made with the Dutch research vessel Tyro, which diverted temporarily from working a leg northwards along 20°W, in order to carry out an intercalibration exercise. Comparison of several of the observational and rate process measurements being carried out on the Charles Darwin was possible and initial results indicate reasonable concordance between data derived from common samples.

2. NARRATIVE

A plot of the track of the Charles Darwin between May 1-May 20 appears in Fig. 1. The drift of the Lagrangian marker drogue during this time is shown in Fig. 2a, while the tracks of all drogues released in the initial deployment zone by RRS Discovery appears in Fig. 2b.

RRS Charles Darwin departed from Barry on schedule at 0810 on 28 April 1990 with a scientific complement of 14 personnel together with four RVS technical staff. A camera team from Ulster TV had been involved in filming aspects of the cruise preparations over the previous four weeks and visited the ship on the day prior to sailing to complete the series. The team also sailed with the ship on the morning of the 28th to film various activities including a dummy CTD dip off Barry before going ashore in the pilot boat at approximately 1015. Course was then set for the drogue target location in the vicinity of 49°N 20°W.

A stop was made at 50° 18.2'N 10° 18.0'W in shelf waters on the morning of April 29 in order to carry out a trial station. A successful CTD/Rosette sampler cast was carried out although some minor problems in the CTD deck software were apparent. Go-Flo bottles were successfully deployed at 2 and 20m and water samples distributed as appropriate for test runs on various instruments and experimental procedures. These casts were followed successively by the deployment of duplicate SAPS at 10m and a zooplankton net in vertical haul mode. Minor adjustments to the SAPS configurations were found to be necessary. Following completion of the station, course was resumed for the target drogue at 1300.

In the absence of a successful communications link with PML, an update on the drogue and rig deployment locations and subsequent positions was obtained through a direct communication link with RRS Discovery, which was continuing work in the study area, on the 1300 radio schedule on April 30. On the basis of the information received course was altered to close the latest updated location of the marker drogue. The Dhan buoy which had

been attached to the Argos float of the marker drogue by RRS Discovery was observed by radar at approximately 1850 at a position some 5 miles north of the ship. Weather conditions were favourable with only a moderate easterly wind. The drogue rig was closed and its identity (Argos i/d no. 3917) confirmed by visual observation at 1920. Station was maintained at a distance of 2 miles from the drogue for the remainder of the day. During this time the four 301 Go-Flo water sampling bottles which had been acid-washed during passage to the area were deployed in the surface layers from the Kevlar line for rinsing purposes.

The sampling programme commenced at 0009 on May 1 with the first CTD dip to 300m being carried out at 49° 51.1'N 18° 56.9'W some 2 miles distant from the marker drogue. The dip was successfully completed with the exception of a malfunction in the in situ fluorometer which was later readily rectified. The profile was characterised by a homogeneous surface well-mixed layer extending to a depth of 30m with temperature and salinity values of 12.4°C and 35.64 respectively. A sharp thermocline was present beneath the mixed layer whilst below 75m temperature and salinity values gradually decreased with the exception of a weak temperature inversion located between 110-120m. At depths of 300m a core of cooler, less saline water present characterised by temperatures <10.83°C and salinities <35.45 was observed; by May 4 equivalent temperature and salinity values within the core had risen to 11.17°C and 35.55 respectively. The cooler, less saline water was assumed to be representative of the core water of the eddy originally defined by RRS Discovery on Leg A1 and used as the definitive locational feature for the deployment of the array of drogues for the BOFS experiment. The observed by the Darwin reflected the lateral drift of the target drogue away from the centre of the eddy gradual reduction in definition of the physical properties of the core water from May 1 to May 4.

During the CTD dip, water bottle samples were collected using the Niskin bottles on the Rosette sampler at 300, 200, 150, 100, 75, 60, 50, 40, 30, 20, 10 and 2m on the up run for subsequent analysis for NO_3-N, NO_2-N, NH_4-N, PO_4-P and Si content and chlorophyll content using the acetone extraction and fluorescence technique. A similar CTD profiling and water bottle sampling protocol was followed at approximately 6h intervals throughout the majority of the survey programme, unless dictated by other sampling requirements, with the water samples being anlaysed as required for a variety of parameters. The 6-hourly CTD profiling schedule constituted one of the main cores of the scientific programme.

Commencing at 0340 on May 1 a series of clean water samples for use in a range of production experiments was taken from depths of 2, 10, 15, 20, 25, 35, 50 and 75m using 301 Go-Flo bottles deployed on Kevlar line. Multi-bottle casts were not found to be possible as line angles were too great on the lower bottles to allow effective contact of the teflon messengers with the bottle firing mechanism. All subsequent Go-Flo samples were thus taken with single bottle deployments: in view of the shallow depths involved together with the finite time required to draw

off the necessary samples, this sampling approach did not cause any loss of time to the scientific programme.

Sub-samples from the Go-Flo bottles were processed to carry out determinations of (i) primary production using the ^{14}C uptake method, (ii) net community production using changes in O_2 production, (iii) bacterial production using the tritiated-thymidine technique, (iv) DOC production and (v) $^{15}NO_3$ and $^{15}NH_4$ uptake. This sequence of determinations was carried out on a 2-3 day cycle throughout the cruise period when conditions allowed with, on certain occasions, the ^{15}N experiments being supplemented by estimates of NH_4 regeneration rates again using ^{15}N tracer techniques, and also microzooplankton grazing rates. Later in the cruise, samples were also taken for the determination of NO_3 uptake based on changes in ambient NO_3 concentrations as assayed by a high resolution analytical technique. Samples for determinations (ii) and (v) above were incubated in situ at the appropriate sampling depth mounted on Dexion frames with samples for (i) and (iv) and high resolution NO_3 uptake also being incubated in situ but on a separate rig suspended from a toroid buoy and attached to the previous rig by 100m of line. This latter rig was attached at some distance to a Dhan buoy fitted with a light, radar reflector and DF transmitter and tethered to the ship by a 200m line for the period of incubation. The first deployment of the full productivity rig was completed by 0648 on 1 May.

The programme continued with further CTD dips to 300m at 0708 and 1335 with samples being taken for DOC, nutrient and chlorophyll (fluorescence) analysis from the standard depths and for pigment (HPLC) and POC and PON analysis from selected depths. The CTD records indicated a homogeneous distribution of chlorophyll fluorescence throughout the mixed layer and with a sharp decrease in the thermocline region between 30-50m. A close qualitative correspondence between the vertical distributions of both fluorescence and temperature in the surface layer was apparent on virtually all CTD traces throughout the cruise with no development of a subsurface chlorophyll maximum being indicated.

The HPLC analyses from the samples of May 1 indicated chlorophyll *a* concentrations of 1.22 $\mu g\ l^{-1}$ in the surface layer whilst size-fractionated samples analysed by extraction and fluorescence techniques showed the greatest chlorophyll concentrations to be associated with the nanoplankton (1-5 μm) fraction. The importance of the nanoplankton was also reflected in the size-fractionated primary production estimates obtained over the course of the day. A series of macro- and microzooplankton net hauls was carried out in the early afternoon followed by a shallow CTD cast to 100m to take water samples for the determination of size particle spectra as required for the interpretation of zooplankton grazing rates. The spectra confirmed a distinct peak of small particles < 3 μm in the surface layer whilst the net samples demonstrated the importance of the smaller macrozooplankton, primarily copepods, in the size range 50-200 μm. Overall there was strong evidence for the

planktonic ecosystem to be dominated by microbial interactions.

During mid-morning of May 1 a CTD dip to 3500m was undertaken with samples being collected between 1000-3500m for the later determination of natural radionuclide activity. The first SAPS cast was commenced at 1652 with five SAPS being deployed at 2374, 2867, 2874, 3374 and 3874m. Some delay occurred in the deployment owing to difficulties in joining the 2000m length of plastic-coated wire employed for mounting the SAPS to the main winch wire required to give the additional depth. The 2000m plastic-coated SAPS wire was deployed from an auxiliary winch located on the aft working deck. Recovery of the SAPS commenced at 0016 on May 2 and was completed by 0310. Following initial inspection of the pumps it was clear that certain problems had been encountered. Although these problems are detailed in the relevant section below, it is appropriate to note some of the main points. The battery pack and pump motor units of the SAPS had loosened and moved relative to one another making access to the wire clamps difficult and leaving connectors more open to damage. A pump unit and motor unit on separate SAPS failed and repairs were subsequently made such that four SAPS units only were available for the remainder of the cruise. The major problem however concerned rupturing of the filters with all filters having broken on this cast. The problem persisted throughout the cruise to a greater or lesser extent on many of the later SAPS deployments and although a reasonable rate of success was obtained with the GF/F filters, only a 50% success rate was achieved when the more fragile Nuclepore filters were used. Several strategies were attempted throughout the remainder of the cruise to alleviate the problem, with particular attention being given to priming of the pumps but no convincing solution was found. It was noted that the SAPS had been extensively re-designed following their successful deployment the previous year and it was thought likely that either some factor in the redesign had unwittingly given rise to the difficulties or that the problems arose from deploying the SAPS over the stern of the Charles Darwin where they were subject to considerable turbulence from the ship's counter during lowering through the surface in the initial stage of deployment.

Following retrieval of the SAPS rig, the productivity rig deployed the previous day was successfully recovered with the exception of bottles from 35m containing samples for $^{15}NO_3$ and $^{15}NH_4$ uptake measurements which were lost from the holding frame. The recovery was followed by a series of zooplankton net tows.

During the previous 24 hours the ship whilst holding station had drifted steadily eastwards to a position approximately 5 miles south of the target drogue. Following the completion of a series of zooplankton net tows at 0511, course was set for a position approximately 2n.m. NE of the drogue such that allowing for expected wind drift of the ship and projected drogue track over the next 24 hr period the ship would pass within approximately 1-1½ miles of the drogue at the nearest point. A similar positioning manoeuvre was subsequently carried out each day following recovery of the productivity rig, generally between

0100-0200, with due allowance being made for projected ship drift and drogue movement. The repositioning prior to the sampling programme of 2 May was completed by 0624 and this was followed immediately by sampling for ^{14}C primary production determinations using the Go-Flo bottles from the Kevlar winch at standard depths. The in situ ^{14}C productivity rig was deployed tethered to the ship as previously by 0745. Two CTD casts were carried out between 0800-1020 for determination of stable isotope concentration (to 100m) and hydrographic and various biological parameters (to 300m), these casts being followed by a suite of zooplankton tows.

From 1205-1745 the first Level I full deep cast was undertaken. The cast consisted of two dips with the first being a routine 300m dip with samples taken from the standard depths for a wide range of parameters and determinations as required by the JGOFS Level I protocol. On the second (deep) dip samples were taken from 400, 500, 600, 700, 800, 1000, 1200, 1500, 2000, 2500, 3000 and 4050m (bottom) for analyses and determinations complementary to those for the shallow section of the Level I cast. Sampling on May 2 was completed by three suites of various zooplankton net tows during the evening and a standard 300m CTD dip at approximately 1830. Similar sampling was carried out in the early hours of May 3.

The productivity rig deployed the previous day was recovered by 0140 on May 3 with the samples being kept in a dark incubator until processing commenced at approximately 0600. During repositioning of the ship, radio contact was established with RRS Discovery owing to some uncertainty as to the identity of two buoys being observed visually by Darwin. The first buoy which displayed a yellow flashing light (5 fl. every 20 secs) was closed and visually identified as BERTHA at 0245. Identification of the target drogue (Metocean buoy 3917, white continuous flashing light) was subsequently confirmed visually at 0318 at 49° 55.5'N 18° 31.4'W while en route to the day's productivity sampling location, again some 2 n.m. NE of the drogue.

A full suite of productivity experiments was initiated by 0628 on May 3 for determination of ^{14}C primary production, $^{15}NO_3$ and $^{15}NH_4$ uptake assays, O_2 production and respiration, DOC production and bacterial production. During the morning a SAPS cast was completed with pumps being deployed at 350, 450, 600 and 800m. All pumps were equipped with GF/F filters and three out of the four filters performed satisfactorily. Standard 300m CTD casts were carried out at approximately 0700, 1300 and 1800 with various combinations of zooplankton net tows being taken in the afternoon and evening.

Owing to the continuing proximity of the BERTHA and target drogue marker buoys, the identity of BERTHA was re-established visually at 0257 at 49° 51.9'N 18° 20.5'W on the morning of May 4 whilst on passage to the relocation position approximately 1 mile north of the marker drogue. Samples for determination of ^{14}C, DOC and bacterial production were taken and the productivity rig deployed by 0557. The major activity of the day consisted of CTD

and Go-Flo casts taken at approximately 4h intervals from 0006 to 2243 to assess the diurnal change in the major chemical and biological variables and to establish diel changes in the various biological rate processes. These included establishing P:I curves for various phytoplankton size fractions, ^{15}N uptake curves using on-deck incubations and DOC and bacterial production estimates. The diel sampling programme was interspersed with suites of various zooplankton net tows and a shallow SAPS cast with pumps being deployed at 15, 50, 125 and 200m. The GF/F filter from the 200m pump was recovered split. During the morning CTD casts, an intermittent signal output was observed on various sensor channels. The fault was traced to a leaking underwater cable connection and the appropriate repairs effected.

The diel sampling experiment was continued on May 5 through to the final CTD cast at 2115, the sampling programme again being interspersed with various zooplankton net tows. A limited suite of productivity and allied measurements were commenced from a deployment of the productivity rig at 0558. Thick fog was encountered for much of the day and this prevented recovery in the early hours of the Dhan buoy attached to the Metocean Argos target buoy 3917 for change of batteries in the flashing light unit. Rendezvous was later made at 1330 with RRS Discovery at 49° 44.2'N 18° 30.7'W prior to her departure from the working area for Barry. Reagents for O_2 and NO_3 determinations and a 20l filter flask were transferred to the Darwin to make good shortages and breakages: in the case of the NO_3 reagents, difficulty had been experienced with a contaminated batch of NH_4Cl.

Foggy conditions continued through the morning of May 6 again preventing a battery change on the flashing light unit of the target marker Dhan buoy. Standard 300m CTD casts were successfully carried out at the routine times and were complemented by a JGOFS Level I deep cast in the afternoon. A further CTD cast for samples for stable isotope determinations was carried out in the top 80m at 0511 and various zooplankton net tows were taken over the course of the day. The daily productivity rig deployment was confined to ^{14}C primary production samples and a series of samples for the determination of NO_3 uptake based on changes in ambient NO_3 concentrations using the high resolution NO_x analyser system.

By May 7 the thick fog which had prevailed for the previous two days had lifted and following the first CTD dip at 0018 and recovery of the productivity rig, course was set for the marker buoy which had been following an essentially southward trajectory for the previous three days. Although the flashing light on the Dhan buoy attached to the Metocean Argos buoy had failed, contact had been maintained successfully by radar. Radio d/f positioning of the rig was found to be logistically awkward and time-consuming with the d/f transmitter having only limited range. The target rig was closed at 0307 with the Dhan buoy being brought inboard for battery change and redeployed at 0314 at a position 49° 33.7'N 18° 35.7'W. No attempt was made to lift the Argos buoy and drogue to check the rig since for the previous

three days or so the system had drifted contra the wind. Although reservations had been expressed by PML about the response of the drogue resulting from the attachment of the Dhan buoy, it was decided that it was necessary to maintain this option given the limited time that the scientific programme allowed for the daily repositioning of the ship on the target buoy. This constraint had arisen as it had been found necessary to tether the in situ productivity rig to the ship, thus restricting movement during the day, rather than having the rig free drifting as had been originally intended. Radar tracking of the Dhan buoy on the target drogue was found to be particularly efficient throughout the cruise.

Following repositioning on May 7, a full range of productivity samples were taken and the incubation rig deployed by first light at 0628. Samples were taken at the same time for a microzooplankton grazing experiment and also for a 36 hr nutrient uptake experiment using size fractionated phytoplankton populations and auto-analytical techniques. Both experiments employed shipboard incubations. During the course of the day the Dhan buoy attached to the productivity rig had to be recovered temporarily to allow refixing of the locating collar for the buoyancy float which had loosened and slipped up the central shaft. Zooplankton net casts and CTD dips were carried out during the day except at 1800 h when a SAPS deployment (SAPS Cast 3) was being undertaken. Two pumps each were deployed at both 1500 and 2000m and recovered successfully although the Nuclepore filter on one of the 2000m pumps had split.

Routine CTD casts were continued through May 8 with two additional casts being carried out for sampling for stable isotopes and natural radionuclides. The daily productivity experiment involving the standard ^{14}C production assay, bacterial production estimates and comparative determinations of NO_3 uptake using the ^{15}N and high resolution ambient NO_3 uptake techniques was initiated at 0615. Intensive zooplankton net sampling was carried out as dictated by the 3-day zooplankton sampling cycle planned for the duration of the cruise. Microzooplankton and bacterial grazing experiments were set up in the late afternoon. During the day problems were encountered with the mechanical sampling unit of the DOC analyser reducing substantially the throughput of samples. The problem was not able to be resolved readily and it was only in the middle part of the cruise that satisfactory sampling was able to be re-established after considerable effort on the part of the RVS support staff. Electrical and mechanical problems were also encountered during the early and mid-part of the cruise with the O_2 and TCO_2 analysers; these were also resolved with the assistance of the RVS technicians to the extent that the equipment was able to be satisfactorily employed, albeit with a reduced sample throughput in the case of the O_2 analyser.

The routine CTD and zooplankton sampling schedule continued throughout May 9 with a full productivity rig deployment being initiated. A Level I deep cast was successfully completed in the afternoon with a full range of chemical and biological samples

being taken. Spooling problems were encountered with the hydrographic winch on the up run on the deep dip of the Level I cast and, although resolvable, some delay was encountered. An unstable CTD output was observed during the 2025 CTD dip following the Level I deep cast and this again was traced to a leak in the underwater cable connection which was subsequently opened up and re-made.

During the course of May 9, a break in the pattern of weather occurred. From May 1 up to May 9 the weather had been characterised entirely by low, grey skies (anti-cyclonic "gloom") but during mid-morning on May 9 the sky cleared and bright, sunny conditions prevailed through to mid-afternoon. No immediate marked change in the physical structure of the water column was observed but the rise in surface chlorophyll concentrations which had commenced on May 6 during the overcast period continued. Prior to May 6 chlorophyll concentrations, as measured by HPLC analysis, averaged 1.52 $\mu g\ l^{-1}$ whereas concentrations of 2.20 $\mu g\ l^{-1}$ were recorded on May 9. Size fractionation techniques suggested that much of this increase had resulted from growth of the nanophytoplankton.

Routine CTD, productivity and zooplankton sampling was continued satisfactorily through May 10. Shallow SAPS casts 6 and 5 were carried out in the morning and evening respectively with a lower filter rupture rate than encountered previously. Although the weather returned to rather more overcast conditions, nevertheless sea surface temperatures commenced to rise with an increased definition of the thermocline. A more intensive CTD and Go-Flo sampling programme was undertaken on May 11 to provide samples for, as previously on May 4 and 5, establishing diel changes in the various hydrographic parameters and biological rate processes. The diel experiment was complemented by a full productivity rig deployment and zooplankton net tows. A microzooplankton grazing experiment was also initiated from the dawn Go-Flo samples while a CTD/water bottle cast was taken for natural radionuclide content later in the day.

The wind increased considerably during the night of May 11/12 resulting in the loss of a limited number of zooplankton tows in the early hours of May 12. The weather also resulted in some damage to a 30l Go-Flo bottle during the dawn sampling routine. Fortunately the bottle was able to be repaired later in the cruise as there was concern over the lack of spares and replacement bottles available for the programme. Despite the weather the productivity rig was deployed at 0610 and a full set of primary, bacterial and DOC production and nutrient uptake experiments was commenced. The wind abated during the day allowing a full suite of standard casts and tows to be carried out, these being supplemented by a full Level I deep cast in the afternoon and a shallow CTD cast for natural stable isotope sampling in the early morning. Spooling problems were again encountered with the hydrographic winch on the up run of the Level I deep cast.

Chlorophyll *a* concentrations continued to increase reaching

a value of 2.71 µg l^{-1} (HPLC analysis); during this period phytoplankton size dominance fluctuated between the >10 µm fraction and the nanoplankton. The strong wind on May 12 resulted also in a deepening and homogenisation of the mixed layer to between 40-45m whereas previously on May 11 a complex thermocline structure had been apparent at depths 25-30m. A pronounced intrusion of colder, less saline water (temperature <10.67°C, salinity <35.47 at 300m) also became evident at depths >100m on May 12 and persisted through to May 13; prior to this equivalent temperature and salinity values at 300m were >11.33°C and >35.55 respectively. In the absence of a spatial survey it was not clear whether the cooler, less saline influence represented a filament associated with spin-off from the original eddy or marginal contact with the upwelled cold core of a secondary eddy. No immediate influence on the associated chlorophyll fluorescence values was evident. By May 12 also the target drogue came under the influence of a strong SEwards directed flow which sometimes resulted in the buoy moving in excess of 12 miles per day, this generally against the direction of the prevailing wind. This trajectory was continued through until May 18.

A major shift in the weather pattern was experienced after May 12 with light winds from a more southerly quarter, more broken skies and much increased daily irradiance. The highest daily PAR total was recorded on May 13. Sampling continued on a routine basis throughout the 13th with a limited productivity rig deployment being undertaken for measurement of ^{14}C primary production and NO_3 uptake using changes in ambient concentration. SAPS serial cast 8 was completed in the afternoon with two pumps each being deployed at 750 and 1000m and although the pumps were recovered successfully, the filters had ruptured on all pumps. The increased irradiance led to increased sea surface temperatures and the re-establishment of secondary temperature structure in the mixed layer. Surface chlorophyll concentrations remained similar to those recorded the previous day at approximately 2.6 µg l^{-1}.

The increase in surface temperature noted on May 13 continued through the following day and this was coupled to a shallowing of the thermocline to 35m. A major jump in chlorophyll concentrations was observed on May 14 with HPLC values of 3.65 µg l^{-1} being recorded from the 1900 CTD cast. Size- fractionated chlorophyll analysis indicated that the growth had primarily occurred in the >5 µm fraction and the increase was accompanied by rapid depletion of silicate concentrations to undetectable levels from previous concentrations of 2-3 µg-at Si l^{-1}. NO_3 concentrations declined concurrently from approximately 5 to 2 µg-at NO_3-N l^{-1}. The evidence thus suggested strongly that a diatom bloom had occurred although immediate microscopical examination did not show obvious dominance by any one diatom species. However this apparent diatom growth has to be viewed in the context of its commencement at a time when Si substrate concentrations were already low, the Si having presumably been used up previously in steady but unspectacular diatom growth. Thus only limited substrate was available when stability and

light conditions became optimal for maximal diatom growth. Under these conditions it is unlikely that a monospecific diatom bloom would have had sufficient time to develop. Heterotrophic flagellate numbers, which had been particularly high during the early stages of the cruise decreased during the run-up to the diatom bloom and decreased significantly further with the onset of the bloom.

The sampling programme continued satisfactorily throughout May 14 with a full productivity rig deployment commencing at 0625 and SAPS serial cast 7 being carried out in the afternoon with 2 pumps located at both 350 and 500m. Rupturing of the pump filters was again a problem. Considerable noise was also evident on the 0630 CTD cast between 200-300m and checks were carried out on the deck Rosette bottle firing unit, both deck and sea cable connections and the winch slip-rings which were thoroughly cleaned. No immediate faults could be detected and the 1235 CTD cast was carried out satisfactorily. Later routine CTD casts and a further cast at 2007 for natural radionuclide samples were also performed satisfactorily.

Radar contact with the target buoy had been lost by 1500 on May 14 owing to the rapid south-eastwards movement of the drogue. Contact was re-made with the buoy by 0231 on May 15 and the ship re-positioned 1.5 miles N.E. of the buoy by 0333. Satisfactory repairs had been made by this time to the DOC analyser and a DOC production experiment was initiated on the productivity rig in addition to ^{14}C production and ambient NO_3 uptake experiments. Experiments for the estimation of microzooplankton and bacterial grazing rates were also commenced during the morning. The 0600 routine CTD cast and 0805 cast for stable isotope samples were carried out satisfactorily as were various zooplankton net tows taken over the course of the day. However the 1208 CTD cast was aborted owing to further problems with noisy signal output. The winch slip-rings were again checked but found to be satisfactory. The CTD sea-unit was opened up and varous PC boards replaced, no spare sea-unit being available, but no instrumental electronic problems were able to be diagnosed. Attention at this stage focussed on the lowering cable, although this was relatively new, and a length at the working end of the cable was removed and a new connection and CTD connector fitted by 0500 on May 16. Testing of the system was delayed until the afternoon of May 16.

A trials deployment of the SAPS was undertaken during the afternoon of May 15 with particular care being taken in the priming of the pumps. Two pumps were deployed at 500m and one each at 350 and 750m and on recovery it was observed that two filters were again ruptured.

The slow warming of the surface layers and shallowing of the thermocline continued through May 15 and 16. A particularly marked intrusion of cooler, less saline water, at intermediate depths similar to that observed on May 12 was recorded on May 14 and 15 with temperature and salinity values at 300m $<10.5^{o}C$ and 35.41 respectively. Considerable microstructure was associated with the intrusion indicative of active mixing at the upper

boundary. This apparent intrusion, like that observed on May 12, also had the effect of shallowing and sharpening the pycnocline. The productivity rig from the deployment of the morning of May 15 was recovered somewhat earlier than usual at 2230 owing to the need to rendezvous the following day with the Duth Research Vessel Tyro which had broken off its survey transect on 20°W to allow the meeting.

Tyro took up position approximately 2 miles north of Charles Darwin at 0600 on May 16 in order to allow intercalibration of various techniques common to both cruises. Exchanges of personnel took place throughout the day with water and sea conditions in the morning and early afternoon being particularly favourable. Scientists from Tyro boarded Darwin in the morning to take samples from the clean Go-Flo bottle casts for setting up comparable productivity experiments back on board Tyro. The productivity rigs on both ships were deployed at 1115. Both vessels carried out full JGOFS Level I deep CTD casts in the afternoon with Darwin personnel transferring to Tyro to collect samples for intercalibration as required. During exchanges of personnel, full opportunity was taken to compare techniques and approaches used by the various groups with considerable benefit being gained from the exercise. The Darwin CTD performed satisfactorily during the deep cast although some noise on the output was still apparent. Metocean Argos buoy 3907 which had previously been deployed by RRS Discovery on April 27 was returned to the Darwin from Tyro during the afternoon having been recovered on May 15 whilst on passage to the Darwin. The crew of the Tyro were able to confirm that the drogue had been detached from the marker buoy at the time of recovery. The productivity rigs on both ships were recovered by 2012 and Tyro departed from the rendezvous position at approximately 2100.

The high surface chlorophyll concentrations observed on May 14 and 15 persisted throughout May 16. A satellite AVHRR image showing surface reflectance in the area 46°-50°N 14°-18°W was received on the Marinet link on May 16 from Plymouth Polytechnic together with a complementary IR image indicating a gyral pattern of high reflectance in the vicinity of the Darwin suggestive of high concentrations of coccolithophores. At this time and also on the following day the sea surface was observed to have a distinct green colour and milky appearance but microscopical examination of fresh 20 µm Apstein net samples revealed few coccoliths but a considerable number of long, thin cylindrical cells (50-100 µm long, 3-4 µm wide), possibly diatoms, which having a high surface:volume ratio may have increased sea surface reflectance.

The final intensive diel sampling programme of the cruise was carried out during May 17 with samples for the various process measurements considered being taken as previously at approximately 4h intervals commencing around 0400. The process measurements were again complemented by routine hydrographic measurements at 4h intervals, an intensive zooplankton sampling schedule, 24h in situ measurements of productivity and microzooplankton grazing experiments. The sampling and

experimental programmes were successfully completed together with a CTD cast in the early afternoon for sampling for natural radionuclide concentrations. During the morning, SAPS serial cast 9 was undertaken with pumps deployed at 15, 50, 125 and 250m; GF/F filters only were fitted to the pumps and all were recovered intact. Recovery of the 250m pump was delayed for a short time following breakage of a hydraulic pipe on one of the aft cranes in the pump room. Repairs to the system were made later in the day.

A very marked decrease in chlorophyll fluorescence values was recorded in the surface waters in the early afternoon of May 17. Although this may be explained in part by the well-established mid-day depression of surface chlorophyll fluorescence, a concurrent major decrease in the HPLC-derived chlorophyll a concentrations was also recorded with 10m values decreasing from 3.49 $\mu g\ l^{-1}$ at 0630 to 1.75 $\mu g\ l^{-1}$ at 1715. No immediately obvious changes occurred in the water characteristics during this time suggesting that the diatom bloom observed over the previous three days had been localised spatially. There were no indications from the vertical fluorescence records of any major shifts in the vertical distribution of chlorophyll a. A further intrusion of cooler, less saline water was again observed in the upper 300m on May 17 and 18, similar to those recorded previously. The feature was not as sharply defined as that recorded on May 15 and lacked evidence of mixing at its upper boundary; nevertheless it had a more marked effect on the sharpening of the pycnocline than did the comparable feature on May 15.

The initial CTD cast at 0015 on May 18 was abandoned owing to a bearing failure on the main winch power pack immediately prior to winch lowering operations. It was estimated that the repair time for the fault was 9h and as a consequence, following requests from the BOFS programme co-ordinator in Plymouth, a decision was taken to break from station and head off in a south-easterly direction to recover the BERTHA rig and Metocean Argos buoy 3916. These rigs, which had been deployed earlier by Discovery as part of the BOFS mesoscale drifter experiment to define the eddy flow field adjacent to the experimental area, had become detached from the central aggregation of the drogues and strong concern was felt about the possible loss of equipment attached to the BERTHA rig and the lack of ship availability for later recovery of the rigs. The productivity rig was recovered by 0220 and course set south-eastwards for the last reported position of BERTHA. Updates on the positions of the Argos buoys on the two rigs were received at frequent intervals from PML via Marinet and direct phone links and radar contact with Bertha was established at approximately 0845. Darwin closed the rig and visual contact was made at 0939. The rig attached to accompanying Metocean Argos buoy 3914 was grappled at 1005 and recovered successfully by 1217 with all components intact. Extreme care was taken in the recovery of the BERTHA thermistor chain to ensure that no damage occurred to the chain while releasing it from the associated deploying line. Course was then set for the last known position of Metocean Argos buoy 3916 and

drogue rig with D/F searches being used to locate the low profile buoy. Contact was established at approximately 1500. Visual contact was made with some difficulty at 1600, owing to the Metocean buoy being painted black, and the buoy with its drogue still attached was successfully recovered by 1623. A course of 279° was then set to resume position adjacent to the Lagrangian experiment target buoy. Position was resumed approximately 2 miles north of the buoy by 2125, this being followed by a standard 300m CTD cast commencing at 2207.

The final full day's work of the cruise was completed on May 19 starting with a 20 µm Apstein net haul from 35m for a microzooplankton sample. A full productivity rig deployment was carried out covering ^{14}C primary production, O_2-based primary production, $^{15}NO_3$ and $^{15}NH_4$ uptake measurements, ambient NO_3 uptake and DOC production. Owing to a backlog of samples, no bacterial production experiment was initiated. Further Go-Flo samples were also taken for longer term (36h) nutrient uptake experiments and also for estimates of microzooplankton grazing rates and for determination of ambient stable isotope and radionuclide concentrations and activity. SAPS cast 10 was carried out during the morning with pumps being deployed at 350, 450, 600 and 800m: all pumps were recovered safely by 1139 with all filters intact.

Rendezvous was made in the early morning with RRS Discovery working the A2 leg of the 1990 BOFS programme and following radio contact with Discovery's PSO, an RVS technician together with certain items of scientific equipment were transferred from Darwin to Discovery. The technician, Phil Taylor, successfully carried out repairs over the course of the day on the Discovery's CTD system, which was non-functioning and which had left the vessel without CTD capability, and returned to Darwin with certain items of stores and two replacement 30 l Go-Flo bottles at 2120. Routine CTD casts and zooplankton net tows continued throughout the day and were supplemented by the final JGOFS Level I deep cast in the afternoon from which a full suite of samples were taken. Considerable variability in the surface chlorophyll fluorescence values was observed during both May 19 and 20 and this variability was reflected in the corresponding HPLC-derived chlorophyll concentrations. Overall, chlorophyll concentrations remained significantly lower than those observed during the earlier "bloom" period while surface nutrient concentrations also remained very low with NO_3 and Si concentrations <0.5 µg-at NO_3-N l^{-1} and <0.2 µg-at Si l^{-1} respectively.

From May 10 to May 18 the target drogue had tracked consistently south-eastwards with, at times, the velocity reaching 14 cm s^{-1}. When Darwin was off station on May 18 the drogue changed course towards the south-west and on May 19 and 20 the course adjusted to a westerly direction.

Opportunity was taken while repositioning the ship in the early hours of May 20 to close the target buoy and replace the batteries in the light unit attached to the associated marker Dhan buoy in order to ensure the light was operational when

Darwin returned to the working area for Leg B2. Position was subsequently taken up 2 miles west of the target drogue at 0400. Go-Flo samples were taken between 0402-0432 and a limited productivity rig deployment commenced at 0601. CTD casts for standard hydrographic measurements were carried out at the routine times over the day while further casts were made at various times for samples for the determination of stable isotope concentrations, bacterial density and production, macrozooplankton associated parameters, natural radionuclide activity and DOC concentrations. A further, relatively weak intrusion of cooler, less saline water into the upper 300m was again recorded from CTD data for May 20. Considerable problems were still being experienced with noisy output from the CTD on this final day and were particularly noticeable on the up runs such that in some instances Niskin bottles had to be fired on a wire-out basis. Suspicion as to the cause of the problem was beginning to focus on the new Neil Brown CTD deck unit which had been fitted to the system immediately before the cruise and which it was thought may have required tuning to the individual cable and CTD sea unit characteristics. This diagnosis was later confirmed following the return of Darwin to RVS. Following the final CTD cast at 2008, the productivity rig was recovered and course was set for Barry at 2200. During the return passage a limited number of samples were taken for selected analyses from the non-toxic supply.

A comprehensive listing of all sampling activity carried out over the duration of the cruise together with all cast numbers appears in Table 1.

Darwin docked on schedule at Barry at 0715 on May 23 following a most successful cruise.

053/1	DEEP	10SDL
055/1	shall	RVS. – but why is ossy fucked.
056/1	shall	RVS opt null
056/2	DEEP	10SDL – ossy messed but shows weeds
056/3	shall	RVS
058/1	shall	RVS
058/5	shall	RVS
061/2.	shall	RVS
061/3	shall	RVS.
061/4	shall	RVS
061/5	shall	RVS
061/6 – light GOOD.	shall	RVS
061/7	DEEP	RVS.
063/3	shall	10SDL. !
063/4	shall	RVS
065/4 – light GOOD	Shall	RVS
		RVS

065/6	shall	10SDL
065/7	shall	RVS
065/8 – light GOOD	shall	RVS
066/2	DEEP	10SDL
067/4	shall	RVS
070/1	shall	RVS
070/2	shall	RVS
070/15 – light GOOD	shall	RVS
073/10	shall	RVS
073/11	shall	RVS
073/12	DEEP	10SDL
073/9	Shall	RVS
079/1	Shall	RVS
079/2	DEEP	10SDL.
079/3	shall	RVS
079/4	shall	RVS
081/3	Shall	RVS
083/1	DEEP	10SDL
084/1	DEEP	10SDL
085/1	DEEP	10SDL
086/1	Shall	RVS

090/4	shall	RVS
095/3	shall	RVS
097/1	shall	RVS
099/1	shall	RVS
104/1	shall	RVS
106/1	S	R
106/2	DEEP	10SDL
DF/1.		

trans – ok for ... slow...

phillipa@e-sclub.

OKY – SCRAPPED.

3. INDIVIDUAL PROJECT REPORTS

3.1 Background Hydrographic and Meteorological Observations

The CTD and associated water sampling programme provided the essential background data necessary for the interpretation of the biological process measurements obtained during the course of the programme. The basic CTD programme consisted of a continuous series of 300m dips at approximately 6-hourly intervals with times varied as necessary to fit other programme requirements. Water samples for a variety of analyses were taken at standard depths of 2, 10, 20, 30, 40, 50, 60, 75, 100, 150, 200 and 300m. Extra CTD casts were made as required to provide samples for stable isotope and natural radionuclide assays and also to complement the macrozooplankton sampling programme. Six full column casts were also carried out over the cruise to provide samples for JGOFS Level I programme requirements. In the absence of a 24-bottle Rosette system, the full column casts were carried out as two dips: the first, a standard cast to 300m and the second to the bottom with samples being taken from 400, 500, 600, 700, 800, 1000, 1200, 1500, 2000, 2500, 3000m and the bottom (usually between 4000-5000m). Temperature calibrations using electronic reversing thermometers were carried out on each dip and calibration samples taken, also from each dip, for determination of salinity, using an Autosal salinometer, and chlorophyll *a* using acetone extraction and fluorescence determination. Profiles of beam transmittance and dissolved oxygen concentrations were also obtained from the CTD system.

In general the CTD system performed reasonably satisfactorily with only a small loss of operating time from faults. The majority of problems encountered have been described in Section 2 above and credit must be given to Phil Taylor (RVS technical staff) for keeping the system running throughout. The most serious problem, which was not resolved until the return of the ship to RVS, concerned the intermittent loss of output from the deck unit. The intermittent nature of the fault made diagnosis difficult although suspicion eventually lay with compatibility of the new system deck unit. Although the problem did not result in any major loss of programme continuity, nevertheless a considerable amount of technician time was taken up in its investigation.

All basic CTD data was logged on the ship's computer and considerable assistance was obtained from access to real-time data plots. Preliminary time-series distributions of the main parameters are shown in the Appendix. The CTD data files were deposited with BODC at the end of the cruise and are currently being cleaned, calibrated and processed as required.

Meteorological data, including PAR, wind velocity and wet and dry bulb air temperatures were recorded continuously throughout the cruise from the Multimet package and logged on the ship's computer. Continuous records of sea surface (4m) temperatures and salinity, chlorophyll fluorescence and dissolved

oxygen concentrations using a pulsed oxygen electrode were also made throughout the cruise with calibration samples being taken routinely. The necessary flow-through water supply was obtained from the ship's non-toxic system. Both the continuous sea-surface data and the meteorological data have been deposited with BODC for cleaning and processing.

Nutrient samples were analysed shipboard for NO_3-N, NO_2-N, NH_4-N, PO_4-P and Si using the RVS Chemlab auto-analyser. The analyser generally performed well throughout the cruise although some difficulty was experienced early on from a NO_3-contaminated batch of NH_4Cl reagent which had been supplied. A steady base-line was maintained while using the reagent and the contamination was not sufficient to prevent the base line being backed off.

The intercalibration exercise with the Tyro was of considerable value. In the exchange of standards, when allowance had been made for the diluting matrix, agreement to within one per cent of the nominal concentration of the U.K. standards was obtained by the Dutch. U.K. determination of the Dutch standards, diluted with deionised water, showed an approximate 10% consistent overestimate in the case of NO_3-N, a small overestimate ($\sim$6%) for PO_4-P and a small but consistent underestimate for Si (Table 2). These trends were also reflected in the concentrations obtained by the two teams from the common samples taken from the Tyro Level I CTD cast (Table 3).

A further problem occurred with the auto-analyser DAS. Persistent electrical noise was experienced throughout the cruise on the output of the analyser (this noise also affected other scientific equipment and the ship's radio equipment) and no success was had in the finding of the source. However, since the noise prevented a stable base line on the analyser being obtained, it was not possible to use the DAS and nutrient values had to be read off and input manually from the analogue record. This task is currently being completed and the data, as previously, will be deposited with BODC.

Tables 4-7 present background data on selected navigational, meteorological and biological variables monitored continuously throughout the cruise while Figs. 1-6 show the ship's track and drift of the Lagrangian drogue over the cruise period together with sections derived from the ship's computer showing changes in temperature, salinity, σ_t and chlorophyll a fluorescence in the top 300m again over the duration of the cruise.

Graham Savidge

3.2 Pigments and Biomarkers

3.2.1 Introduction

The aim of this project was to conduct a sampling and survey programme of organic biomarker compounds in order to identify and quantify the fluxes and fates of organic carbon during the "spring bloom" in the North East Atlantic. These biomarkers may be used as chemotaxonomic tools to indicate the principal classes present and to assess the fate of the phytobiomass in the water column. In addition, information on degradation activity from zooplankton grazing and microbial decomposition may also be obtained.

3.2.2 Surveys

3.2.2.1 Time Series Study

The objective was to track the temporal changes in pigments in the upper mixed layer during the course of the bloom. Samples were taken each day at 10m and 30m from CTD casts at 0600 and 1800. One litre water samples were filtered through 25mm GF/F filters.

3.2.2.3 Level One Casts

The objective was to obtain vertical profiles of pigments down to 300m. Samples were taken at 2, 10, 20, 30, 40, 50, 60, 75, 100, 150, 200 and 300m from six shallow (0-300m) CTD casts. Two litre water samples were filtered through 47mm GF/F filters.

3.2.2 Size Fractionated Pigment Distribution

The aim was to determine the distribution of pigments in various size fractions of the algal community. Samples were taken at 10m and 35m from Go-Flo bottle casts at 0430 on selected days. Initially, one litre samples were filtered through a stack of three 47mm Nuclepore filters (5, 1, 0.2 µm) separated by 200 µm nylon mesh, and one litre was filtered through a 47mm GF/F filter (total). Further one litre samples were taken for filtration on Nuclepore filters for a comparison of the filtration procedure. One litre was filtered through a stack of filters as described above, and another litre was filtered through a set of filters by first filtering through a 5 µm filter, collecting this filtrate, then filtering through a 1 µm filter, collecting the filtrate and finally filtering through a 0.2 µm filter.

3.2.2.4 Tyro/Darwin Intercalibration

On May 16 an intercalibration exercise was undertaken with Dutch scientists in the study area. Duplicate two litre samples were taken at 2, 10, 15, 20, 25 and 35m from Go-Flo bottle casts between 0845 and 1015 and filtered through 47mm filters. One set of filters was retained for analysis of pigments and the

duplicate set handed to Dr Gijs de Kraay on board the Tyro.

3.2.2.5 Underway Sampling

One litre samples were taken from the non toxic sea water supply on the return leg and filtered through 25mm GF/F filters for analysis of pigments. These samples will give an indication of the onshore-offshore gradient distribution of pigments and also serve as a calibration for the in situ flow-through fluorometer.

3.2.2.6 SAP Survey of the Water Column

The aim was to obtain surface to bottom vertical profiles of pigments, POC and organic polymers. Ten SAP casts were completed with particulate matter being collected from various depths on 293mm GF/F filters. Subsamples from the filters were taken for organic compounds (Mark Gough, PML), lipids (Maureen Conte, Bristol Univ.) and stable isotopes (Hilary Kennedy, UCNW) using a 58mm punch. Further subsamples for pigments and POC were taken using a 22mm punch.

3.2.3 Observations and Results

3.2.3.1 Time Series Study

A total of 64 samples were analysed for pigments during the cruise using a Shimadzu HPLC system and a Perkin Elmer fluorescence detector. The HPLC performed satisfactorily, but there were problems with changing retention times, due probably to changes in temperature during the day in the main laboratory. Vibration from the ship's engines also caused considerable noise in the baselines of the chromatograms.

Preliminary chl a concentrations were estimated from the fluorescence chromatograms, and at the 10m depth these increased from 1.2 µg/l on May 1 to reach a maximum of 3.7 µg/l by May 15 (Table 8). Thereafter, chl a concentrations at 10m decreased over the next 5 days until we departed from the study area on the May 20. Chl a levels at 30m (bottom of the mixed layer) were lower than at 10m and varied considerably between 0.5 and 2.9 µg/l. In the late afternoon on May 17 and 20 concentrations at 30m were greater than at 10m, indicating that the algal community was beginning to sink to deeper depths.

Quantitation of the major chloropigments and carotenoids is not yet complete, but observation of the chromatograms indicated the presence in all samples of chl c3, chl c1 and c2, peridinin, butanoyloxyfucoxanthin, fucoxanthin, hexanoyloxyfucoxanthin, diadinoxanthin, lutein/zeaxanthin, chl b, chl a and B-carotene. This suite of pigments indicates that the microalgal community was composed mainly of prymnesiophytes, diatoms, dinoflagellates and chlorophytes/ prochlorophytes. In addition, chlorophyllide a, phaeophorbide a, phaeophorbide-like and phaeophytin a were also detected. The phaeophorbides appeared to be the dominant breakdown products of chl a and most likely originated from zooplankton faecal material.

3.2.3.2 Level One Casts

A total of 6 x 12 samples (72) were taken and frozen for later analysis of pigments by HPLC.

3.2.3.3 Size Fractionated Pigment Distribution

Nineteen samples were analysed for pigments on board and the distribution of chl a between various size fractions is shown in Table 9. The results for May 12 show that the procedure used in filtration appears to influence the size distribution of pigments. The stack procedure resulted in the greatest percentage of chl a being detected in the >5 µm fraction (48%), whereas the procedure of filtering through each filter independently gave the greatest proportion in the 1-5 µm fraction (55%). Further research is required to optimize the filtering procedure for size fractionation.

3.2.3.4 Tyro/Darwin Intercalibration

The six samples were analysed and the preliminary depth profile of chl a revealed a decrease in the concentration of the pigment from 2m to 35m (Table 10). Further work up of the chromatographic data has to be completed.

3.2.3.5 Underway Sampling

Eight samples were taken at various positions on the return leg and frozen for later analysis of pigments. A note was also made of the reading on the flow-through fluorometer.

3.2.3.6 SAP Survey

Considerable problems were encountered in the deployment of the SAP pumps, the main problem being with split filters. Five pumps were initially deployed on May 1 for a deep cast to 4000m and on recovery only one pump appeared to have operated satisfactorily. Subsequent tests revealed that three of the pumps could be used without further attention, while RVS personnel managed to get a fourth pump operational. Details of the problems with the pumps have been prepared by Hilary Kennedy.

Twenty-seven GF/F samples were obtained from depths ranging from 15m to 3500m, and 10 of these filters were found to have splits varying in length from 50-70mm to 290mm. Subsamples from 1500 and 2000m were analysed for pigments and the chromatograms indicated the presence of chl a and phaeophorbides at these depths. However, the noisy baselines on these chromatograms led to difficulties in distinguishing the chromatographic peaks from baseline noise and it was decided to postpone analysis of SAP samples until these could be done at PML under more stable conditions.

Ray Barlow

3.3 ^{14}C Size-fractionated Primary Production and High Resolution Nitrate Uptake Estimated

The experimental procedures performed on CD46/90 were adopted in order to determine the temporal and spatial variations in the size spectra of natural assemblages of phytoplankton, and to assess the relationship of the above variations with other biological and chemical processes occurring in the water column.

Primary production by the different size fractions of phytoplankton was estimated during the cruise using ^{14}C uptake experiments. Three modes of ^{14}C uptake experiment were carried out during the cruise period: in situ incubations, on deck incubations and P:I experiments employing an artificial light gradient incubator. As for the 1989 sampling programme, all ^{14}C uptake experiments involved size fractionating the phytoplankton after the incubation period into the 0.2 - 1.0 um, 1.0 - 5.0 um and > 5.0 um size fractions. Clean water sampling techniques were again used, with all samples being collected from Go-Flo bottles mounted on Kevlar line. Improvements in clean sampling techniques this year included the successful use of modified teflon messengers and filling/rinsing treatments of the Go-Flo bottles prior to sailing.

In situ productivity experiments were performed each day over the cruise period except for May 18, using samples obtained from each of the standard sampling depths of 2, 10, 15, 20, 25, 35 m. A detailed listing of the times of commencement and completion and recovery of the deployment of the in situ experiments together with details of concurrent in situ estimates made is given in Table 11. A parallel UK - Netherlands in situ ^{14}C uptake intercalibration experiment was performed on May 16 using common water samples obtained using UK Go-Flo samplers, and with the deployment and recovery of the productivity rigs being synchronised. The shipboard liquid scintillation counter was used to compare the activities of ^{14}C stock solutions used by Tyro and Darwin.

A number of in situ experiments were performed concurrently and at depths common to the above ^{14}C uptake experiments; these included changes over 24 h in chlorophyll a concentration and nitrate concentration, and the estimation of net exudation of photosynthate.

A series of ^{14}C uptake experiments were performed, using an on deck incubator, as a component within a programme of diel experiments. These experiments were carried out in order to examine diel variation in the ^{14}C uptake and photosynthetic characteristics of the phytoplanktonic populations over the water column. The ^{14}C incubations were part of a series of measurements, carried out by several cruise participants, to investigate diel variations in a range of biological rate

processes and standing stocks. The ^{14}C diel experiments were performed over selected incubation periods: 0600-1000h, 1000-1400h, 1400-1800h and 1800-2200h.

Samples were obtained from 2 m and 35 m from Go - Flo samplers two hours prior to each incubation period for the on deck ^{14}C uptake experiments. Neutral density screening was employed to simulate the % surface PAR predicted for the above sampling depths. In addition to the on deck experiments, common water samples were used to perform concurrent P:I experiments (12 irradiances) on May 4, 5, 11 and 17.

A suite of seven P:I characterisations, in these instances using 4h incubation periods and a range of 24 irradiances, was also carried out using samples from the surface mixed layer and the thermocline region in order to assess differences in P:I characteristics as related to the prevailing vertical stability. The experiments was carried out using samples collected over various dates from selected depths as follows: May 1 (2m), May 2 (10m), May 3 (35m), May 7 (2m), May 10 (2m), May 14 (2m) and May 20 (35m).

Measurements of the net exudation of photosynthate over 24 h, as estimated from $DO^{14}C$ production, were obtained on selected dates using the treated filtrate (< 0.2 um) from the size - fractionated samples that had been incubated in situ. These measurements were made in order to examine the pattern of net exudation rates over the duration of the cruise, with samples being taken from the standard sampling depths on May 1, 3, 5, 7, 9, 10, 13, 15, 17. In addition to the above estimation of net exudation using $DO^{14}C$, measurements of initial and final DOC concentrations (after 24 h incubation), obtained from common water samples, were made by another cruise participant. It is hoped that this will afford comparisons between changes in DOC over the water column over a 24 h period and the net production of $DO^{14}C$ during this time.

Chlorophyll a concentrations were determined for the 0.2 - 1.0 um , 1.0 - 5.0 um and > 5.0 um fractions using water samples common to those drawn for the ^{14}C in situ incubations. Changes in chlorophyll a concentration over the 24 h in situ incubation period were also monitored. Initial and final (after 24 h) concentrations were obtained for each of the above fractions over the water column throughout the cruise, with the exception of the May 18 when no final samples were incubated in situ.

In order to obtain samples of natural phytoplanktonic assemblages over the water column, water was sampled from the Go-Flo casts used to obtain water for the ^{14}C uptake in situ

experiments and added to tissue culture flasks, two per depth. The planktonic material in each flask was then preserved using either Gluteraldehyde or Lugol's solution. This preserved material will be used in conjunction with image analysis, carried out at PML, to determine phytoplanktonic size spectra over the water column throughout the cruise period.

Nitrate analyses, using the NOx chemiluminescent analyser, were performed for both uptake experiments and routine nitrate measurements. Routine measurements were made when ambient nitrate concentrations of < 1.0 uM were encountered, these being typically associated with the upper region of the surface mixed layer during the spring bloom. Nitrate uptake experiments were carried out using size fractionated samples, which were placed into an on-deck incubator. Fractionated water samples were obtained prior to the incubation using differential filtration under gravity to obtain < 5 um and < 1 um fractions; an unfractionated sample was also used for each of the uptake experiments. Uptake rates for each fraction were therefore obtained by difference (< 1 um, 1 - 5 um and > 5 um) at 0, 1, 2, 4, 6, 8, 10 and, on occasions, 12 h over the incubation period.

Experiments measuring changes in nitrate concentration over a 24 h incubation period were performed concurrently and at common depths to those used for the ^{14}C in situ experiments. Changes in nitrate concentration were calculated by subtracting final from initial concentration. Initial concentration referred to the nitrate concentration of the sample measured immediately after the water had been drawn from the Go-Flo sampler, whilst final concentration referred to a common sample, the nitrate concentration of which was measured after the retrieval of the in situ incubation rig, after 24 h. In the majority of instances, the on deck and in situ approaches were performed concurrently, thus permitting an appraisal of on deck versus in situ nitrate uptake rates and also the examination of the relative contribution to community uptake rates by the selected size fractions.

Nitrate uptake experiments were performed on the following dates: May 6, 8-9, 12-15 and 18-19.

Philip Boyd

3.4 Primary Productivity and Community Respiration by O_2 and TCO_2 Changes

3.4.1 Objectives and Experimental Protocol

The objectives of this programme were to determine 24h rates of primary production and community respiration using the precise automated Winkler titration for dissolved oxygen and the coulometric method for total inorganic carbon determinations.

In situ rates of O_2 and TCO_2 flux were measured at 2, 10, 20, 35 and 75m on May 1, 3, 7, 9, 14, 17 and 19 over periods of approximately 20h. Parallel estimates of ^{14}C production and ^{15}N production were carried out at 2, 10, 20 and 35m with bacterial production being estimated in samples from all five depths. Sample water for the incubations was collected around 0400 in Go-Flo bottles using clean techniques. Light and dark incubation bottles were filled (4 replicates for O_2; 3 replicates for TCO_2) and the light bottles incubated in situ mounted on Dexion frames set at the depth of sample collection. The frames were attached to the ^{14}C productivity rig and tethered to the ship; dark bottles were incubated shipboard in deck incubators. The rigs were deployed around 0600 and recovered in the early hours of the following morning prior to fixation.

In addition to the in situ estimates, two O_2 and TCO_2 diel change experiments were run in conjunction with parallel determinations of phytoplankton ^{14}C uptake characteristics. Twice daily calibrations of the pulsed oxygen electrode continuously monitoring dissolved oxygen concentrations from the non-toxic supply were also carried out. Calibrations for the CTD oxygen electrode were performed as required and all JGOFS Level I sampling requirements were fulfilled. Table 12 lists the detailed sampling schedule of O_2 and TCO_2 measurements carried out during Darwin cruise 46/90.

3.4.2 Conclusions

Several instrumental problems were encountered at the start of the cruise in both the O_2 and TCO_2 analytical systems. These problems were eventually resolved although all oxygen determinations had to be carried out manually.

Preliminary analysis of the data set obtained appears particularly encouraging. Rates of gross production of O_2 increased from 7.9 µmol kg^{-1} on May 1 (PQ=2) to 23.9 µmol kg^{-1} on May 9 (PQ=1.35) and decreased again to 15.2 µmol kg^{-1} on May 19. All gross production profiles showed a surface maximum.

Net production followed a similar trend with values increasing from approximately 5.0 µmol kg^{-1} on May 1 to 16.8 µmol kg^{-1} on May 9 and decreasing to 3.3 µmol kg^{-1} on May 19. Initially respiration rates were low, of the order of 2 µmol kg^{-1}, and consistent with depth. However during the course of the cruise, values increased to approximately 11 µmol kg^{-1}.

Emily Wood

3.5 ^{15}N New and Regenerated Productivity

3.5.1 Introduction

The main objective of the cruise was to monitor the uptake of 'new' and 'regenerated' forms of nitrogen in primary productivity during the development of an open ocean phytoplankton bloom. Planktonic 'new' production is represented by the input and uptake of NO_3 from upwelling, eddy diffusion, riverine and atmospheric sources, whereas planktonic 'regenerated' production is represented by the uptake of NH_4, urea, amino acids and dissolved organic nitrogen compounds recycled within the euphotic zone. Here, standard ^{15}N techniques using ^{15}N labelled nitrate and ammonium were to be used to study new and regenerated productivity respectively.

3.5.2 Sampling Method and Data Collection

3.5.2.1 Introduction

An intensive sampling programme was devised with the aim of monitoring changes in new and regenerated productivity over time utilising both 24h in situ productivity rigs and 6h on board incubations. In addition, diel sampling was carried out on 3 occasions sampling at 4 hourly intervals over a minimum time period of 24 hrs. Table 13 gives details of all samples taken during the cruise.

3.5.2.2 In situ Productivity Sampling

Water samples were collected 2 hrs before dawn using 30l Go-Flo bottles mounted on Kevlar line. Sampling depths were fixed at 2, 10, 15, 20, 25 and 35m to simplify productivity rig deployment. Irradiance data available from CTD casts will enable light intensities at these depths to be calculated, which, with minor daily deviations, should cover a 100-0.1 % light intensity range.

At most sample depths repeat firing of Go-Flo bottles was necessary to accomodate individuals water requirements. Wherever possible the same Go-Flo bottle was used for O_2 and ^{14}C productivity experiments to enable meaningful comparison of productivity data and to allow for calculations of C:N ratios. For the 2m surface water sample this was not always possible and comparative analyses between two separate 2m Go-Flo water samples were made to check for possible variations over a sampling time interval of 5-10 minutes. In conjunction with several of the ^{15}N productivity experiments samples were taken for ^{15}N natural abundance work carried out by Hilary Kennedy (see Table 20).

3.5.2.3 On-board Incubations

On-board incubations were carried out on alternate days when it was not possible to carry out 24h in situ incubations due to logistics of sample turn around. A temperature-controlled

artificial light incubator was used to incubate samples over a 6h period of constant light. Meshes over bottles were used to simulate the light intensity of 4 depths: 2m (no mesh), 10m, 35m and 50m. Table 13 indicates the depths and frequency of on board incubations.

3.5.2.4 $^{15}NO_3$ and $^{15}NH_4$ Substrate Additions

Throughout the entire sampling procedure and sample preparation prior to rig deployment, care was taken to avoid light shock of the samples. $^{15}NO_3$ and $^{15}NH_4$ were added to replicate 21 water samples to give 10% of the ambient NO_3 and NH_4 concentrations measured at each depth. Difficulties were encountered with this due to alternating high and low nitrate values from CTD casts flanking the Go-Flo sampling. An attempt was made to predict these variations and to spike with substrate conncentrations of values intermediate to the two casts.

Towards the end of the cruise as the phytoplankton bloom developed and nitrate values dropped to nearly undetectable, nitrate was spiked to end concentrations of 0.02 µm l^{-1} compared to initial surface water end concentrations of 0.5 µm l^{-1} at the start of the cruise. NH_4 values changed less dramatically with surface water spiked end concentrations dropping from 0.1 µm l^{-1} initially, to final values of 0.01 µm l^{-1}. At depth, NO_3 and NH_4 concentrations were high and increased slightly over the cruise. At 35m ambient NO3 values rose from 6 µm l^{-1} to a mid-cruise peak of 8 µm l^{-1} on May 11 and dropped back to 6 µm l^{-1} from May 13 onwards. Whilst NH_4 remained at an ambient concentration of between 1.0-1.8 µm l^{-1} it dropped slightly to <1.0-1.0 µm l^{-1} in the final stage.

3.5.2.5 Rig Deployment and Recovery

Productivity rigs were deployed pre-dawn and recovered the following day at 0130-0200. ^{15}N water samples were incubated in situ in conjunction with O_2 and CO_2 productivity samples on the same line and bottle frames, whilst ^{14}C was incubated on a different rig set-up with a horizontal separation from the first rig of 100m.

3.5.2.6 Sample Processing

On recovery of the rigs ^{15}N samples were filtered and size fractionated with >75 µ and <5 µ fractions. Filtering of all samples usually took between 6-8 hrs, and it is suggested that a more efficient filtration system should be devised to speed up the filtering process which inevitably progressively prolongs the incubation of deeper samples. Pending filtration, all samples were sorted at ambient seawater temperatures in the dark to reduce NO_3 and NH_4 uptake rates over this period.

3.5.2.7 Sample Analysis

No on-board analysis was carried out. All filters were frozen in preparation for analysis by mass spectrometry at PML.

Sarah Bury

3.6 Size-fractionated Phytoplankton Multiple Nutrient Uptake Experiments

A series of size-fractionated phytoplankton nutrient uptake experiments were carried our during the cruise in order to determine interactions between the uptake of NO_3-N, NH_4-N, Si and PO_4 over the course of 32h incubations. Nutrient changes were established using auto-analytical techniques and a common experimental approach used throughout.

Water samples were collected from 2m and 35m, the latter representing a sample from the bottom of the well mixed euphotic zone coincident approximately with the nutricline. Light levels at these depths were in the region of 50% and 1% surface irradiance respectively and were experimentally re-created in the on-deck flow through incubator using a combination of perspex sheeting and black cotton shading.

Whole samples were fractionated prior to incubation using negative or reverse filtration to derive a <5µm and a <1µm fraction. The <0.2µm fraction was collected under low vacuum.

Water samples were collected from Go-Flo casts at approximately 0400, stored in the dark until use and fractionated at 0900 prior to incubation which commenced at 1000 approximately. Samples were incubated in 2l polycarbonate bottles and sub-samples for nutrient analysis were taken at 0, 10, 20, 30, 40 and 50 mins and 1, 1.5, 2, 4, 6, 8, 10, 13, 20, 22, 24, 26, 28, 30, 32h after the start of each experiment. The more intense sampling carried out during the first hour was designed to establish any initial rapid ammonia uptake while the program as a whole continued over 32h so as to include two periods of daylight and one of darkness such that any diurnal changes in uptake rate could be detected.

Following collection the sub-samples were immediately placed in the dark at 4°C until analysis could be carried out on the RVS Chemlab Autoanalyser. This period of storage was kept to a minimum. Each sub-sample was analysed for NO_3-N, NO_2-N, NH_4-N, PO_4-P and Si.

Six uptake experiments were carried out during the cruise on May 2-3, 4-5, 7-8, 9-10, 12-13 and 14-15. As the cruise progressed, ambient nutrient concentrations decreased and the experimental procedure was modified to take this into account. Silicate concentrations decreased first to undetectable levels and at this time experimental bottles were spiked with 4µM of silicate. Under these conditions a secondary objective was to study possible nutrient limitation of phytoplankton growth and sampling was restricted to 2m since at 35m nutrient concentrations were unlikely to be limiting. This experimental protocol was followed for the experiment on May 17-18. When other nutrient concentrations subsequently decreased markedly, a final nutrient enhancement experiment was carried out using an

array of spiking combinations. In these later experiments, sample fractionation was omitted due to practical constraints in favour of increasing the possible range of nutrient additions. Using a 2m surface sample the following nutrient combinations were added: NO_3-N, Si, NH_4-N, NO_3-N + Si, NH_4-N + Si, NO_3-N + Si + NH_4-N. 4µM spikes of both NO_3-N and Si were used in each case and NH_4-N additions of 2µM where relevant. In addition, unenriched samples from 2m and 35m were also incubated at 50% and 1% Io respectively over the incubation period of 30h. This procedure was carried out for the final experiment of May 19-20.

Linda Gilpin

3.7 Mesozooplankton Biomass and Grazing

3.7.1 Objectives

The main objectives of this programme were two-fold:

(i) To characterize the water column in terms of phytoplankton biomass and particulate composition (carbon:nitrogen, carbohydrates and proteins, and species composition) and the changes in these parameters through a short term period covering the spring bloom in the north-east Atlantic, in order to evaluate the influence of water column conditions on the development of zooplankton communities and their grazing capabilities.

(ii) To characterize the structure of zooplankton communities, with emphasis on the mesozooplanktonic fraction, as they develop through the spring bloom period in the north-east Atlantic, and to evaluate their grazing impact on phytoplankton biomass and primary production.

3.7.2 Sampling

The sampling programme consisted of serial vertical hauls by a variety of zooplankton nets worked on a 3-day cycle continuously throughout the cruise. These samples were augmented by a limited number of water bottle samples taken from the CTD/Rosette Niskin or Go-Flo bottles. Details of the sampling programme appear in Table 14.

3.7.3 Preliminary Results

3.7.3.1 Particulates

All analyses, except phytoplankton biomass by fluorescence, are to be analysed back in the laboratory. The levels of chlorophyll *a* in the water column were relatively high during the whole sampling period (1-20 May) in the surface 30m. Below this depth, the levels decreased sharply. The >5µm fraction was variable, accounting for between 10 and 50% of the total biomass. In a small exercise of intercalibration, the field values of chlorophyll *a* read in the fluoprometer were relatively close to those measured by HPLC.

3.7.3.2 Mesozooplankton Biomass

The mesozooplankton was dominated by copepods in the small size fraction (200-500µm); also copepods in smaller sizes (microzooplankton) were abundant. Among the dominants groups were *Paracalanus*, *Microsetella*, *Oithona* and copepodite early stages.

There was a marked vertical migration by the medium (500-1000µm) and large (1000-2000µm) size fractions, which were almost absent in the surface 200m during the day but migrated to surface

waters around dusk and disappeared by dawn. These fractions were dominated by Pleuromamma species and Metridia, in different developmental stages. Developmental stages of amphipods were abundant in these samples, and gelatinous forms appeared more to the end of the period. Large 'spines', apparently derived from radiolarians, acantharians or other, were very abundant in most of the samples making the fractionation of the samples extremely difficult.

Complementary samples were taken for analyses of development of copepod stages during the period, for estimation of mesozooplankton by the 200µm mesh (both ends), and for fecal pellets.

An intercalibration exercise with the Dutch vessel Tyro was carried out during daylight on 16 May. This exercise will allow us to assess possible bias in sampling biomass with the WP2-200 net.

3.7.3.3 Mesozooplankton Grazing

The levels of pigments in the guts of copepods were relatively high in all three size classes with marked diel variations, mainly due to the migration of the medium and large size fractions of copepods. The levels in the large fraction were three times higher than those measured last year in the area during summer conditions when lower levels of chlorophyll prevailed. Large Pleuromamma were responsible for the high gut pigment values, and this is the same species from which last year results were obtained. Only a few late stages of Calanus appeared towards the end of the cruise. It is interesting to remark the fact that Pleuromamma is a poorly studied genus; its position as a feeder has been only vaguely defined. Through previous results and this year observations, we can provide evidence that the species in the area are major phytoplankton consumers and, by migrating, they actively transport particulate material down the water column. The measurements on board of evacuation rate in filtered seawater were relatively low, suggesting that after feeding in the surface waters, they may produce fecal pellets at depths down to 300-500 metres.

Carmen Morales
Bob Head

3.8 Microzooplankton Trophodynamics

3.8.1 Aims

(i) To determine microzooplankton herbivorous activity in the surface mixed layer.

(ii) Determination of microzooplankton biomass and size distribution from vertical profiles in the surface mixed layer.

Profiles and grazing rate measurements were made on alternate days during the 20 days on station, resulting in a total of 12 grazing experiments and 12 profiles, 4 of which were for Level I measurements. A summary of all sampling details is given in Tables 15-17.

3.8.2 Dilution Grazing Experiments

Dilution experiments were carried out using the dilution approach of Landry & Hassett (1982). Water was collected from 30 litre Go-Flo bottles from either 10 or 25m at dawn and screened through a 200µm mesh. Dilutions were made up in 2 litre bottles and incubated at ambient light and temperature levels for 24 hours. Samples were taken at 0, 12 and 24 hours for determination of chlorophyll concentration, nutrient abundance, trophic composition and biomass. Size fractionated chlorophylls were taken for half of the experiments using polycarbonate membrane filters of pore sizes, 0.2, 2 and 10µm.

3.8.3 Vertical Profiles

Microzooplankton biomass samples were collected in conjunction with the grazing experiments. Water was collected using the CTD; 9 depths were chosen from the top 300m, these being detailed in Table 16. Appropriate volumes of water were fixed in 1% acid Lugols for determination of total microzooplankton abundance, 2% glutaraldehyde for determination of nanoplankton abundance and 2% buffered formaldehyde to determine what proportion of the ciliates were plastidic and what proportion of the microplanktonic dinoflagellates were non-plastidic. Samples were also preserved in glutaraldehyde, stained with DAPI and proflavin, filtered onto Nuclepore filters and stored frozen for subsequent analysis by epifluorescence microscopy.

3.8.4 Apstein Net Hauls

A series of 20µm Apstein net hauls through the surface mixed layer were performed. Half of the sample was fixed in 1% Lugols for qualitative analysis in the laboratory, the other half used for live microscopic observation.

3.8.5 Results

Grazing: most of the analysis for the grazing experiments will be done in the laboratory, but results of the 2 experiments

already analysed suggest that microzooplankton are turning over approximately 20-30% of the phytoplankton biomass each day.

Apstein net samples: Microscopic observation of live samples indicated a change in the species composition throughout the duration of the cruise. In the early stages samples were dominated by the tintinnid Dictyocysta, Ceratium sp., silicoflagellates, radiolarians and acantharians while small dinoflagellates were also numerous. Dictyocysta numbers seemed to fall off towards the end of the cruise, giving way to a wider variety of diatoms and dinoflagellates, Ceratium sp., Peridinium sp., Gonyaulax, Dinophysis, Rhizosolenia and Chaetoceros and some tintinnids including Eutintinnus and Codonellopsis.

Elaine Edwards

3.9 Trophic Role of Planktonic Ciliates

3.9.1 Introduction and Aims

Planktonic ciliates comprise a major group within the microzooplankton. They are significant grazers of microbial production and are potentially important as agents in the transfer of this microbial production to higher trophic levels within pelagic food webs. The aim of this study was to investigate the trophic role of ciliates from North Atlantic surface waters during the duration of the cruise, allowing further insights into microzooplankton trophodynamics. Specific objectives were to:

(i) determine ciliate community production by size fractionation assay

(ii) determine macrozooplankton grazing of ciliate production by size fractionation assay

(iii) qualitatively determine the size selectivity of individual ciliate taxa using inert fluorescent microspheres as tracers of food particle uptake.

3.9.2 Methods

A total of 5 fractionation experiments and 10 microsphere grazing experiments were undertaken on water samples taken by Go-Flo bottles from 10m and 25m depth (sampling details outlined in iv (5). Experiments were undertaken in conjunction with microzooplankton grazing experiments.

3.9.2.1 Size Fractionation Assays

Minimum estimates of growth rate and production of ciliates can be calculated from the change in abundance and biomass of cells during incubation in the absence of larger macrozooplankton (>200µm) predators. Comparisons with unfractionated controls thus allows the determination of macrozooplankton predation on ciliates. For each experiment replicate 2-litre unfractioned and 150µm fractioned samples were incubated under ambient light conditions for 0, 24 and 48 hours and then preserved for determination of ciliate abundance and biomass by inverted microscopy. During some experiments additional samples were incubated for 6 hours and for 24 hours in situ. 50µm fractioned treatments were also undertaken.

3.9.2.2 Microsphere Grazing Assays

For each experiment inert fluorescent microspheres of 1, 5 and 10µm size were added to 250ml water samples at 10% ambient algal and bacterial concentrations. The samples were incubated under ambient temperature and light conditions for 0, 10, 30 and 60 minutes and then preserved for the qualitative determination of microsphere uptake by inverted fluorescent microscopy.

3.9.3 Results

A complete assessment of the results of both the fractionation and microsphere grazing experiments awaits the post-cruise analysis of the preserved samples. Preliminary analysis of the initial fractionation experiments was, however, undertaken on ship revealing a diverse ciliate community at both 10m and 25m. Negative growth rates were observed for most ciliate taxa with losses of up to 50% of some ciliate populations during 24 hours incubation. These negative rates can be attributed to predation upon ciliates by high numbers of small metazoans observed within the fractionated samples; however, other methodological loss factors may have contributed. Predation by the macrozooplankton of up to 50% of the larger ciliate populations was also observed at 10m depth, but not at 25m. These preliminary data thus indicate a significant flux of ciliate production to metazoans within the micro- and macrozooplankton.

3.9.4 Other Activities

Other activities included the establishment of cultures of common ciliate taxa and assistance with Level I microzooplankton sampling.

3.9.5 Sample Details

Assay	Expt. no.	Go-Flo Cast No.	Depth (m)
Fractionation	1	0305G13-15	25
	2	0705G13-15	10
	3	1105G12-14	25
	4	1505G10-12	10
	5	1905G19-21	25
Microsphere	1	0105G12	10
	2	0305G15	25
	3	0505G10	10
	4	0705G15	25
	5	0905G13	10
	6	1105G14	25
	7	1305G08	10
	8	1505G12	25
	9	1705G12	10
	10	1905G21	25

3.10 Plankton Taxonomic Observations

3.10.1 Net Samples

These samples were taken by 20µm Apstein net haul from about 30-50m deep to surface as part of the Level 1 microzooplankton measurements. For each sample half was preserved and half observed live on ship. The observations are therefore, at best, semi-quantitative. Only robust organisms larger than 20µm in size, i.e. some components of the microplankton (20-200µm) and the macroplankton (>200µm), will have been sampled by the net.

Throughout the cruise the following were observed on live samples:

Diatoms:	Asterionella sp. Chaetoceros type Coscinodiscus sp. Rhizosolenia sp. Thalassiosira type Common unidentified long thin type + others
Dinoflagellates:	Ceratium furca type C.fusus type C.tripos type Dinophysis sp. Gonyaulax sp. Gymnodinium sp. Gyrodinium sp. Noctiluca sp. Oxytoxum sp. Peridinium sp. Prorocentrum sp. + others
Chrysophytes	Phaeocystis type Silica flagellates
Foraminiferans:	Unidentified
Radiolarians:	Unidentified
Acantharians:	Unidentified
Ciliates:	Codonella sp. Codonellopsis sp. Dictyocysta sp. Eutintinnus sp. Laboea sp. Parundella sp. Proplectella sp. Salpingella sp. Stombidium type

Crustacean Zooplankton: Unidentified

The algal community was dominated on most occasions by Ceratium, Peridinium type, Asterionella, Rhizosolenia (at the start of the cruise) and the common long thin unidentified diatom (towards the end). The loricate ciliate Dictyocysta was also common. About ten days into the cruise numbers of algae seemed to increase at the same time as silica levels decreased with numbers then dropping to their former level.

3.10 Sedimented Whole Water Samples

These samples (acid Lugol's fixed) were taken as part of the planktonic ciliate fractionation experiments but are similar to a complete set of preserved Level I microzooplankton samples to be analysed in Plymouth. Three sets from 25m on May 3 and 11 and from 10m on the May 7 were able to be analysed on the ship. The information is useful since it is quantitative for both robust and fragile microplankton (20-200µm) forms. The following were common: Ceratium sp., Peridinium type, Rhizosolenia sp., silico flagellates, and the unidentified long thin diatom in all samples. In addition Asterionella sp. and Phaeocystis type were abundant at 25m on the May 11. Ciliates (2000-6000 l^{-1}) and nauplii and copepodite stages (approximately 100 l^{-1}) were also common on all three occasions. No coccolithophores were observed in either these or the net samples.

3.10.3 Stained Whole Water Samples Filtered onto 0.2µm Nuclepores

These samples (glutaraldehyde fixed) were taken on 4 occasions throughout the cruise and are similar to a complete set of stored Level I samples to be analysed in the USA. They are quantitative and allow observation of the nanoplankton (2-20µm). The following counts were observed:

Date	Depth (m)	Group	Count (ml^{-1})
3.5.90	25	CYANO	4×10^4
		HNAN	1×10^3
		ANAN	4×10^3
9.5.90	20	CYANO	5×10^4
		HNAN	1×10^3
		ANAN	4×10^3
15.5.90	10	CYANO	5×10^4
		HNAN	1×10^4
		ANAN	3×10^4
19.5.90	25	CYANO	4×10^4
		HNAN	4×10^3
		ANAN	8×10^3

where: CYANO = Cyanobacteria
HNAN = Heterotrophic Nanoflagellates
ANAN = Autotrophic Nanoflagellates

Although these counts have not been replicated, they show an increase in ANAN on May 15, although this may be a result of the shallower sampling depth. Most of the ANAN and HNAN cells were very small (>5µm) and, although unidentified, at least 5 or 6 different types were seen including a small diatom. They were much more common than the larger algae (rarely observed on the filters) and this concurs with the size fractionated chlorophyll data generated during the cruise.

Ray Leakey

3.11 Microbiology

3.11.1 Objectives

The objectives of the 1990 cruise were built around the previous years data set and incorporated questions highlighted at the international JGOFS meeting in Kiel in March 1990. These primary objectives were:

(i) To follow the changes in bacterioplankton abundance and activity in a single body of water during the onset and development of a spring bloom.

(ii) To follow up the question of diel periodicity in bacterioplankton populations. Data from the 1989 cruise (Discovery 182) showed that such periodicity can be a source of considerable variation.

(iii) To investigate the importance of community bacterivory in the cycling and retention of carbon in the mixed layer and to develop an alternative, independent method for its determination.

(iv) To carry out intercalibration and intercomparison studies of bacterial abundance and activity with other members of the JGOFS community.

(v) To monitor changes in cyanobacterial populations in a single body of water during the onset and development of a spring bloom.

(vi) To conduct a pilot experiment to assess the feasibility of measuring the carbon content of natural oceanic bacterial populations.

Additional aims included running a sea trial of the Kontron image analysis system and collecting live flagellate and ciliate cultures in order to identify some of the major bacterivores.

3.11.2 Cruise Report

3.11.2.1. Thirteen predawn, shallow (0-75m) profiles were sampled for bacterial abundance (expressed as number of cells per litre) and activity (expressed as picomoles of thymidine incorporated per litre, per hour: pmol l^{-1} h^{-1}). These samples were coordinated with primary productivity measurements, ^{15}N uptake experiments, and measurements of CO_2, O_2 and DOC in order to assess the proportion of primary production flowing through the microbial loop. In addition, six profiles taken at noon (one of 0-100m, two of 0-300m and three of 0-400m) were sampled for the same parameters.

In general the shape of the profiles reflected the physical parameters and were much less "spiky" than the profiles observed a month later in 1989 suggesting a less stable structure in 1989. The surface values were similar to those observed at 47°N and

56°N last year at around 2-3 pmol l^{-1} h^{-1}. From the five Level I casts, only one day showed a significantly higher value, that is on May 9 when surface values were 5 pmol l^{-1} h^{-1} but with these values decreasing sharply to 3 pmol l^{-1} h^{-1} between 10 and 20m. Experimental "blanks" had higher values than these estimated last year, partly, but not entirely, due to the presence of particulates in the ships water supply contaminating the reagents used (these were removed by filtration once recognised). Epifluorescence microscopy will determine if there was much detrital matter which may have contributed to these high blanks in the seawater.

3.11.2.2. Three experiments were carried out to monitor closely the diel periodicity of bacterial activity and abundance. Samples were taken from above and below the thermocline to compare the response of these two potentially separate communities. The measurements were also coordinated with determinations of ^{14}C uptake, ^{15}N uptake and measurements of CO_2, O_2 and DOC changes.

3.11.2.3. Three experiments to determine the importance of community bacterivory were undertaken using a modification of the Landry and Hassett dilution technique. Two of these three were coordinated with similar experiments measuring community herbivory and protozoan growth rates. Due to the intensive sampling programme for bacterial parameters, it was decided to limit the number of grazing experiments to three.

It had been planned to develop an alternative and independent method in collaboration with Dr P Burkill (PML), making use of the analytical flow cytometer. Unfortunately, due to last minute alterations in cruise personnel, this was not possible. However, concentration and prestaining of natural bacterial populations, preparatory steps in this procedure, were carried out with varying degrees of success.

3.11.2.4. Two intercalibration exercises were carried out for the measurement of bacterial activity and abundance: On May 16, 10 samples were taken from the CTD cast aboard the Tyro (Netherlands): collaborator, P Quist; and on May 19, 3 samples were sent from the RRS Discovery (UK): collaborator, Dr C Turley. Also on May 19 samples were collected from 2m and 2000m, preserved and distributed between 8 JGOFS participants; H Ducklow (USA), D Kirchman (USA), P Quist (NL), C Turley (UK), A Pomroy (UK), H Hoppe (FRG), K Lochte (FRG) and M Stirling (UK) for bacterial abundance determinations. These samples constitute the intercalibration exercises.

In addition, on May 19 full Level I casts were carried out on board both RRS Charles Darwin and RRS Discovery who were occupying the same station. These profiles gave the opportunity for an intercomparison exercise. Results from both intercalibration and intercomparison samples have yet to be exchanged.

3.11.2.5. Six shallow profiles were analysed for cyanobacterial

abundance. The profile shapes are very similar to the corresponding bacterial activity profiles (Fig. 7) reflecting the dominance of physical parameters in determining the vertical distribution of many microbial properties.

3.11.2.6. In response to some lively discussions at the Kiel meeting, a pilot study to assess the feasibility of measuring the carbon content of natural bacterial populations was carried out in collaboration with Dr H Kennedy (UCNW Bangor). The samples have yet to be analysed.

There were no problems in the use of the image analysis system aboard the Darwin. The cruise programme, a Lagrangian study, meant there was little or no steaming at full power which can result in engine vibration distorting the captured images.

Moragh Stirling

3.12 Determination of Non-Volatile Dissolved Organic Carbon

3.12.1 Introduction

Determination of non-volatile dissolved organic carbon (DOC) was to be performed by High-Temperature Catalytic Oxidation (HTCO) using a Shimadzu TOC-500 Total Organic Carbon Analyser.

International scientific interest surrounds the measurement of DOC by HTCO due to the exclusivity of controversially high concentrations, as initially determined by Sugiura and Suzuki (Mar. Chem., 24 (1988), 105-131) using a commercially unavailable 3% platinised alumina catalyst (Sumitomo 60).

Receipt of a sample of the 3% Pt catalyst from Dr Yoshimi Suzuki, following his recent visit to PML, facilitated the opportunity for shipboard determination of these recently reported DOC concentrations.

3.12.2 Objectives

Participation in the BOFS 1990 cruise programme provided the opportunity for:

(i) Determination of the non-volatile DOC in the north east Atlantic using state-of-the-art chemicals and technolgy in pursuit of confirmation of results obtained by Dr Suzuki during the 1989 JGOFS programme.

(ii) Following the changes during the progression of a phytoplankton bloom related in the DOC concentration of surface waters.

(iii) Attempting to detect and quantify a relationship between primary productivity and DOC production/consumption through in situ productivity experiments.

(iv) Participating in diel sampling programmes to investigate short term diel changes in rate processes in the surface mixed layer.

(v) Archiving samples using a variety of preservation techniques in order to extend the opportunities for laboratory analysis of offshore samples.

(vi) Providing JGOFS Level 1 DOC measurements for submission to the BOFS database at BODC, Bidston.

(vii) Assessing the relative performance of the 3% Pt (Sumitomo) catalyst relative to some more readily available substitutes.

(viii) Collaboration with colleagues aboard RV Tyro (Netherlands) and exchanging water samples to facilitate shipboard intercalibration of DOC analysers.

3.12.3 Experiments

3.12.3.1. Vertical Profiles

Determination of DOC concentrations at all standard depths from the surface (300m) CTD casts; performed at intervals throughout the cruise. Sampling the surface mixed layer (2m-35m) using Go-Flo bottles, enhancing the vertical resolution of DOC in this upper zone and providing a time series data set.

3.12.3.2. Primary Productivity

Pre-dawn sampling of the surface waters (2, 10, 15, 20, 25, 35m); 60ml bottles filled and attached to productivity rigs with replicates at 2m and 35m; incubated in situ for 24 hours; dark bottles placed in deck incubators, again with replicates at 2m and 35m.

3.12.3.3 Diel Cycling

4-hourly sampling from Go-Flo bottles at 2m and 35m; 3 and 4-hourly sampling from CTD at 300, 150, 75, 50, 30 and 10m.

3.12.3.4 JGOFS Level 1 DOC Measurements

Full vertical profiles of the water column (surface - 300m; 400m - bottom). Samples analysed on board and replicates archived, using a different method of preservation for each cast.

3.12.3.5 Catalyst Intercomparison

Sampling a full suite of depths from a 300m CTD profile (cast 1305C01), filtering (GF/F) and storing at 4°C in the dark. Consecutive shipboard analyses of profile samples carried out using 3% Pt (Sumitomo), 100% Pt (IONICS) and 0.5% Pt (Shimadzu) catalysts to compare relative DOC oxidation efficiencies of the various catalysts.

3.12.3.6 Intercalibration with R.V. Tyro

Transferred to RV Tyro for collection of common intercalibration samples from surface-bottom CTD casts. Netherlands instrument (IONICS 555 Carbon Analyser) was not running probably owing to a combination of vibration from the ship and a faulty infra red gas analyser. Selection of samples taken for analysis aboard RRS Charles Darwin to investigate small scale spatial resolution of DOC concentrations throughout the water column.

The sampling programme for DOC measurements carried out during the cruise is summarised in Table 18.

3.12.4 Results

The TOC-500 performed optimally at mid-range sensitivity.

Baseline noise had an over-riding influence on the sample signal at high range setting. Reproducibility was generally below cv=5%, although vibration when winches were operating often affected measurement, moving precision of replicate injections into the 5-10% range. Preliminary interpretation of data demonstrated surface water concentrations between 150-280µMC, that is in the range observed in North Pacific waters (240-280µMC), and not previously reported for the north east Atlantic. Sharp decline through the upper water column was consistent with the observations of Suzuki and Peltzer from the JGOFS North Atlantic Bloom Experiment (NABE) (unpublished).

The DOC maximum coincided with the AOU maximum around 1000m (Wood, pers. comm.) in contrast with previous data acquired using HTCO techniques in conjunction with the 3% Pt catalyst. Deep water DOC minimum was of the order previously observed (125-150µMC), whilst the bottom water concentrations, in excess of 200µMC, were significantly greater than reported elsewhere. The surface mixed layer DOC maximum around 10-20m coincided with the fluorescence maximum and was consistent with the production of dissolved organic compounds through primary production.

3.12.5 Comments

The auto-sampler injector block started to mis-align prior to injection on May 6, resulting in broken injector needles and termination of analyses. Whilst the cause was not positively identified, random movement of the injector block was observed and measures were taken to reduce this by replacement of teflon bushes on guide rods (Tony Poole, RVS). Several days analysis were lost, however, due to this problem.

Manual injection was attempted for CTD profile 0805C03. However, this approximately doubled the analysis time to ~20 minutes per sample. Analysis of standards and the twelve samples required on-hands time of almost 7 hours and 30 minutes, severely limiting the number of samples which could be processed. Coupled with this, precision for replicate injections fell repeatedly into the >10% range.

Axel Miller

3.13 Stand Alone Pumps (SAPS)

A total of 13 casts of the Stand Alone Pumps (SAPS) were made using GF/F and Nuclepore filters for subsequent lipid, pigment, lignin, POM, radionuclide and stable isotope analysis. The complete listing of SAP samples is given in Table 19.

The inital cast was a SAP trial to check the pump performance and filter processing method. On the second deployment, which was a deep cast (400m), we encountered some problems. Near the end of the run of the plastic coated wire it was found to have bitten in on itself. The reasons for this were that firstly the wire had been wound onto the drum at a relatively low tension and secondly that the swivel attached to the end of the wire had not allowed the wire to scroll properly on the drum. To complete the deployment of the SAPS the load had to be relieved from the drum in order to free the wire. On the recovery of the SAPS it was noted that the battery pack and motor pump assemblies had rotated relative to each other restricting the access to the wire clamps which made it difficult to take the SAPS off the wire.

During the post deployment maintenance checks the following faults were found. The pump of SAP 009 showed evidence of excessive wear in the lower spindle location and excessive end float causing the impellor to foul or hit the motor casing. Also the motor on SAP 007 showed an electrical fault as well as an insufficient running clearance in the driving magnet assembly. When measured it was found to be 39/1000" instead of 55/1000". To provide one full working unit we used the motor from SAP 007 and the pump from 009. The fault with the motor should be able to be rectified but the pump will have to be replaced.

The bolts around the IOS release bar were tightened and the battery pack dropped relative to the motor pump assembly to allow easier access to the wire clamps. However further realignment needs to be made to further improve access to the wire clamps and to allow for filter assembly in situ. Consequent to this dip strops were also used to further reduce the risk of SAP loss from the wire.

All of the filters from this cast had been torn during the deployment presumably due to the heave of the ship during a high swell. At the time of the cast the wind was 18 knots and the swell had a period of 6 seconds and a height of 12 feet.

Further casts using only GF/F filters were mostly successful. However we kept encountering problems with Nuclepore filters (less than 50% success rate). Successful deployments using Nuclepore filters on Discovery last year suggest that one of the major contributors to the tearing of filters may be the heave experienced during deployment of the SAPS off the aft deck of Darwin. The only alternative would be to deploy the SAPS off the starboard A frame, away from the aft end of the ship.

The SAP deployments undertaken on this cruise have suggested certain measures, in addition to those enumerated above, that should be taken to improve the pumps performance. These include:

1. Rotation of the outlet of the pump to make deployment of primed pumps easier.

2. Reassembly of line between outlet of filter unit and pump to ensure good seals and correct spacing.

3. Relocation of cartridges to facilitate priming of the pumps when they are in-line.

Furthermore, trials need to be undertaken to investigate the causes of non-homogenous distribution of material on the filter (inner third often has a much heavier loading) and splitting especially when using GF/F filters.

Hilary Kennedy

3.14 Stable Isotope Sampling

Temporal and spatial records of the vertical distribution of the isotopic composition of suspended particulate matter were obtained in conjunction with samples for primary productivity and nitrate uptake rate studies either from the CTD rosette mounted Niskin bottles or the Go-Flo bottles. All samples were filtered through a 200µm mesh and in some casts the samples were used to provide samples of the <5µm size fraction. The detailed sampling schedule is given in Table 20.

Hilary Kennedy

3.15 Radionuclide Sampling

Samples of dissolved and particulate material for radionuclide analysis were taken in conjunction with the stable isotope sampling to provide information on radio-isotopic disequilibrium and organic matter regeneration and recycling in the upper water column. Further samples were also taken on a continuous basis from the ship's non-toxic supply system over the course of the cruise. Details of the sampling schedule are given in Table 21.

Hilary Kennedy

3.16 Level 1 POC/PON

Daily casts were made for POC and PON samples. On 100m casts samples were taken from depths of 2, 10, 20, 30, 40, 60 and 100m. For 300m and bottom casts sample depths were 2, 10, 20, 30, 50, 75, 100, 150, 200, 300 and 500, 800, 1500, 2500 and bottom respectively. The detailed sampling schedule appear in Table 22.

Hilary Kennedy

4. RVS SUPPORT

A high level of support was received from RVS personnel during both the preparatory stages of the cruise and the cruise proper. Particular mention must be made of the assistance received at all stages by the technical and computing staff.

Some comment is appropriate however concerning the provision and preparation of some of the items of RVS equipment employed during the cruise. The scientific programme depended on the availability of good quality CTD data and use of the associated rosette sampling system. Although a substantial number of spares was carried for the CTD system and rosette, no back up sea units were available for Darwin 46/90. It is recognised that by good fortune we had embarked for the cruise one of the RVS technicians most conversant with the CTD system and also that no faults occurred in the CTD system which may potentially have crippled the scientific programme. However, in the not unlikely event that a major CTD failure had occurred, the lack of a spare CTD sea unit immediately available for replacement could have caused a major disruption and loss to the continuity of the scientic experiment. Given the level of investment in cruise science and the international context of the BOFS programme, any such description caused by the lack of a spare CTD unit would have resulted in the write-off of considerable economic input and prestige. For a cruise forming a component of a major multiship exercise depending heavily on a CTD rosette system, it is essential that a complete set of system replacement units be carried on board.

These comments concerning the CTD system must also be taken in the context of the age of the CTD equipment available. The Neil Brown CTDs available at RVS and elsewhere in the U.K. are mostly older systems which have been heavily used and may be expected to display faults with increasing frequency. Strong consideration should be given by RVS to investment in new CTD equipment as a matter of some priority.

Similar comments concerning the lack of back-up equipment applied also in the case of the 301 Go-Flo bottles supplied by RVS. Four were requested for the cruise as a minimum working requirement, but no back-ups were available. Their deployment for clean sampling was essential for much of the substantial microbiological programme and given the nature of their construction, some damage during the cruise must be considered a real possibility. Such damage did indeed occur, fortunately to not all of the bottles at any one time, and the lack of any back-up bottles did delay the sampling programme to some extent. Again, really only by good fortune did the programme not suffer severely and for future cruises of a similar nature adequate back-up bottles must be available on board.

As a further point, the ongoing intermittent fault in the output of the CTD which developed during the latter half of the cruise, was eventually tracked down to the new deck unit fitted

prior to the cruise. Luckily the fault again did not significantly affect the scientic programme. However it appeared that, despite the very best efforts by RVS personnel, insufficient technical resources were available during the cruise prepration period to check out the CTD system.

Ship facilities performed well throughout the cruise with only minor routine problems being experienced. As a detail, when there is a cruise requirement for D/F tracking of drogues it would assist co-ordination of navigation if the D/F receiver could be located on the bridge.

5. COMMUNICATIONS

Any multiship exercise such as the 1990 BOFS programme, especially where multiple drogue tracking and central shore-based programme co-ordination is involved, is heavily dependent on well established ship-shore communications. During the early stages of the cruise it became clear that the main intended line of communication with PML, the satellite fax link, was not able to be operated apparently due to a fault or non-compatibility of the ship's fax machine. No equivalent fall-back line of communication was available and for a time an ad hoc message relay system via Discovery operated. The Marinet system, used successfully the previous year, was eventually reinstated and was employed successfully for the remainder of the cruise although logistically its use was less convenient for the shore based programme co-ordinator. The difficulties encountered resulted in considerable frustration to the ship's radio officer and clearly in any future exercise of a similar nature, more planning and checking out of the lines of communication prior to the cruise is essential.

6. ACKNOWLEDGEMENTS

Special thanks are due to Capt. P MacDermott, the officers and crew of RRS Charles Darwin for their valuable assistance given throughout the cruise. Their willing co-operation and interest in the scientific programme contributed much to the pleasant working atmosphere and ultimately to the success of the cruise.

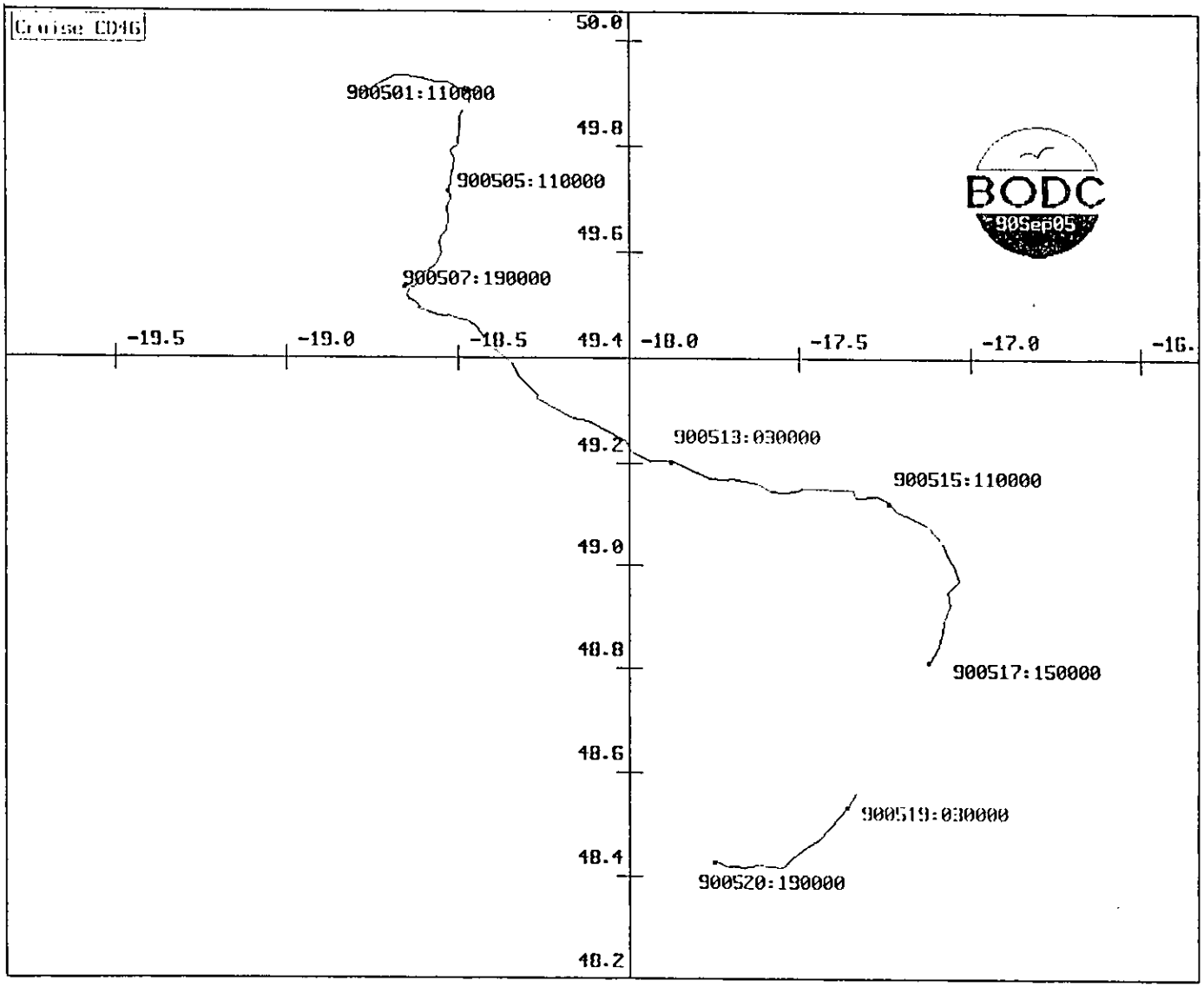

Fig. 1. Track of RRS Charles Darwin cruise 46/90, May 1 - May 20 1990

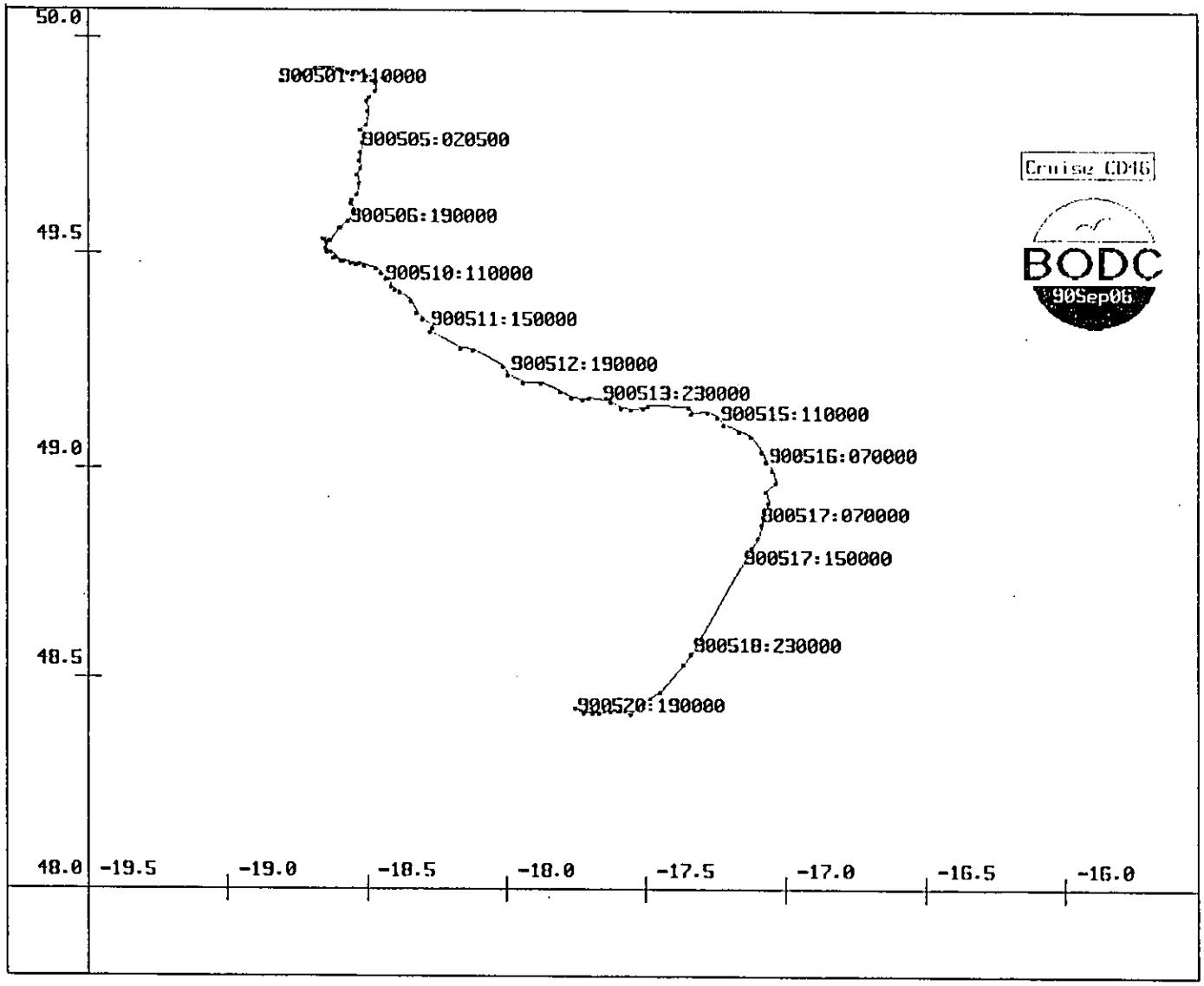

Fig. 2a. Track of Lagrangian experiment marker drogue, May 1 - May 20 1990

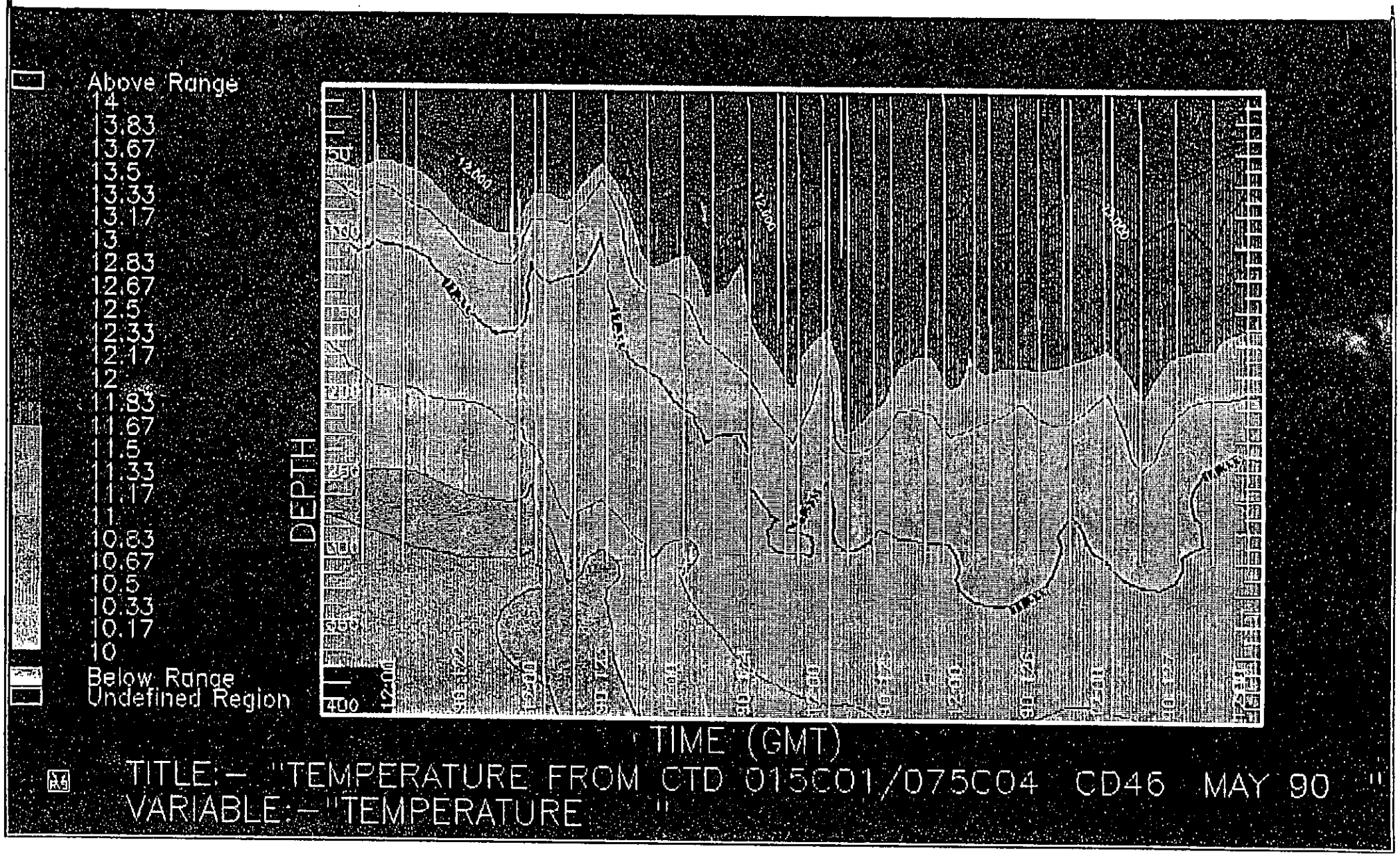

Fig. 3(a) Distribution of temperature (°C) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 1-7 1990

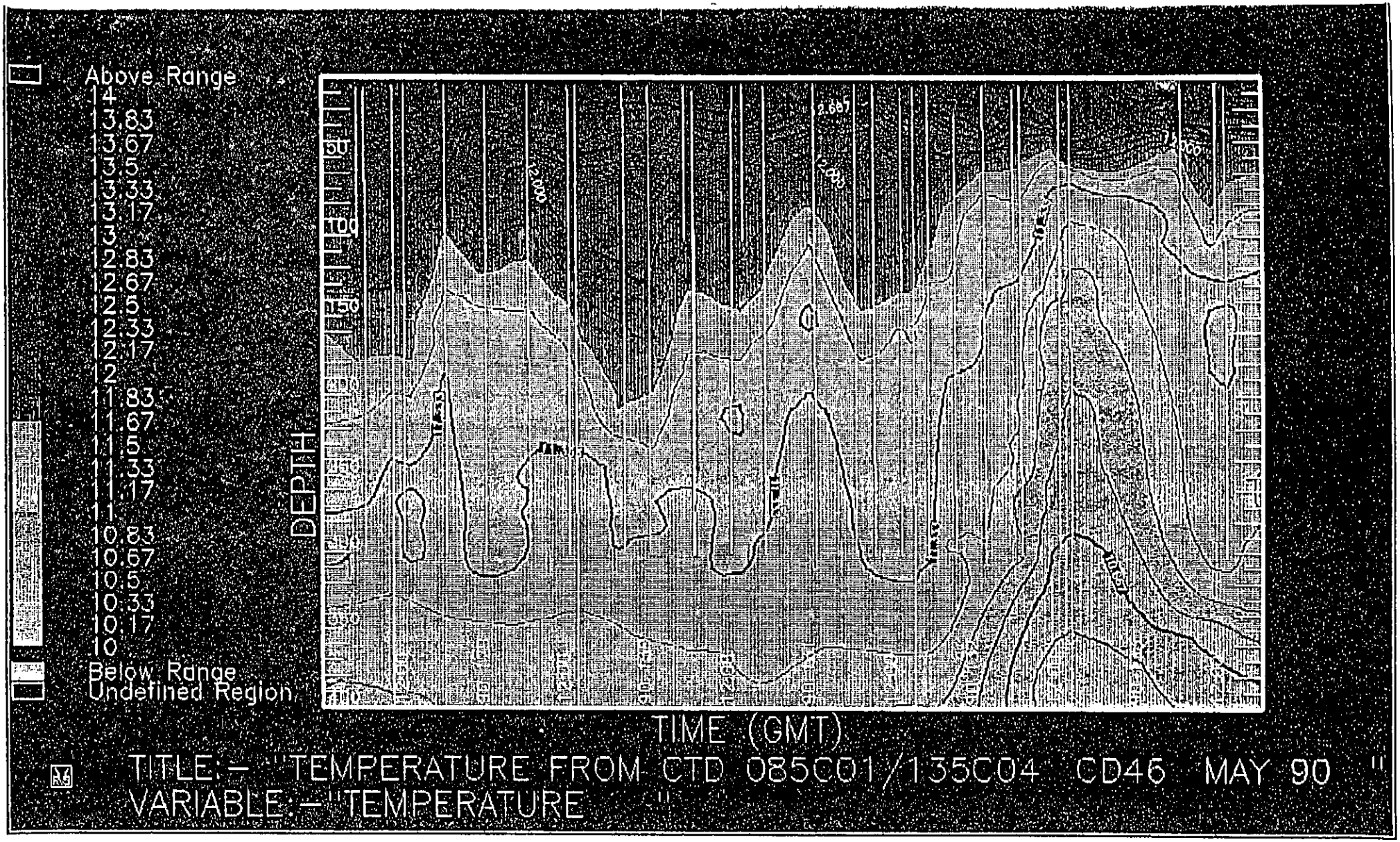

Fig. 3(b) Distribution of temperature (^{o}C) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 8-13 1990

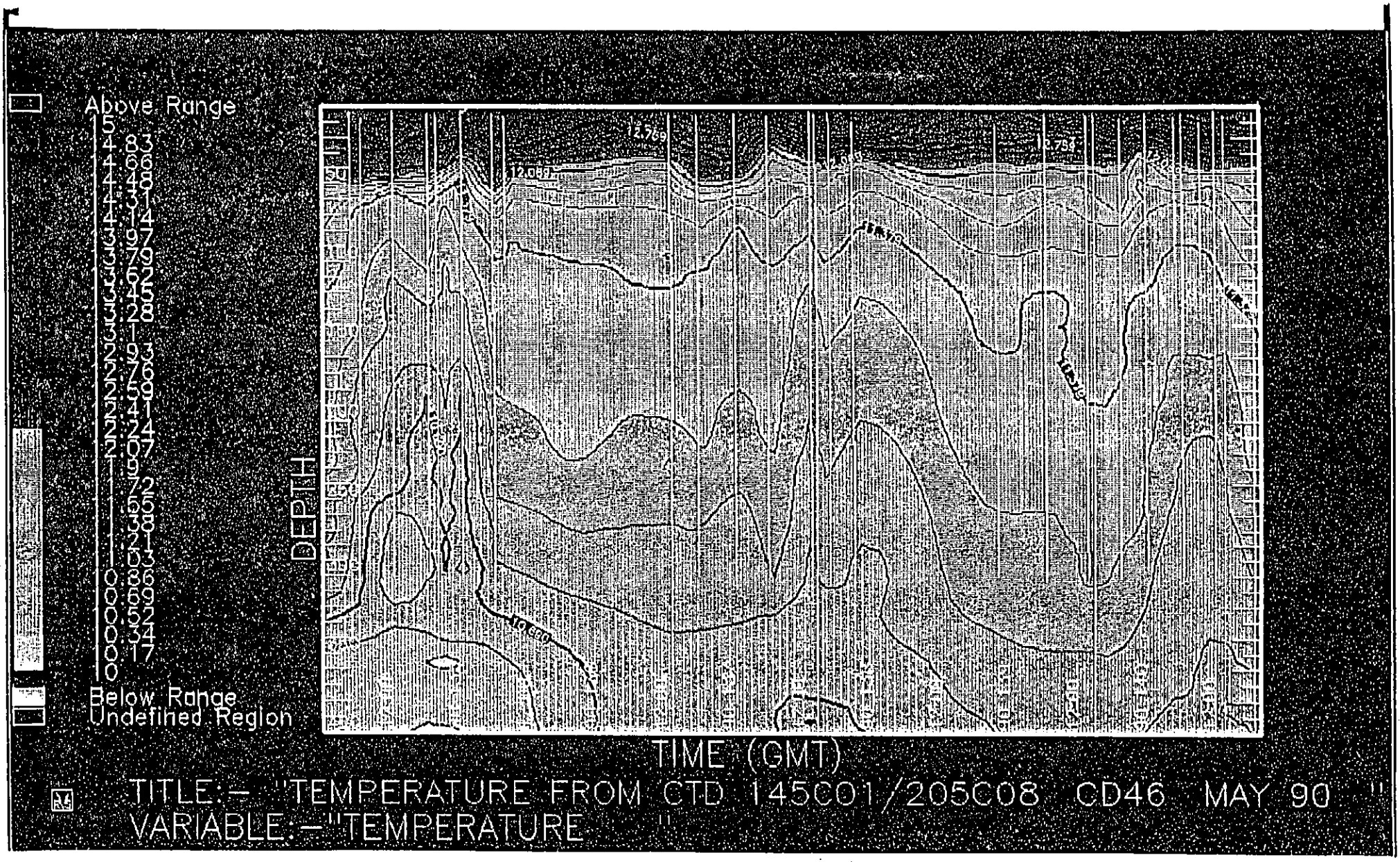

Fig. 3(c) Distribution of temperature (^{o}C) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 14-20 1990

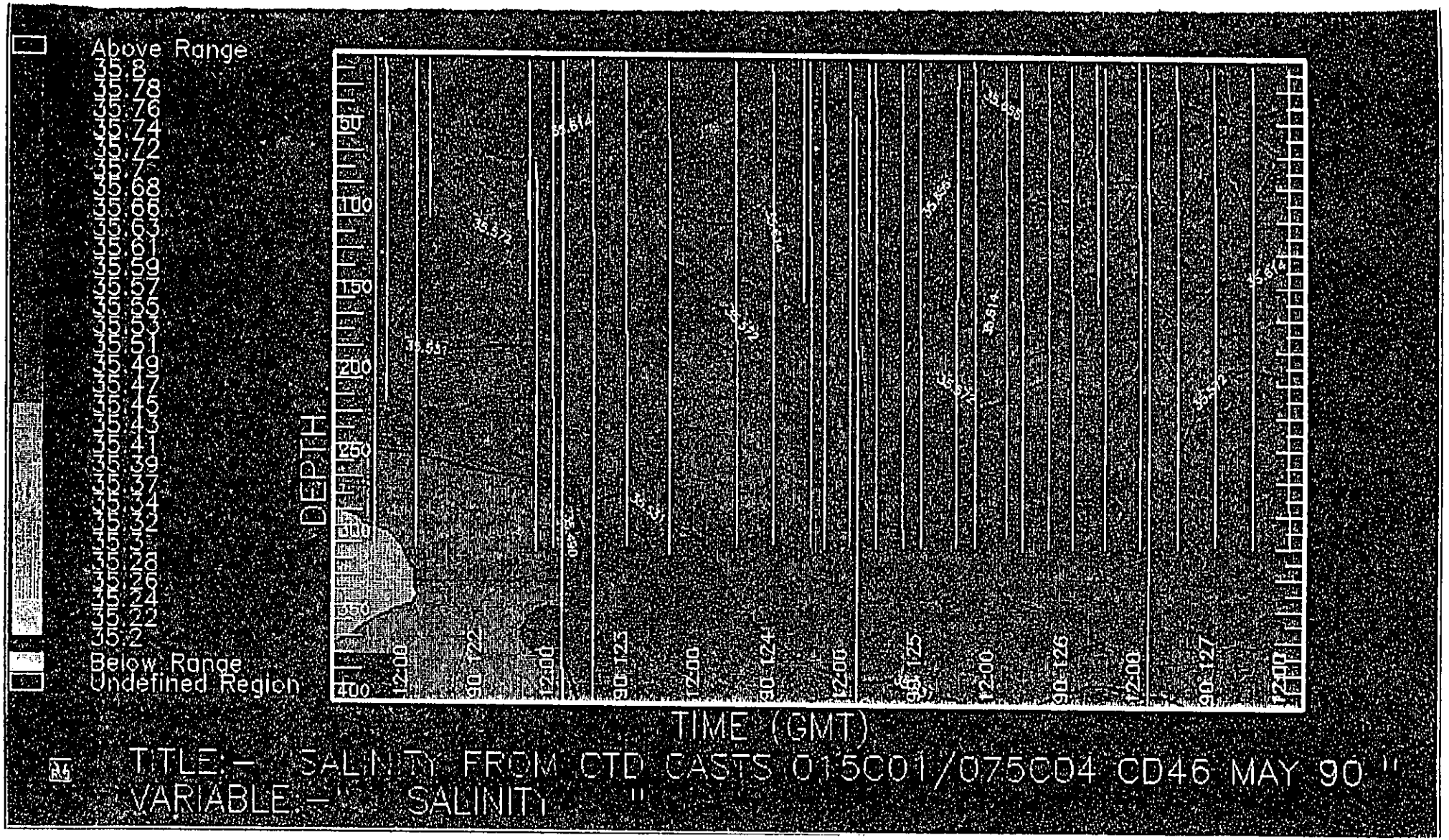

Fig. 4(a) Distribution of salinity in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 1-7 1990

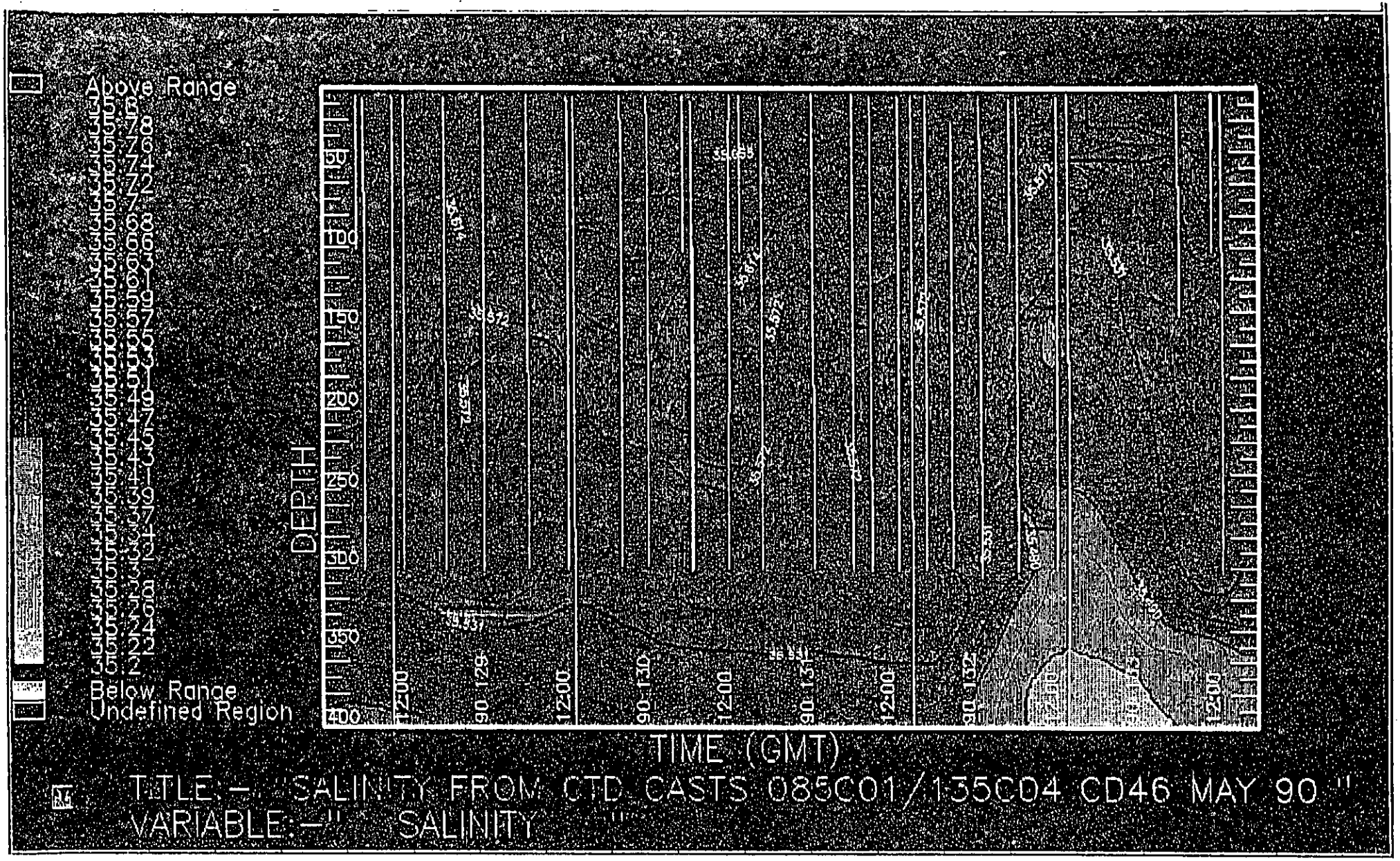

Fig. 4 (b) Distribution of salinity in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 8-13 1990

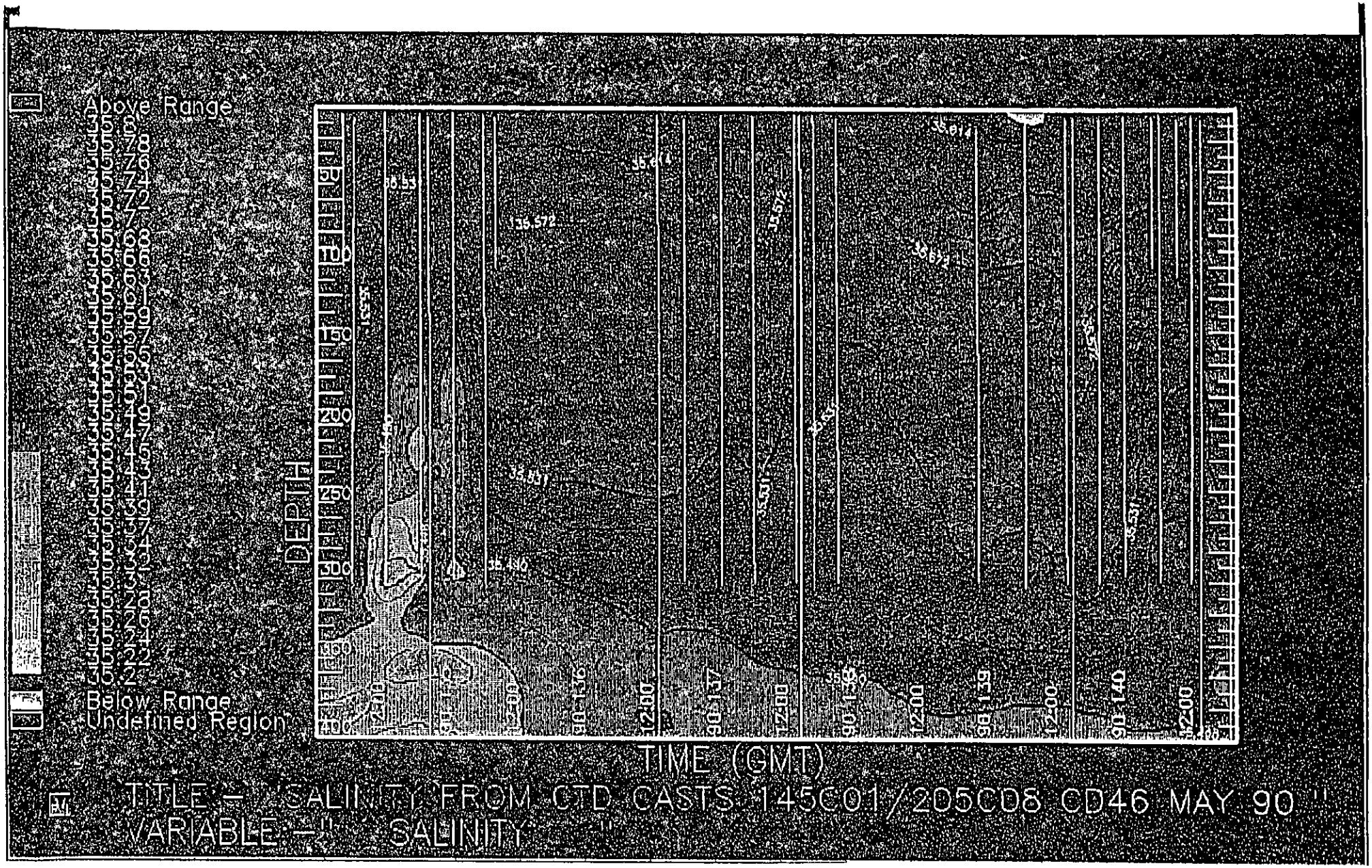

Fig. 4 (c) Distribution of salinity in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 14-20 1990

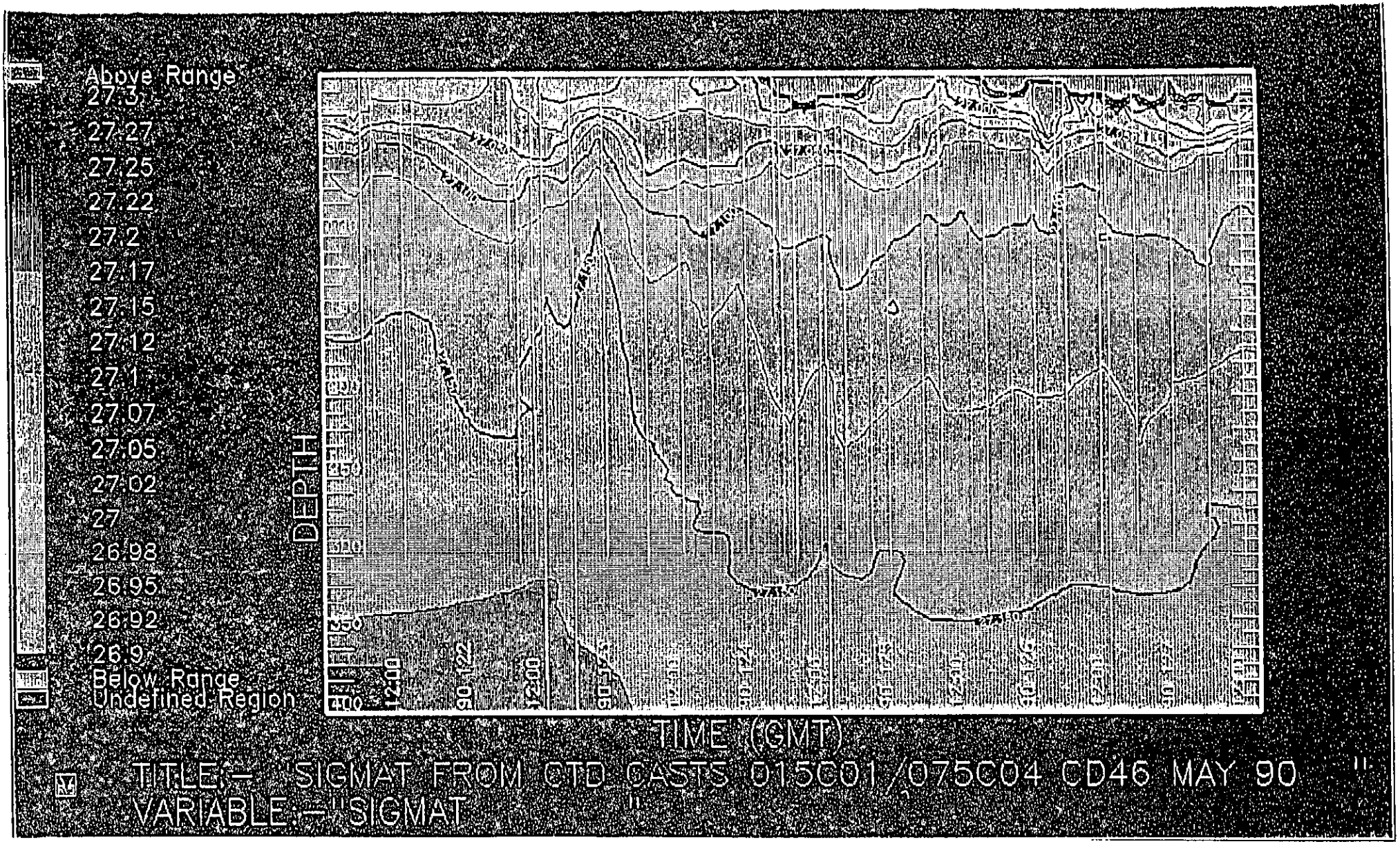

Fig. 5 (a) Distribution of σ_t in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 1-7 1990

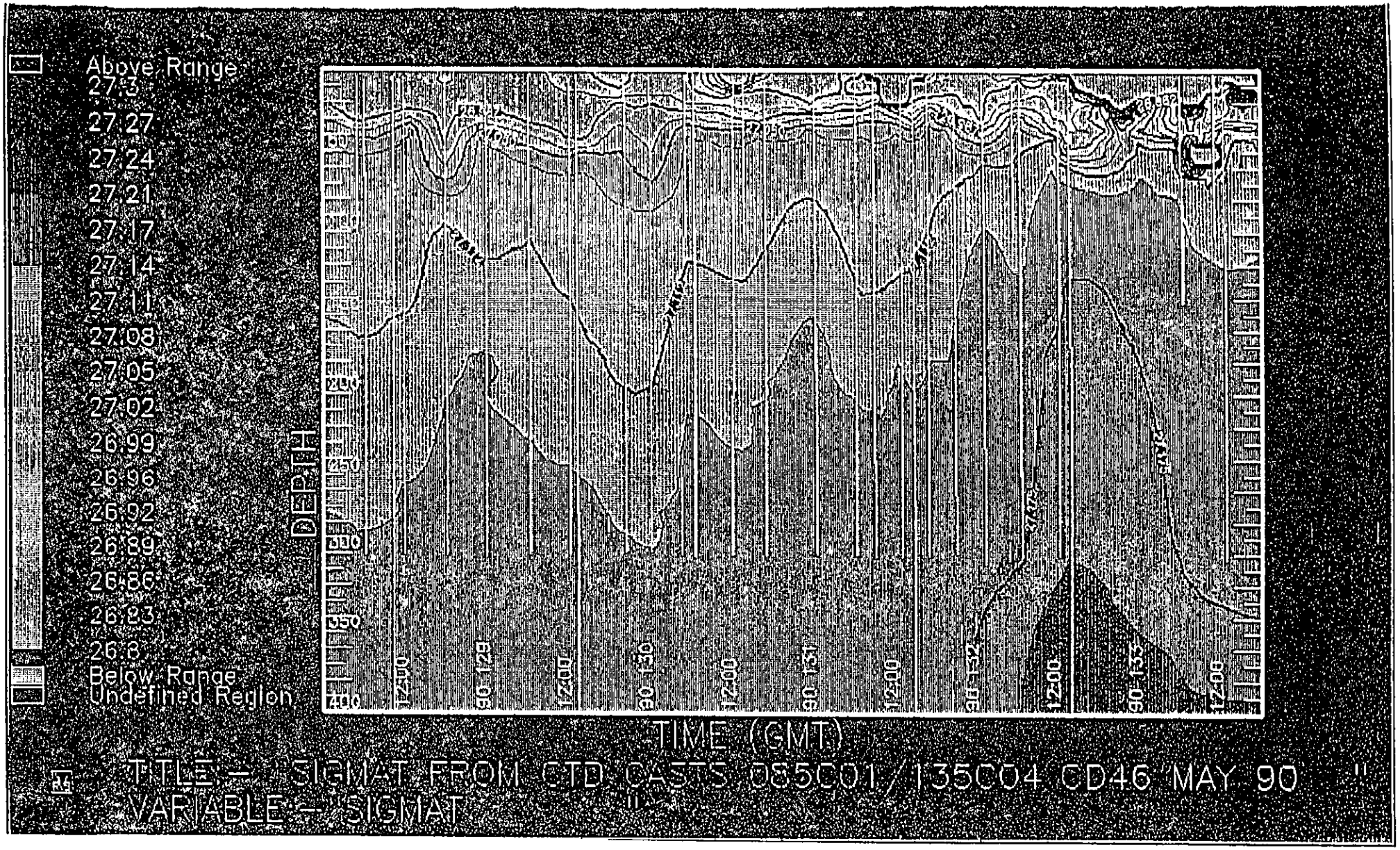

Fig. 5 (b) Distribution of σ_t in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 8-13 1990

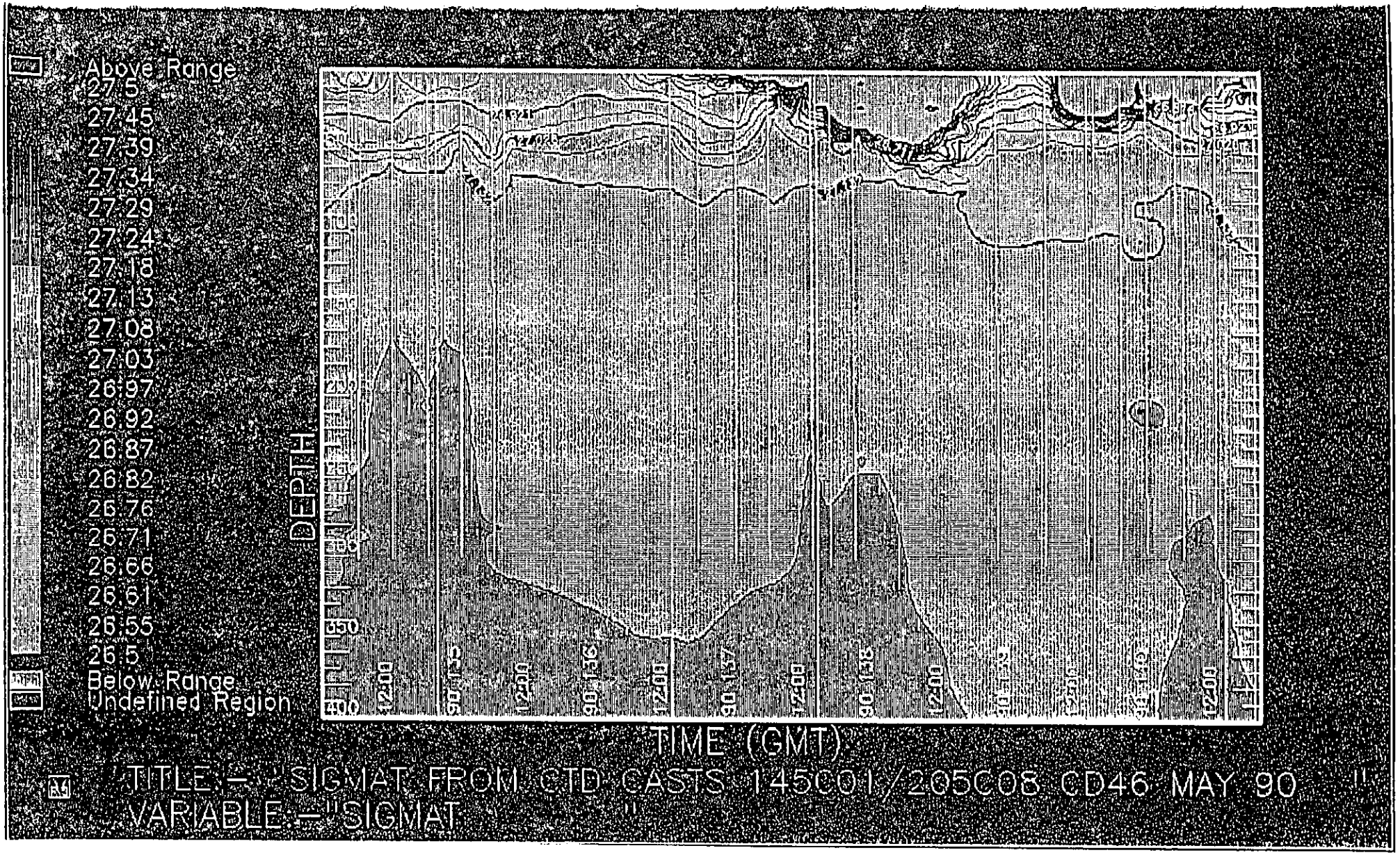

Fig. 5 (c) Distribution of σ_t in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 14-20 1990

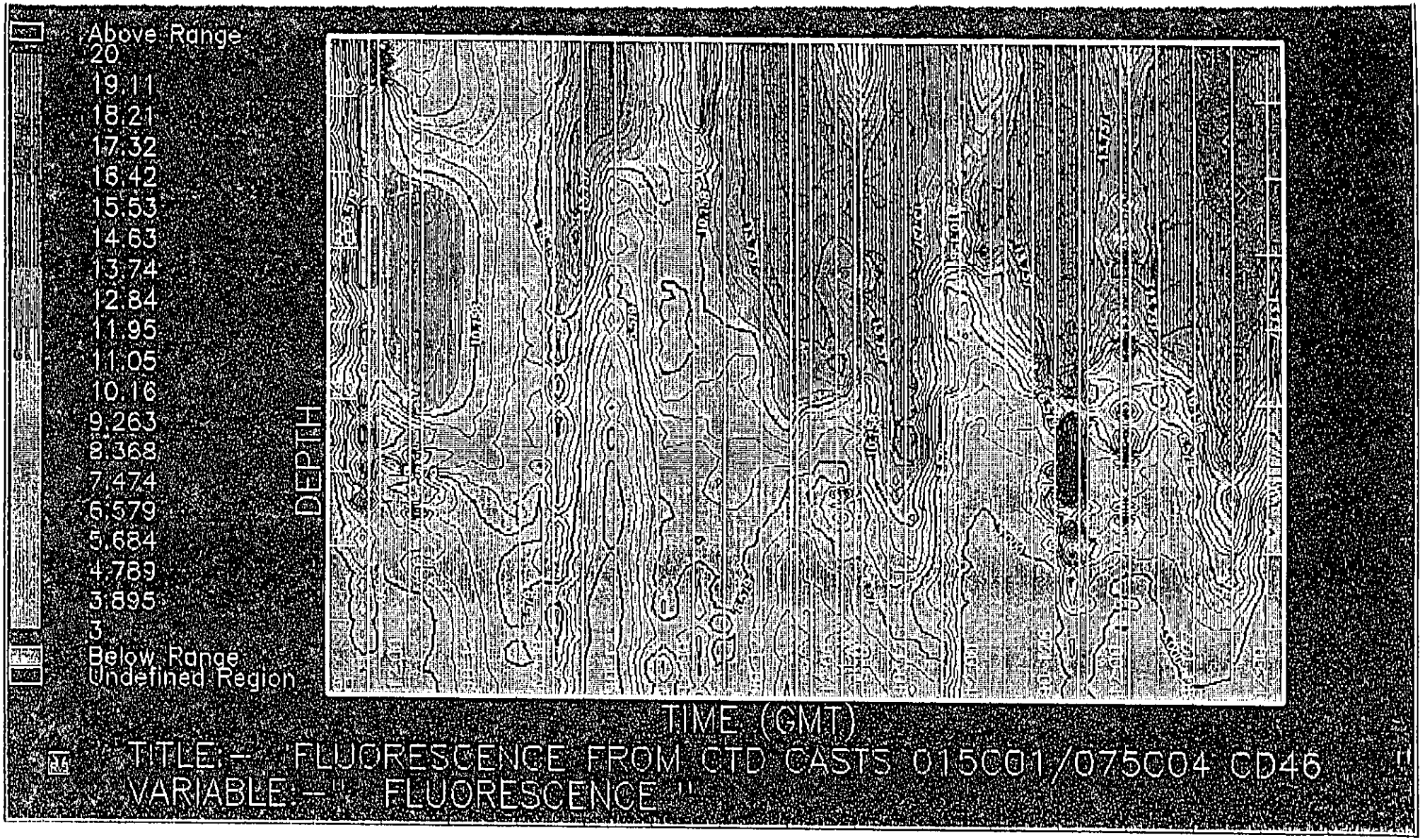

Fig. 6 (a) Distribution of chlorophyll a fluorescence (relative units) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 1-7 1990

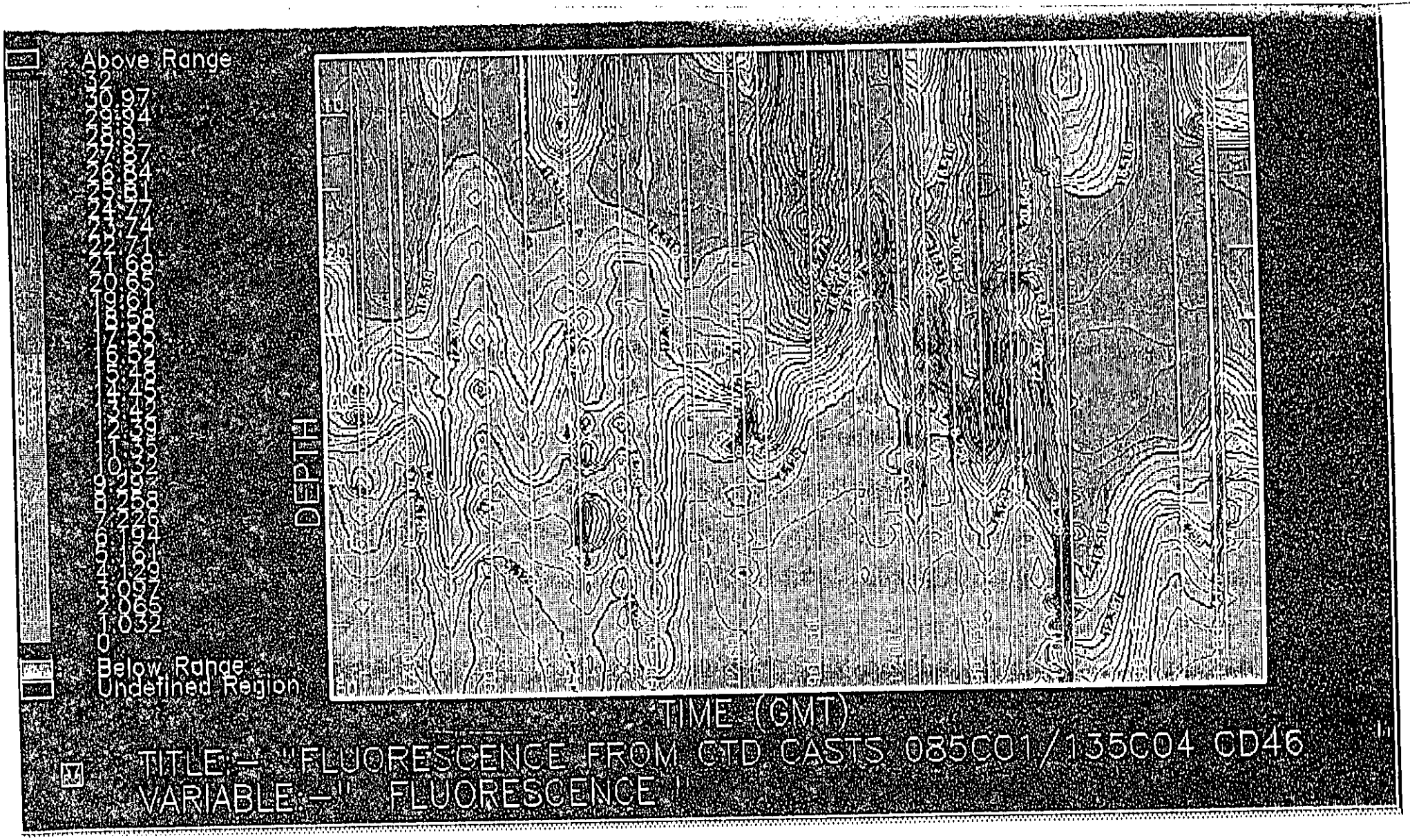

Fig. 6 (b) Distribution of chlorophyll a fluorescence (relative units) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 8-13 1990

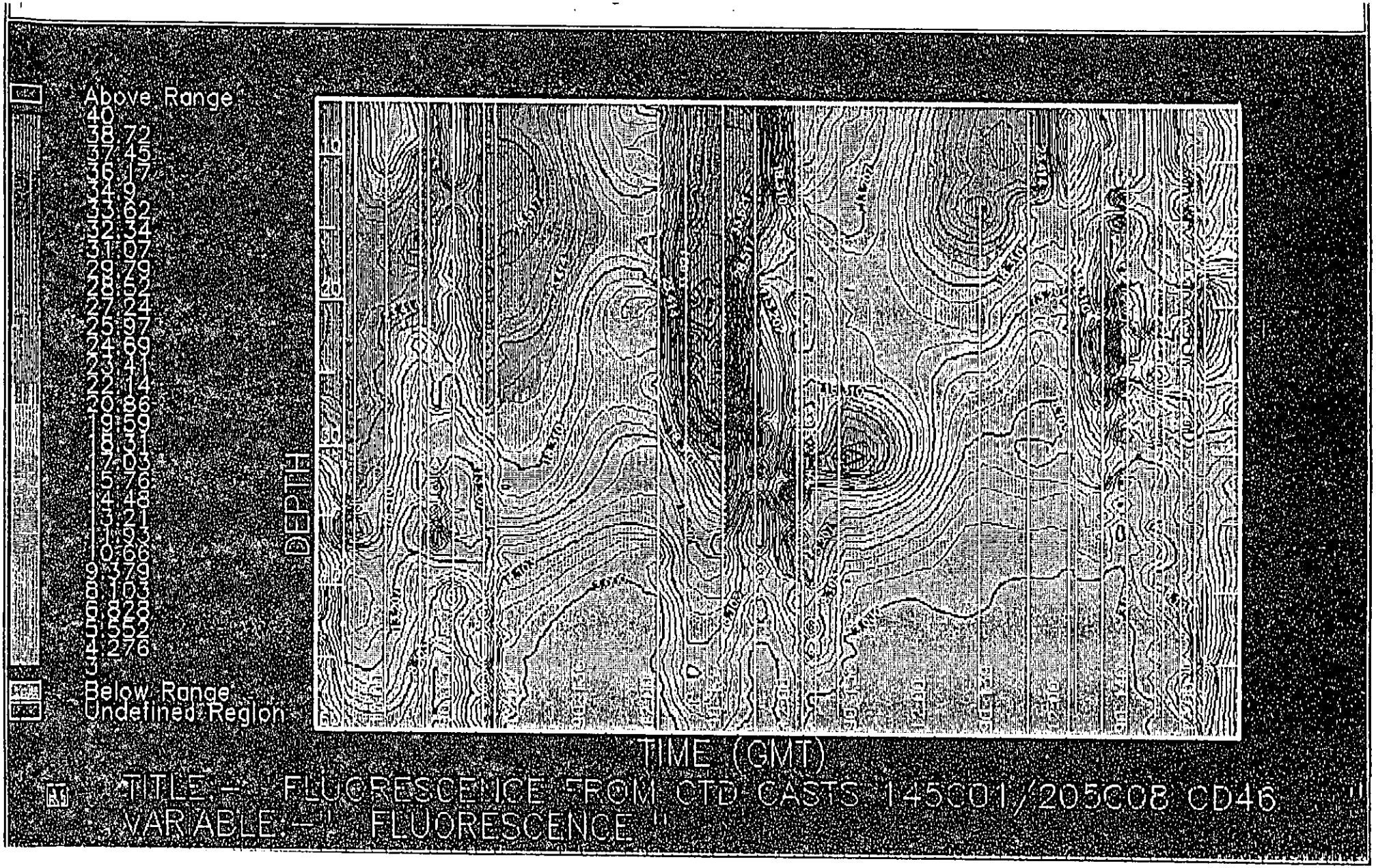

Fig. 6 (c) Distribution of chlorophyll a fluorescence (relative units) in surface 300m adjacent to BOFS Lagrangian drogue, north-east Atlantic, May 14-20 1990

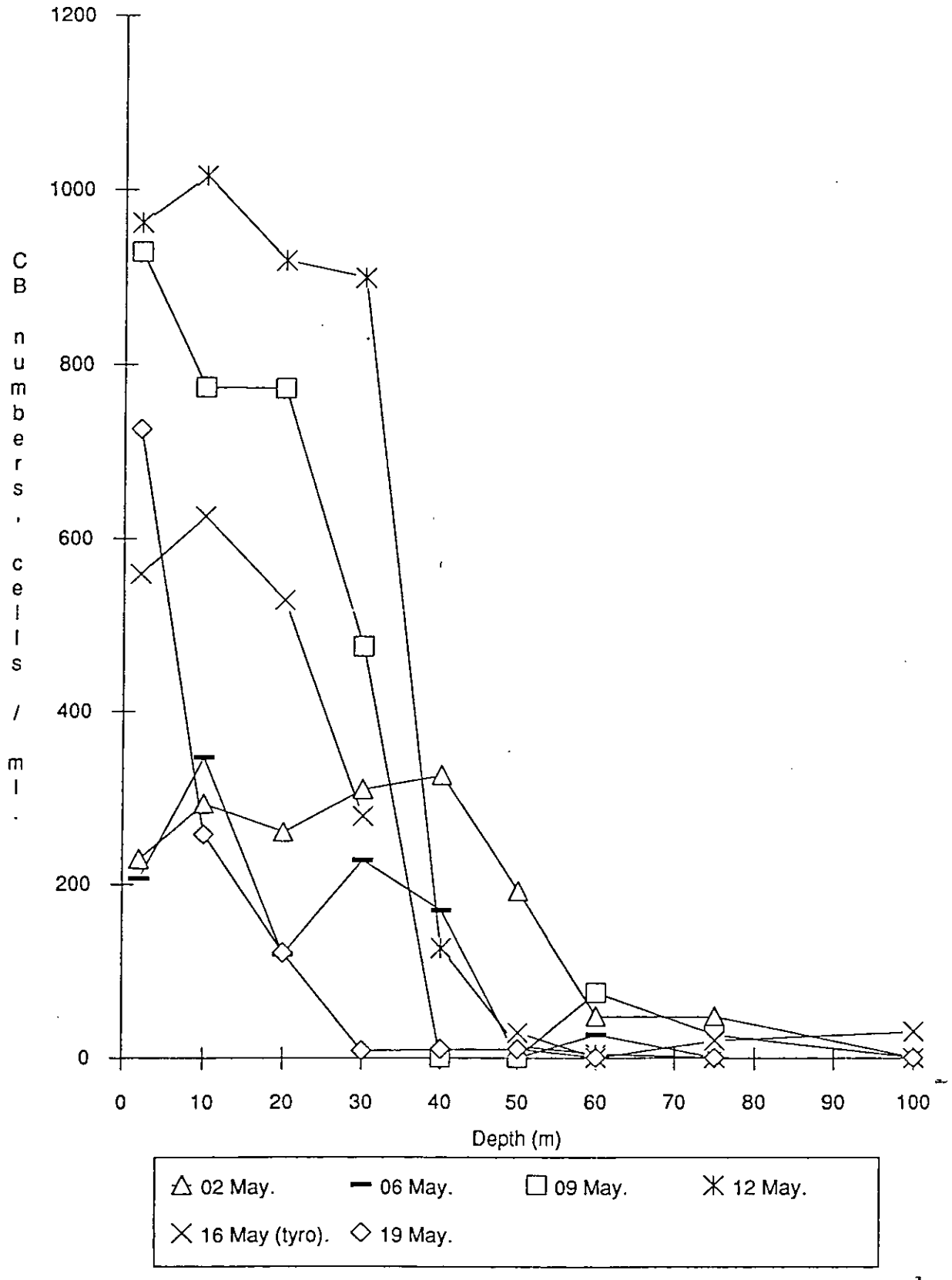

Fig. 7(a) Depth distribution of bacterial cell densities (cells ml^{-1}) during Darwin cruise 46/90

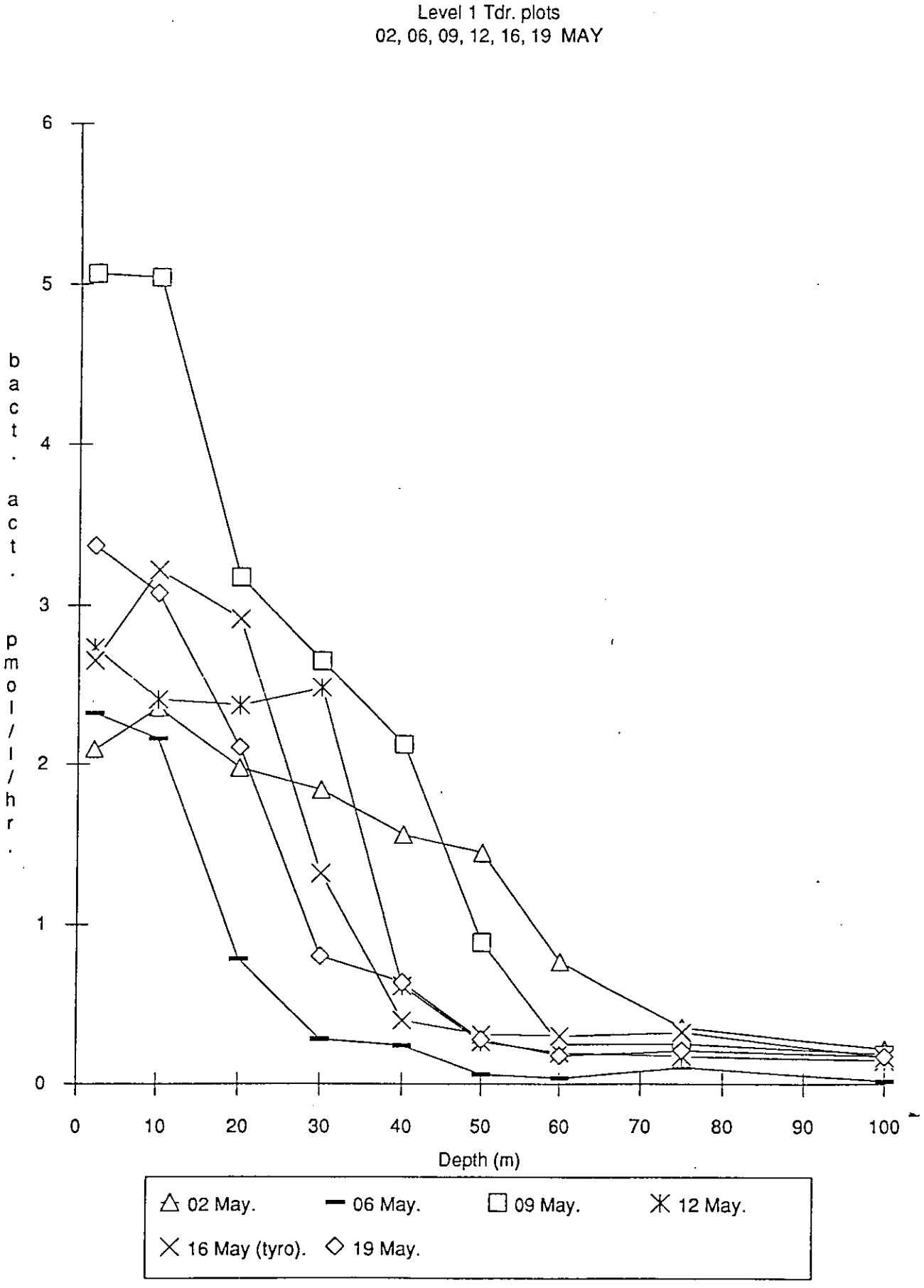

Fig. 7(b) Depth distribution of bacterial production (picomoles of thymidine incorporated per litre per hour) during Darwin cruise 46/90

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
2904C1	0950 1023 50 18 01N	150 010 18 13W	CTD	2,10,20,30,40,50,60,75,100, 125,140	CHL,NUTS,DOC	FLUOROMETER NOT WORKING
2904G1	1055 1110 50 17 59N	150 010 18 25W	BOTTLE	2,20		
2904S1	1120 1247 50 17 51N	150 010 18 33W	SAP	10(X2)		
2904Z1	1250 1259 50 15 33N	150 010 32 42W	ZNET	100		
0105C1	0008 0051 49 50 56N	4020 018 56 11W	CTD	2,10,20,30,40,50,60,75,100, 150,200,300	NUTS,CHL	
0105G1	0344 49 51 35N	018 54 03W	BOTTLE	2,10	15NO3,PP,DOC,BP,BN,NOX	
0105G2	0415 49 51 37N	018 53 51W	BOTTLE	15	PP,15NO3,SI,DOC,BP,BN	
0105G3	0420 49 51 35N	018 53 49W	BOTTLE	20	PP,15NO3,SI,DOC,BP,BN	
0105G4	0425 49 51 36N	018 53 46W	BOTTLE	25	PP,15NO3,SI,DOC,BP,BN	
0105G5	0431 49 51 36N	018 53 42W	BOTTLE	35	PP,15NO3,SI,DOC,BP,BN	
0105G6	0437 49 51 36N	018 53 40W	BOTTLE	50	DOC,BP,BN	
0105G7	0445 49 51 37N	018 53 37W	BOTTLE	75	O2P,DOC,BP,BN	
0105G8	0451 49 51 37N	018 53 31W	BOTTLE	2	O2P,NO3AA,TCO2P	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0105G9	0456 49 51 38N	018 53 28W	BOTTLE	10	O2P,MIZ,TCO2P	
0105G10	0500 49 51 40N	018 53 25W	BOTTLE	20	O2P,TCO2,P	
0105G11	0510 49 51 38N	018 53 19W	BOTTLE	35	O2P,NO3AA	
0105G12	0521 49 51 38N	018 53 15W	BOTTLE	10	MIZ	
0105C2	0655 0738 49 51 52N	4030 018 52 04W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), O2,DOC,MIZ	
0105C3	0845 1222 49 52 16N	018 50 07W	CTD	1000,1500,2000,2500, 3000,3500	RN	
0105C4	1337 1420 49 51 22N	4060 018 46 40W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,POC,PON	
0105Z1	1429 1537 49 51 06N	018 46 08W	ZNET	50,100,200	BIOMASS,GUT CONTENT, MICROSCOPY	AP-20X3,AP-55X1, WP2-100X1,WP2-200X3
0105C5	1546 1604 49 50 44N	4060 018 45 34W	CTD	2,10,20,30,60,100	CHL,PPTC,C:N,CARBO, PROTEINS,SZDIS	SAMPLES FOR MAZ
0105S1	1646 0310 49 50 19N	4035 018 44 40W	SAP	2500,2995,3000,3500,4000		SEE TABLE FOR DETAILS SAPS CAST 4
0205Z1	0450 0511 49 53 59N	018 33 34W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2,WP2-500X1
0205G1	0624 49 57 31N	018 35 56W	BOTTLE	2	PP,BP,DOC,BN	
0205G2	0630 49 57 29N	018 35 48W	BOTTLE	10	PP,BP,DOC,BN	TIME ESTIMATED

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0205G3	0635 49 57 29N	018 35 41W	BOTTLE	15	PP,BP,DOC,BN	TIME ESTIMATED
0205G4	0640 49 57 27N	018 35 34W	BOTTLE	20	PP,BP,DOC,BN	TIME ESTIMATED
0205G5	0650 49 57 20N	018 35 20W	BOTTLE	25	PP,BP,DOC,BN	TIME ESTIMATED
0205G6	0700 49 57 20N	018 35 06W	BOTTLE	35	PP,BP,DOC,BN	TIME ESTIMATED
0205G7	0710 49 57 18N	018 34 54W	BOTTLE	50	BP,BN	TIME ESTIMATED
0205G8	0720 49 57 16N	018 34 41W	BOTTLE	75	BP,BN	
0205C1	0800 0840 49 57 09N	018 34 05W	CTD	5,15,25,35,50,60,80	SI	DUPLICATE BOTTLES AT 50,60,80M
0205C2	0915 1020 49 56 51N	018 33 35W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), O2,DOC,MIZ	
0205Z2	1030 1052 49 56 29N	018 32 45W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2,WP2-500X1
0205C3	1205 1250 49 56 11N	018 31 43W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC,O2,DOC, BP,BN,POC,PON,TCO2	LEVEL 1, SHALLOW PORTION
0205Z3	1255 1325 49 55 46N	018 30 52W	ZNET	100	BIOMASS, GUT CONTENT GRZ EXP	APS-55X1,WP2-200X2, WP2-500X1
0205C4	1342 1745 49 55 38N	4225 018 30 11W	CTD	400,500,600,700,800,1000, 1200,1500,2000,2500,3000,4050	NUTS,CHL,O2,DOC,BP,BN, POC,PON,TCO2	LEVEL 1, DEEP PORTION
0205Z4	1746 1801 49 54 52N	018 26 29W	ZNET	100	GUT CONTENT	WP2-200X1,WP2-500X1

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0205C5	1830 1928 49 54 33N	018 25 34W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC,O2,DOC, MAZ,SZDIS	
0205Z5	2029 2038 49 54 01N	018 23 47W	ZNET	35	APS-20X2	
0205Z6	2235 2254 49 53 43N	018 21 58W	ZNET	100	GUT CONTENT	WP2-200X1,WP2-500X1
0305C1	0005 0037 49 53 16N	018 20 53W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
0305Z1	0051 0120 49 52 57N	018 20 17W	ZNET	100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X3,WP2-500X1
0305G1	0339 49 56 22N	018 32 52W	BOTTLE	2	PP,15NH4R,O2P,DOC,BP,BN	
0305G2	0345 49 56 24N	018 32 49W	BOTTLE	2	15NO3,NO3AA	TIME ESTIMATED
0305G3	0350 49 56 25N	018 32 45W	BOTTLE	2	SI	TIME ESTIMATED
0305G4	0400 49 56 28N	018 32 37W	BOTTLE	10	PP,15NO3,O2P,DOC,BP,BN	TIME ESTIMATED
0305G5	0408 49 56 31N	018 32 22W	BOTTLE	15	PP,15NO3,DOC,BP,SI,BN	
0305G6	0413 49 56 32N	018 32 15W	BOTTLE	20	PP,15NO3,O2P,DOC,BP,BN	
0305G7	0419 49 56 26N	018 32 26W	BOTTLE	25	PP,15NO3,DOC,BP,SI,BN	
0305G8	0426 49 56 26N	018 32 26W	BOTTLE	35	PP,O2P,DOC	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0305G9	0433 49 56 28N	018 32 24W	BOTTLE	35	15NO3,NO3AA	
0305G10	0439 49 56 28N	018 32 22W	BOTTLE	50	BP,DOC,BN	
0305G11	0450 49 56 27N	018 32 21W	BOTTLE	75	O2P,DOC,BP,BN	
0305G12	0500 49 56 27N	018 32 17W	BOTTLE	25(X4)	MIZ	
0305G13	0634 0706 49 56 32N	018 32 34W	BOTTLE	25		
0305C2	0706 0800 49 56 43N	018 32 40W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30) MIZ,DOC,O2	
0305S1	0834 1208 49 56 21N	018 31 53W	SAP	350,450,600,800		SEE TABLE FOR DETAILS SAPS CAST 2
0305C3	1304 1336 49 56 24N	018 29 16W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,POC,PON,MAZ, SZDIS	
0305Z2	1417 1514 49 56 32N	018 28 48W	ZNET	100	BIOMASS, GUT CONTENT, GRZ EXP	APS-55X1,WP2-200X4, WP2-500X1
0305C4	1800 1847 49 56 08N	4060 018 27 28W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC	
0305G14	2110 2125 49 56 08N	018 25 35W	BOTTLE	25,50	MAZ,GRZ EXP	
0305Z3	2210 2329 49 56 09N	018 25 28W	ZNET	50,100,200	BIOMASS, GUT CONTENT	APS-20X2,APS-55X2,WP2-100X1, WP2-200X4,WP2-500X1
0405C1	0006 0035 49 55 50N	018 24 21W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0405G1	0413 49 53 25N	018 32 53W	BOTTLE	2	PP,BP,DOC,BN	
0405G2	0417 49 53 24N	018 32 59W	BOTTLE	10	PP,BP,MIZ,DOC,BN	
0405G3	0420 49 53 22N	018 33 03W	BOTTLE	15	PP,BP,DOC,BN	
0405G4	0425 49 53 19N	018 33 09W	BOTTLE	20	PP,BP,DOC,BN	
0405G5	0435 49 53 18N	018 33 12W	BOTTLE	25	PP,BP,DOC,BN	
0405G6	0446 49 53 15N	018 33 17W	BOTTLE	35	PP,BP,DOC,BN	
0405G7	0450 49 53 14N	018 33 15W	BOTTLE	50	BP,BN	
0405G8	0456 49 53 14N	018 33 10W	BOTTLE	75	BP,BN	
0405C2	0514 0538 49 53 10N	018 33 09W	CTD	5,15,25,35,50,60,80	SI	DIEL EXP
0405C3	0610 0654 49 53 17N	018 33 09W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), O2,DOC	DOWNCAST RERUN, LOGGING FAULT
0405G8A	0804 0825 49 53 04N	018 32 47W	BOTTLE	2,35	PP,15NO3(2),BP,BN	NO CAST NUMBER LOGGED
0405C4	0835 0915 49 53 05N	018 32 48W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,DOC	DIEL EXP. CTD ERROR U/W CONNECTION REMADE
0405G9	1202 49 52 16N	018 31 28W	BOTTLE	2	PP,15NO3,BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0405G10	1233 49 52 11N	018 31 04W	BOTTLE	35	PP,15NO3,BP,BN	
0405G11	1220 49 52 12N	018 31 10W	BOTTLE	75	BP	
0405G12	1231 49 52 10N	018 31 05W	BOTTLE	50	15NO3	
0405C5	1238 1307 49 52 09N	4060 018 31 01W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,DOC,POC, PON	DIEL EXP
0405C6	1349 1420 49 51 33N	4060 018 30 43W	CTD	2,25,50,100,350,500	RN	
0405Z1	1435 1531 49 51 04N	018 30 42W	ZNET	50,100,200	BIOMASS, GUT CONTENT	APS-20X1,APS-55X3, WP2-200X4
0405C7	1541 1606 49 51 01N	4060 018 31 25W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,PTC,C:N, CARBO,PROTEINS,SZDIS	
0405G13	1612 49 50 46N	018 31 54W	BOTTLE	2	BP,BN	
0405G14	1616 49 50 44N	018 31 57W	BOTTLE	35		
0405G15	1623 49 50 44N	018 31 56W	BOTTLE	75	BP,BN	
0405C8	1655 1725 49 50 45N	4060 018 31 48W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), O2,DOC	DIEL EXP
0405S1	1800 2035 49 51 01N	018 32 18W	SAP	15,50,125,200		SAPS CAST 1
0405Z1A	2050 2057 49 50 49N	018 31 40W	ZNET	35	MIZ	NO CAST NUMBER LOGGED

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0405C9	2110 2145 49 50 37N	4060 018 31 33W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC,O2	DIEL EXP
0405G13A	2210 49 50 30N	018 30 57W	BOTTLE	2	BP,BN	CAST SERIAL NOS REPEATED
0405G14A	2220 49 50 30N	018 30 51W	BOTTLE	35		CAST SERIAL NOS REPEATED
0405G15A	2233 49 50 29N	018 30 44W	BOTTLE	50		CAST SERIAL NOS REPEATED
0405G16	2243 49 50 25N	018 30 40W	BOTTLE	75	BP,BN	
0405Z2	2304 2340 49 50 21N	018 30 35W	ZNET	100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X2, WP2-500X2
0505C1	0012 0035 49 50 21N	4060 018 29 54W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC	DIEL EXP
0505Z1	0333 49 46 47N	018 32 47W	ZNET	100	BIOMASS	WP2-200
0505Z2	0338 49 46 45N	018 32 50W	ZNET	100	GUT CONTENT	WP2-200
0505G1	0410 49 46 34N	018 33 07W	BOTTLE	2	PP,15NO3,BP,DOC,BN	
0505G2	0414 49 46 33N	018 33 11W	BOTTLE	10	PP,BP,DOC,BN	
0505G3	0418 49 46 33N	018 33 11W	BOTTLE	15	PP,BP,DOC,BN	
0505G4	0423 49 46 35N	018 33 10W	BOTTLE	20	PP,BP,DOC,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0505G5	0432 49 46 36N	018 33 05W	BOTTLE	25	PP,BP,DOC,BN	
0505G6	0437 49 46 37N	018 33 03W	BOTTLE	35	PP,BP,DOC,BN	
0505G7	0445 49 46 38N	018 33 00W	BOTTLE	50	BP,BN	
0505G8	0455 49 46 36N	018 32 58W	BOTTLE	75	BP,BN	
0505G9	0500 49 46 36N	018 32 49W	BOTTLE	25	MIZ	
0505G10	0508 49 46 35N	018 32 47W	BOTTLE	25	MIZ	
0505C2	0600 0644 49 46 17N	4060 018 32 43W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), MIZ	DIEL EXP
0505Z3	0700 0712 49 45 48N	018 32 39W	ZNET	100	GUT CONTENT	WP2-200X1
0505G10A	0809 0825 49 45 38N	018 32 55W	BOTTLE	2	BP,BN	NO CAST NUMBER LOGGED, ONLY ONE BOTTLE DEPTH KNOWN
0505C3	0912 0945 49 45 09N	4025 018 32 50W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2	DIEL EXP
0505Z4	1105 1127 49 44 26N	018 32 08W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
0505G11	1210 49 44 09N	018 31 29W	BOTTLE	2	PP,BP,15NO3,BN	
0505G12	1215 49 44 09N	018 31 22W	BOTTLE	35	PP,15NO3	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0505G13	1220 49 44 09N	018 31 16W	BOTTLE	50	15NO3	
0505G14	1225 49 44 08N	018 31 11W	BOTTLE	75	BP,BN	
0505C4	1418 1436 49 43 59N	4025 018 30 37W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,PPTC,SZDIS, PTC	DIEL EXP
0505G15	1600 1610 49 43 36N	018 30 11W	BOTTLE	2	15N	
0505C5	1648 1722 49 43 31N	4025 018 30 37W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	DIEL EXP
0505Z5	1800 1830 49 43 18N	018 30 49W	ZNET	50,100	BIOMASS, GUT CONTENT, GRZ EXP	APS-20X1,WP2-200X3
0505C6	2115 2145 49 41 58N	4025 018 29 35W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2	DIEL EXP
0505Z6	2230 2245 49 41 34N	018 29 19W	ZNET	50,100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X4,WP2-500X1
0605Z1	0007 0046 49 40 56N	018 28 25W	ZNET	50,100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X4,WP2-500X1
0605C1	0055 0133 49 40 30N	018 28 01W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
0605G1	0409 49 39 39N	018 33 14W	BOTTLE	2	PP,NOX	
0605G2	0412 49 39 38N	018 33 13W	BOTTLE	10	PP,NOX	
0605G3	0419 49 39 38N	018 33 10W	BOTTLE	15	PP,NOX	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0605G4	0421 49 39 37N	018 33 10W	BOTTLE	20	PP,NOX	
0605G5	0423 49 39 37N	018 33 09W	BOTTLE	25	PP,NOX	
0605G6	0431 49 39 34N	018 33 02W	BOTTLE	35	PP,NOX	
0605C2	0511 0550 49 39 21N	3910 018 32 34W	CTD	5,15,30,35,40,50,80	SI	
0605C3	0625 0700 49 39 14N	3895 018 31 49W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC,BP,BN,CBN	
0605Z2	1107 1140 49 37 48N	018 30 57W	ZNET	50,100	BIOMASS, GUT CONTENT, GRZ EXP	APS-55X1,WP2-100X1, WPS-200X2
0605C4	1206 1232 49 37 50N	3895 018 30 21W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,DOC,HPLC, BP,BN,POC,PON,TCO2	LEVEL 1 SHALLOW PORTION
0605C5	1332 1615 49 37 58N	4020 018 29 18W	CTD	400,500,600,700,800,1000,1200, 1500,2000,2500,3000,3960	NUTS,CHL,O2,DOC,BP,BN, POC,PON	LEVEL 1 DEEP PORTION
0605C6	1812 1845 49 36 04N	4900 018 28 25W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	
0605G7	2102 2107 49 34 53N	018 28 10W	BOTTLE	10	MAZ,GRZ EXP	
0605Z3	2150 2157 49 34 31N	018 28 07W	ZNET	35		APS-20X1
0605Z4	2235 0002 49 34 30N	018 28 03W	ZNET	50,100,200	BIOMASS, GUT CONTENT, GRZ EXP	APS-20X2,APS-55X2, WP2-100X1,WP2-200X5,WP2-500X1
0705C1	0014 0049 49 34 16N	4060 018 27 15W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0705G1	0347 49 35 11N	018 36 07W	BOTTLE	2	PP,O2P,DOC,BP,TCO2P,BN	
0705G2	0350 49 35 11N	018 36 06W	BOTTLE	2	15NO3,NO3AA	TIME ESTIMATED
0705G3	0353 49 35 10N	018 36 05W	BOTTLE	2	SI	TIME ESTIMATED
0705G4	0405 49 35 07N	018 36 00W	BOTTLE	10	PP,O2P,15NO3,DOC,BP,BN	TIME ESTIMATED
0705G5	0412 49 35 04N	018 35 57W	BOTTLE	15	PP,15NO3,DOC,BP,SI,BN	TIME ESTIMATED
0705G6	0420 49 35 01N	018 35 52W	BOTTLE	20	PP,O2P,15NO3,DOC,BP,BN	
0705G7	0430 49 34 56N	018 35 45W	BOTTLE	25	PP,15NO3,DOC,BP,SI,BN	
0705G8	0437 49 34 55N	018 35 41W	BOTTLE	35	PP,O2P,DOC,BP,BN	
0705G9	0443 49 34 55N	018 35 36W	BOTTLE	35	15NO3,NO3AA	
0705G10	0450 49 34 55N	018 35 31W	BOTTLE	50	BP,DOC,BN	
0705G11	0500 49 34 53N	018 35 26W	BOTTLE	75	BP,DOC,BN	
0705G12	0505 0520 49 34 50N	018 35 22W	BOTTLE	10(X4)	MIZ	
0705C2	0640 0710 49 34 13N	4925 018 35 13W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0705C3	1236 1305 49 32 22N	4025 018 34 14W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2(2), TCO2(2),POC,PON	
0705Z1	1355 1505 49 32 18N	 018 33 46W	ZNET	25,50,100,200	BIOMASS, GUT CONTENT	APS-20X1,APS-55X2, WP2-100X1,WP2-200X6
0705C4	1515 1532 49 32 16N	4025 018 33 30W	CTD	2,10,20,30,60,100	CHL,PTC,C:N,CARBO, PROTEINS,SZDIS	SAMPLES FOR MAZ
0705S1	1540 2230 49 32 22N	 018 33 23W	SAP	1500(X2),2000(X2)		SAPS CAST 3
0805C1	0007 0038 49 33 06N	 018 30 13W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
0805Z1	0044 0105 49 33 09N	 018 29 51W	ZNET	50,100	BIOMASS, GUT CONTENT	WP2-200X3
0805G1	0405 49 29 55N	 018 36 52W	BOTTLE	2	PP,15NO3,BP,BN,NOX	
0805G2	0410 49 29 55N	 018 36 53W	BOTTLE	10	PP,15NO3,BP,BN,NOX	
0805G3	0418 49 29 54N	 018 36 56W	BOTTLE	15	PP,BP,BN,NOX	
0805G4	0422 49 29 54N	 018 36 58W	BOTTLE	20	PP,BP,BN,NOX	
0805G5	0426 49 29 55N	 018 37 00W	BOTTLE	25	PP,BP,BN,NOX	
0805G6	0432 49 29 55N	 018 37 02W	BOTTLE	35	PP,15NO3,BP,BN,NOX	
0805G7	0440 49 29 56N	 018 37 04W	BOTTLE	50	BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0805G8	0448 49 29 56N	018 37 09W	BOTTLE	75	BP,BN	
0805C2	0510 0534 49 29 55N	4030 018 37 21W	CTD	5,15,20,25,30,40,60,100	SI	
0805Z2	0538 0600 49 30 14N	018 37 15W	ZNET	50,100	BIOMASS, GUT CONTENT	WP2-200X3
0805C3	0617 0650 49 30 30N	4030 018 37 19W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC	
0805Z3	0905 0930 49 31 03N	018 37 43W	ZNET	50,100	BIOMASS, GUT CONTENT	WP2-200X3
0805C4	1002 1050 49 31 12N	4030 018 37 26W	CTD	2,25,50,100,350,500	RN	
0805C5	1202 1226 49 31 31N	4030 018 36 59W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2(2),TCO2(2), POC,PON,PTC,SZDIS	
0805Z4	1308 1329 49 31 49N	018 37 06W	ZNET	50,100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X3
0805G9	1630 1642 49 32 03N	018 37 49W	BOTTLE	10(X3)	MIZ, BDILEX, GRZ EXP	
0805Z5	1650 1720 49 31 58N	018 38 03W	ZNET	50,100	BIOMASS, GUT CONTENT	WP2-200X3
0805C6	1802 1833 49 31 40N	4030 018 38 45W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	
0805Z6	2100 2120 49 31 01N	018 39 49W	ZNET	50,100	BIOMASS, GUT CONTENT	WP2-200X3
0905C1	0001 0027 49 30 48N	4030 018 40 26W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0905Z1	0050 0138 49 30 29N	018 40 10W	ZNET	50,100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X2,WP2-500X4
0905G1	0340 49 31 45N	018 35 25W	BOTTLE	2	PP,BP,NOX,BN	
0905G2	0343 49 31 44N	018 35 29W	BOTTLE	2	15NO3,O2P,TCO2P	
0905G3	0347 49 31 44N	018 35 35W	BOTTLE	2	SI	
0905G4	0352 49 31 47N	018 35 31W	BOTTLE	10	PP,O2P,15NO3,BP,BN,NOX	
0905G5	0357 49 31 50N	018 35 24W	BOTTLE	2	NO3AA	
0905G6	0402 49 31 53N	018 35 18W	BOTTLE	15	PP,15NO3,BP,SI,BN,NOX	
0905G7	0409 49 31 58N	018 35 09W	BOTTLE	20	PP,O2P,15NO3,BP,BN,NOX	
0905G8	0414 49 31 59N	018 35 01W	BOTTLE	25	PP,15NO3,BP,SI,BN,NOX	
0905G9	0419 49 31 58N	018 34 56W	BOTTLE	35	PP,O2P,15NO3,BP,BN,NOX	
0905G10	0425 49 31 52N	018 34 59W	BOTTLE	35	NO3AA	
0905G11	0432 49 31 45N	018 35 03W	BOTTLE	50	BP,BN	
0905G12	0442 49 31 36N	018 35 09W	BOTTLE	75	O2P,BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
0905G13	0448 49 31 30N	 018 35 12W	BOTTLE	10	MIZ, GRZ EXP	
0905C2	0623 0650 49 30 57N	4015 018 35 12W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	
0905Z2	1107 1133 49 29 21N	 018 36 33W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
0905G14	1141 1200 49 29 07N	 018 36 25W	BOTTLE	2,10,35	15NO3	
0905C3	1217 1245 49 28 53N	4040 018 36 26W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,DOC,HPLC,PTC,CBN MIZ,BP,BN,POC,PON,TCO2,SZDIS	LEVEL 1 SHALLOW PORTION
0905C4	1323 1618 49 28 28N	4050 018 36 28W	CTD	400,500,600,700,800,1000,1200, 1500,2000,2500,3000,4032	NUTS,CHL,O2,DOC,POC, PON,TCO2	LEVEL 1 DEEP PORTION, SPOOLING PROBLEMS ON UPCAST
0905G15	2010 2020 49 25 43N	 018 34 34W	BOTTLE	5,10		
0905C5	2025 2046 49 25 42N	4180 018 34 29W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	UNSTABLE CTD O/P, LEAK IN U/W CONNECTOR
0905Z3	2200 2330 49 25 22N	 018 34 27W	ZNET	25,50,100	BIOMASS, GUT CONTENT GRZ EXP (CANCELLED)	APS-20X1,APS-55X1,WP2-100X1, WP2-200X4,WP2-500X1,WP2-500DX2
1005C1	0016 0042 49 24 39N	4180 018 34 25W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
1005G1	0410 49 29 12N	 018 28 10W	BOTTLE	2	PP,15NO3	
1005G2	0415 49 29 10N	 018 28 08W	BOTTLE	10	PP,15NO3,HPLC	
1005G3	0418 49 29 08N	 018 28 07W	BOTTLE	15	PP	

Station	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1005G4	0422 49 29 06N	018 28 05W	BOTTLE	20	PP	
1005G5	0444 49 28 52N	018 27 54W	BOTTLE	25	PP	
1005G6	0450 49 28 48N	018 27 51W	BOTTLE	35	PP,15NO3	
1005G7	0458 49 28 42N	018 27 45W	BOTTLE	50		NO RECORD OF SAMPLES TAKEN
1005G8	0507 49 28 36N	018 27 39W	BOTTLE	75		NO RECORD OF SAMPLES TAKEN
1005C2	0522 0544 49 28 25N	4135 018 27 37W	CTD	5,15,25,30,35,40,60	SI	
1005C3	0631 0708 49 27 43N	4160 018 27 32W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	
1005S1	0900 1130 49 27 03N	018 27 24W	SAP	50,100		SAPS CAST 6
1005C4	1206 1229 49 27 06N	4190 018 25 59W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2(2),TCO2(2), POC,PON,BP,BN	
1005Z1	1246 1330 49 27 04N	018 25 40W	ZNET	100	BIOMASS, GUT CONTENT	APS-20X1,APS-55X1, WP2-200X2,WP2-500DX1
1005C5	1356 1409 49 27 06N	4190 018 25 08W	CTD	2,10,20,30,60,100	CHL,PPTC,C:N,CARBO, PROTEINS,SZDIS	SAMPLES FOR MAZ
1005C6	1700 1728 49 27 10N	4175 018 23 42W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	CHL,NUTS,HPLC(10,30)	
1005S2	1800 2004 49 27 17N	018 23 14W	SAP	15,30		SAPS CAST 5

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1005Z2	2330 0021 49 26 54N	 018 18 19W	ZNET		BIOMASS, GUT CONTENT, MIZ	WP2-200X4,WP2-500X2, APS-20X1,35
1105C1	0029 0054 49 26 06N	4155 018 17 47W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	DIEL EXP
1105Z1	0311 0336 49 24 17N	 018 21 05W	ZNET	30,100	BIOMASS, GUT CONTENT	WP2-200X4
1105G1	0337 49 23 52N	 018 20 42W	BOTTLE	2	PP,O2P,DOC	
1105G2	0340 49 23 49N	 018 20 44W	BOTTLE	2	PP,15NO3,DOC,BP,SI,BN	
1105G3	0344 49 23 45N	 018 20 47W	BOTTLE	10	PP,15NO3,DOC,BP,SI,BN	
1105G4	0349 49 23 40N	 018 20 51W	BOTTLE	15	PP,15NO3,DOC,BP,SI,BN	
1105G5	0358 49 23 30N	 018 20 57W	BOTTLE	20	PP,15NO3,DOC,BP,SI,BN	
1105G6	0405 49 23 25N	 018 21 08W	BOTTLE	25	PP,15NO3,DOC,BP,SI,BN	
1105G7	0411 49 23 22N	 018 21 18W	BOTTLE	35	PP,15NO3,DOC,BP,SI,BN	
1105G8	0417 49 23 20N	 018 21 15W	BOTTLE	50	BP,BN	
1105G9	0427 49 23 16N	 018 21 12W	BOTTLE	75	BP,BN	
1105G10	0432 49 23 13N	 018 21 10W	BOTTLE	35	PP	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1105G11	0437 49 23 10N	018 21 09W	BOTTLE	25	MIZ	
1105G12	0442 49 23 07N	018 21 07W	BOTTLE	25	MIZ	
1105G13	0447 49 23 04N	018 21 04W	BOTTLE	25	MIZ	
1105G14	0451 49 23 02N	018 21 02W	BOTTLE	25	MIZ	
1105C2	0618 0656 49 21 51N	4230 018 20 28W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC	DIEL EXP
1105Z2	0702 0722 49 21 27N	018 20 37W	ZNET	30,100	BIOMASS, GUT CONTENT	WP2-200X4
1105G15	0804 4230 49 21 00N	018 20 36W	BOTTLE	2	PP,15NO3,O2P,BP,TCO2P, BN	
1105G16	0810 49 20 57N	018 20 35W	BOTTLE	10	15NO3	TIME ESTIMATED
1105G17	0820 49 20 55N	018 20 30W	BOTTLE	35	15NO3,PP,BP,BN	TIME ESTIMATED
1105G18	0830 49 20 53N	018 20 25W	BOTTLE	75	BP,BN	
1105C3	0905 0935 49 20 46N	4230 018 20 07W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC	DIEL EXP
1105Z3	1100 1124 49 20 18N	018 19 08W	ZNET	30,100	BIOMASS, GUT CONTENT	WP-200X4
1105G19	1206 49 20 08N	018 18 10W	BOTTLE	2	PP,15NO3,BP,O2P,TCO2P, BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1105G20	1215 49 20 06N	018 18 05W	BOTTLE	35	PP,BP,BN	TIME ESTIMATED
1105G21	1226 49 20 04N	018 17 53W	BOTTLE	75	BP,BN	
1105C4	1302 1332 49 19 45N	4185 018 17 11W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC,PTC,SZDIS, POC,PON	DIEL EXP
1105C5	1502 1538 49 19 06N	4140 018 15 05W	CTD	2,25,50,100,300,500	RN	
1105G22	1600 49 18 43N	018 14 08W	BOTTLE	2	PP,15NO3,O2P,BP,BN	
1105G23	1610 49 18 41N	018 14 05W	BOTTLE	10	15NO3	TIME ESTIMATED
1105G24	1620 49 18 39N	018 13 50W	BOTTLE	35	PP,15NO3,BP,BN	TIME ESTIMATED
1105G25	1629 49 18 40N	018 13 41W	BOTTLE	75	BP,BN	
1105C6	1705 1735 49 18 32N	4085 018 12 48W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	DIEL EXP
1105Z4	1805 1827 49 18 04N	018 11 21W	ZNET	30,100	BIOMASS, GUT CONTENT	WP2-200X4
1105G26	2001 49 17 23N	018 08 56W	BOTTLE	2	15NO3,BP,BN	
1105G27	2012 49 17 17N	018 08 45W	BOTTLE	35	BP,BN	TIME ESTIMATED
1105G28	2025 49 17 15N	018 08 26W	BOTTLE	75	BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1105C7	2105 2130 49 17 05N	4150 018 07 31W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	DIEL EXP
1105Z5	2204 2247 49 16 39N	018 06 30W	ZNET	30,100	BIOMASS, GUT CONTENT GRZ EXP	APS-55X1,WP2-200X4, WP2-500DX1
1205Z1	0011 0020 49 15 43N	018 03 25W	ZNET	30,100	BIOMASS, GUT CONTENT	WP2-200X4
1205C1	0110 0155 49 15 09N	018 01 52W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
1205G1	0416 49 19 06N	018 08 31W	BOTTLE	2	PP,15NO3,DOC,BP,BN,NOX	
1205G2	0428 49 19 00N	018 08 16W	BOTTLE	10	PP,15NO3,HPLC,DOC,BP, BN,NOX	
1205G3	0433 49 18 59N	018 08 09W	BOTTLE	15	PP,DOC,BP,BN,NOX	
1205G4	0441 49 18 57N	018 08 01W	BOTTLE	20	PP,DOC,BP,BN,NOX	
1205G5	0450 49 18 53N	018 07 51W	BOTTLE	25	PP,DOC,BP,BN,NOX	
1205G6	0456 49 18 51N	018 07 47W	BOTTLE	35	PP,15NO3,DOC,BP,BN,NOX	
1205G7	0503 49 18 50N	018 07 42W	BOTTLE	35	NO3AA	
1205G8	0510 49 18 48N	018 07 41W	BOTTLE	50	BP,BN	
1205G9	0520 49 18 41N	018 07 33W	BOTTLE	75	BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1205C2	0526 0558 49 18 34N	4090 018 07 27W	CTD	5,20,25,30,35,40,60	SI	
1205C3	0630 0705 49 18 04N	4090 018 06 43W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	
1205Z2	1106 1129 49 18 21N	018 00 01W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
1205G10	1155 49 17 42N	017 58 29W	BOTTLE	5	15NO3	
1205G11	1205 49 17 40N	017 58 12W	BOTTLE	10	15NO3	TIME ESTIMATED
1205G12	1211 49 17 39N	017 58 03W	BOTTLE	35	15NO3	
1205C4	1219 1247 49 17 29N	4080 017 57 46W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,O2,DOC,HPLC,PTC,CBN MIZ,BP,BN,POC,PON,TCO2,SZDIS	LEVEL 1 SHALLOW PORTION
1205C5	1358 2010 49 16 16N	4135 017 55 45W	CTD	400,500,600,700,800,1000,1200 1500,2000,2500,3000,4124	NUTS,CHL,O2,DOC,POC, PON	LEVEL 1 DEEP PORTION. SPOOLING PROBLEM ON UPCAST
1205G13	2030 2045 49 15 22N	017 52 42W	BOTTLE	10		
1205Z3	2200 2310 49 14 50N	017 52 02W	ZNET	30,100	BIOMASS, GUT CONTENT, GRZ EXP	APS-20X1,APS-55X1,WP2-200X3, WP2-500X1,WP2-500DX2
1305G1	0420 49 12 56N	017 51 51W	BOTTLE	2	PP,NOX	
1305G2	0424 49 12 53N	017 51 46W	BOTTLE	10	PP,NOX	TIME ESTIMATED
1305G3	0428 49 12 51N	017 51 41W	BOTTLE	15	PP,NOX	TIME ESTIMATED

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1305G4	0434 49 12 47N	017 51 36W	BOTTLE	20	PP,NOX	TIME ESTIMATED
1305G5	0438 49 12 43N	017 51 34W	BOTTLE	25	PP,NOX	TIME ESTIMATED
1305G6	0446 49 12 35N	017 51 27W	BOTTLE	35	PP,NOX	TIME ESTIMATED
1305G7	0452 49 12 25N	017 51 23W	BOTTLE	25	MIZ	TIME ESTIMATED
1305G8	0500 49 12 18N	017 51 17W	BOTTLE	25	MIZ	TIME ESTIMATED
1305G9	0506 49 12 12N	017 51 12W	BOTTLE	25	MIZ	
1305C1	0610 0647 49 11 10N	4055 017 50 44W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC	
1305Z1	1000 1050 49 08 19N	017 48 10W	ZNET	30,100	BIOMASS, GUT CONTENT	APS-20X1,APS-55(X1), WP2-100X1,WP2-200X3
1305C2	1115 1130 49 08 08N	4080 017 47 01W	CTD	2,10,20,30,60,100	CHL,PPTC,C:N,CARBO, PROTEINS,SZDIS	SAMPLES FOR MAZ
1305G9A	1136 49 08 04N	017 46 48W	BOTTLE	2	15NO3	
1305G10	1139 49 08 05N	017 46 47W	BOTTLE	10	15NO3	
1305G11	1143 49 08 05N	017 46 44W	BOTTLE	35	15NO3	
1305C3	1244 1305 49 07 54N	4077 017 45 38W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,POC,PON,O2(2), TCO2(2)	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1305S1	1345 1750 49 07 53N	017 44 36W	SAP	750(X2),1000(X2)		SAPS CAST 8
1305C4	1802 1836 49 08 33N	4265 017 39 03W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), MIZ	
1305Z2	2300 2335 49 08 34N	017 32 55W	ZNET	30,35,100	BIOMASS, GUT CONTENT, GRZ EXP, MIZ	APS-20X1,WP2-200X4, WP2-500DX1
1405C1	0013 0042 49 08 16N	4265 017 31 43W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	PROBLEMS CTD READOUT 200-300M
1405Z1	0304 0319 49 10 53N	017 34 54W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2
1405G1	0341 49 10 32N	017 34 09W	BOTTLE	2	O2P,15NO3,BP,TCO2,BN	
1405G2	0351 49 10 30N	017 34 08W	BOTTLE	2	PP,15NO3	
1405G3	0354 49 10 31N	017 34 09W	BOTTLE	10	PP,15NO3,O2P,BP,BN	
1405G4	0408 49 10 30N	017 34 04W	BOTTLE	2	NO3AA	
1405G5	0414 49 10 28N	017 33 58W	BOTTLE	15	PP,15NO3,BP,BN	
1405G6	0419 49 10 25N	017 33 55W	BOTTLE	20	PP,15NO3,O2P,BP,BN	
1405G7	0423 49 10 24N	017 33 54W	BOTTLE	25	PP,15NO3,BP,BN	
1405G8	0429 49 10 25N	017 33 45W	BOTTLE	35	PP,15NO3,O2P,BP,BN	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1405G9	0442 49 10 33N	017 33 28W	BOTTLE	35	NO3AA	
1405G10	0449 49 10 32N	017 33 20W	BOTTLE	50	BP,BN	
1405G11	0457 49 10 30N	017 33 10W	BOTTLE	75	O2P,BP,BN	
1405C2	0500 0531 49 10 30N	4740 017 33 11W	CTD	5,15,30,35,40,45,60	SI	
1405C3	0630 0720 49 10 27N	4740 017 30 58W	CTD	2,10,20,30,40,50,60 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	NOISY CTD RECORD
1405Z2	0900 0920 49 11 54N	017 28 47W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2
1405C4	1235 1300 49 14 31N	4740 017 26 58W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,POC,PON,PPTC	
1405G12	1305 49 14 56N	017 26 48W	BOTTLE	2	15NO3	
1405G13	1310 49 15 00N	017 26 43W	BOTTLE	10	15NO3	
1405G14	1315 49 15 04N	017 26 42W	BOTTLE	35	15NO3	
1405Z3	1324 1402 49 15 13N	017 26 41W	ZNET	35,100	BIOMASS, GUT CONTENT, MIZ	APS-55X1,WP2-200X2, APS-20X2
1405S1	1410 1746 49 15 51N	017 26 25W	SAP	350,500		SAPS CAST 7
1405Z4	1746 1807 49 18 36N	017 25 35W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1405C5	1830 1905 49 18 53N	4815 017 26 16W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), PTC,SZDIS	
1405C6	2007 2045 49 19 23N	4815 017 26 39W	CTD	2,25,50,100,350,500	RN	
1405Z5	2105 2130 49 19 41N	 017 26 50W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2
1505Z1	0007 0038 49 20 09N	 017 27 05W	ZNET	100	BIOMASS, GUT CONTENT GRZ EXP	WP2-200X2,WP2-500DX2
1505C1	0040 0100 49 20 10N	4810 017 27 17W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
1505G1	0405 49 09 30N	 017 18 02W	BOTTLE	2	PP,15NO3,DOC	
1505G2	0410 49 09 32N	 017 18 02W	BOTTLE	2	NOX	
1505G3	0414 49 09 34N	 017 18 02W	BOTTLE	10	PP,15NO3,DOC,NOX	
1505G4	0423 49 09 39N	 017 18 02W	BOTTLE	15	PP,DOC,NOX	
1505G5	0430 49 09 44N	 017 18 00W	BOTTLE	20	PP,DOC,NOX	
1505G6	0438 49 09 48N	 017 17 58W	BOTTLE	25	PP,DOC,NOX	
1505G7	0451 49 09 55N	 017 17 49W	BOTTLE	35	PP,15NO3,DOC,NOX	
1505G8	0454 49 09 58N	 017 17 52W	BOTTLE	10	MIZ,BDILEX	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1505G9	0457 49 10 01N	017 17 56W	BOTTLE	10	MIZ,BDILEX	
1505G10	0500 49 10 02N	017 17 54W	BOTTLE	10	MIZ,BDILEX	
1505G11	0511 49 10 08N	017 17 50W	BOTTLE	10	MIZ,BDILEX	
1505G12	0516 49 10 10N	017 17 48W	BOTTLE	10	MIZ,BDILEX	
1505C2	0600 0643 49 10 22N	4815 017 17 14W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC,MIZ	
1505C3	0805 0830 49 10 27N	4815 017 16 08W	CTD	5,15,25,30,40,60	SI	
1505Z1A	1106 1130 49 08 59N	017 15 15W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
1505G13	1155 49 08 31N	017 15 17W	BOTTLE	10	GRZ EXP	
1505C4	1208 1230 49 08 22N	4815 017 15 20W	CTD			CAST ABORTED NOISY O/P
1505S1	1336 1610 49 07 42N	017 15 33W	SAP	350(X1),500(X2),750(X1)		EXTRA SAPS CAST DEPLOYMENT TRIAL
1505Z2	2305 0005 49 05 25N	017 15 21W	ZNET	30,100	BIOMASS, GUT CONTENT, GRZ EXP	APS-20X1,APS-55X1,WP2-100X1, WP2-200X3,WP2-500X1,WP2-500DX1
1605G1	0850 49 02 05N	017 04 22W	BOTTLE	2	PP,O2P,CHL	TYRO INTERCALIB EX
1605G2	0853 49 02 04N	017 04 23W	BOTTLE	2	15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1605G3	0857 49 02 03N	017 04 21W	BOTTLE	10	PP,O2P,CHL	TYRO INTERCALIB EX
1605G4	0913 49 02 00N	017 04 18W	BOTTLE	10	15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX
1605G5	0918 49 01 59N	017 04 17W	BOTTLE	15	PP,15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX
1605G6	0925 49 01 58N	017 04 20W	BOTTLE	20	PP,O2P,CHL	TYRO INTERCALIB EX
1605G7	0931 49 01 57N	017 04 19W	BOTTLE	20	15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX
1605G8	0939 49 01 55N	017 04 17W	BOTTLE	25	PP,15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX
1605G9	0949 49 01 52N	017 04 12W	BOTTLE	35	PP,O2P,CHL	TYRO INTERCALIB EX
1605G10	0955 49 01 51N	017 04 10W	BOTTLE	35	15NO3,CHL,HPLC,DOC	TYRO INTERCALIB EX
1605C1	1308 1620 49 01 24N	4810 017 03 42W	CTD	400,500,600,700,800,1000,1200, 1500,2000,2500,3000,4780	NUTS,CHL	TYRO INTERCALIB LEVEL 1 DEEP CAST
1605C2	1745 1820 49 01 04N	4810 017 02 10W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	TYRO INTERCALIB LEVEL 1 SHALLOW CAST
1605Z1	2305 2328 49 01 43N	017 00 17W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
1705C1	0030 0054 49 01 14N	4810 017 00 10W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
1705Z1	0309 0325 48 55 36N	017 04 14W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1705G1	0340 48 55 36N	017 03 45W	BOTTLE	2	O2P,DOC,BP,BN	TIME ESTIMATED
1705G2	0345 48 55 33N	017 03 46W	BOTTLE	2	NO3AA	TIME ESTIMATED
1705G3	0350 48 55 30N	017 03 47W	BOTTLE	2	PP,15NO3,SI	TIME ESTIMATED
1705G4	0400 48 55 23N	017 03 48W	BOTTLE	10	PP,15NO3,SI	TIME ESTIMATED
1705G5	0410 48 55 17N	017 03 49W	BOTTLE	10	O2P,DOC	
1705G6	0421 48 55 12N	017 03 50W	BOTTLE	15	PP,15NO3,DOC	
1705G7	0428 48 55 11N	017 03 51W	BOTTLE	20	PP,15NO3,O2P,DOC	
1705G8	0433 48 55 11N	017 03 48W	BOTTLE	25	PP,15NO3,DOC	
1705G8A	0438 48 55 10N	017 03 47W	BOTTLE	35	PP,O2P,DOC	CAST MISNUMBERED IN LOG
1705G9	0447 48 55 09N	017 03 42W	BOTTLE	35	PP,15NO3,DOC	
1705G10	0457 48 55 07N	017 03 33W	BOTTLE	75	BP,BN	
1705G10A	0505 48 54 59N	017 03 21W	BOTTLE	10	MIZ	CAST NOT NUMBERED IN LOGS
1705G10B	0512 48 54 56N	017 03 16W	BOTTLE	10	MIZ	CAST NOT NUMBERED IN LOGS

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1705C2	0610 0640 48 54 44N	4810 017 02 35W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30), DOC	DIEL EXP
1705Z2	0710 0722 48 54 20N	017 02 14W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200(X2)
1705C3	0722 0751 48 54 17N	4810 017 02 14W	CTD	2,10,20,30,60,100	CHL,PPTC,C:N,CARBO, PROTEINS,SZDIS	SAMPLES FOR MAZ
1705G11	0804 48 54 11N	017 02 07W	BOTTLE	2	O2P,BP,TCO2P,BN	
1705G12	0809 48 54 11N	017 02 06W	BOTTLE	2	PP,15NO3,SI	
1705G13	0815 48 54 09N	017 02 04W	BOTTLE	10	15NO3,SI	
1705G14	0826 48 54 06N	017 01 58W	BOTTLE	35	PP,15NO3,SI,DOC	
1705G15	0834 48 54 04N	017 01 57W	BOTTLE	75	BP,BN	
1705S1	0900 1145 48 54 02N	017 01 52W	SAP	15,50,125,200		SAPS CAST 9
1705Z3	1215 1225 48 53 40N	017 00 04W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
1705G16	1306 48 53 33N	016 59 25W	BOTTLE	2	O2P,DOC,BP,TCO2P,BN	
1705G17	1310 48 53 31N	016 59 23W	BOTTLE	2	PP,15NO3,SI	TIME ESTIMATED
1705G18	1315 48 53 28N	016 59 18W	BOTTLE	35	PP	TIME ESTIMATED

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1705G19	1320 48 53 29N	016 59 17W	BOTTLE	75	BP,BN	TIME ESTIMATED
1705C4	1328 1400 48 53 30N	4810 016 59 13W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC	DIEL EXP
1705C5	1430 1504 48 53 16N	4810 016 58 28W	CTD	2,25,50,100,350,500	RN	
1705G20	1610 48 53 04N	016 57 46W	BOTTLE	2	O2P,BP,BN	
1705G21	1615 48 53 03N	016 57 43W	BOTTLE	2	15NO3,SI	TIME ESTIMATED
1705G22	1620 48 53 02N	016 57 41W	BOTTLE	10	15NO3,SI	TIME ESTIMATED
1705G23	1630 48 53 00N	016 57 38W	BOTTLE	35	15NO3,SI	TIME ESTIMATED
1705G24	1640 48 52 57N	016 57 36W	BOTTLE	75	BP,BN	
1705C6	1655 1725 48 52 50N	4810 016 57 26W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,DOC, HPLC(10,30)	DIEL EXP
1705Z4	1800 1813 48 52 34N	016 56 21W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2
1705G25	2020 48 52 29N	016 56 15W	BOTTLE	2	BP,O2P,BN	
1705G26	2025 48 52 29N	016 56 15W	BOTTLE	75	BP,BN	
1705C7	2104 2134 48 52 26N	4810 016 56 19W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	DIEL EXP

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1705Z5	2205 2225 48 52 30N	016 56 24W	ZNET	100	BIOMASS, GUT CONTENT	WP2-200X2
1805C1	2207 2240 48 36 10N	4600 017 18 46W	CTD	10,20,30,40,50,60,75, 100,150,200,300(X2)	NUTS,CHL	
1805Z1	2320 0056 48 35 48N	017 19 11W	ZNET	50,100,200	BIOMASS, GUT CONTENT, GRZ EXP	APS-20X1,APS-55X1,WP2-100X1, WP2-200X4,WP2-500X1,WP2-500DX2
1905MIZ1	0040 48 35 10N	017 19 09W	ZNET	35	MIZ	APS-20X1
1905G1	0340 48 34 15N	017 19 20W	BOTTLE	2	PP,O2P,DOC,TCO2P,NOX	
1905G2	0343 48 34 14N	017 19 22W	BOTTLE	2	15NO3,SI	
1905G3	0346 48 34 14N	017 19 23W	BOTTLE	2	NO3AA	
1905G4	0355 48 34 09N	017 19 24W	BOTTLE	10	O2P,DOC,TCO2P	
1905G5	0358 48 34 07N	017 19 24W	BOTTLE	10	PP,15NO3,SI,NOX	
1905G6	0405 48 34 03N	017 19 26W	BOTTLE	15	PP,15NO3,DOC,NOX	
1905G7	0411 48 33 59N	017 19 28W	BOTTLE	20	PP,O2P,15NO3,DOC,NOX	
1905G8	0421 48 33 54N	017 19 29W	BOTTLE	25	PP,15NO3,DOC,NOX	
1905G9	0426 48 33 51N	017 19 30W	BOTTLE	35	O2P,DOC	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1905G10	0438 48 33 46N	017 19 28W	BOTTLE	35	PP,15NO3,SI,NOX	
1905G11	0448 48 33 41N	017 19 28W	BOTTLE	75	O2P	
1905G12	0450 48 33 40N	017 19 29W	BOTTLE	2	RN	
1905G13	0454 48 33 37N	017 19 29W	BOTTLE	10	RN	
1905G14	0500 48 33 34N	017 19 29W	BOTTLE	15	RN	
1905G15	0506 48 33 30N	017 19 29W	BOTTLE	20	RN	
1905G16	0510 48 33 28N	017 19 30W	BOTTLE	25	RN	
1905G17	0516 48 33 25N	017 19 31W	BOTTLE	35	RN	
1905G18	0520 48 33 23N	017 19 32W	BOTTLE	25	MIZ, MIZ GRZ EXP	
1905G19	0523 48 33 20N	017 19 26W	BOTTLE	25	MIZ	
1905G20	0528 48 33 17N	017 19 18W	BOTTLE	25	MIZ	
1905G21	0533 48 33 15N	017 19 18W	BOTTLE	25	MIZ	
1905C1	0633 0704 48 32 25N	4500 017 19 33W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
1905S1	0720 1139 48 31 57N	017 19 54W	SAP	350,450,600,800		SAPS CAST 10
1905Z1	1225 1331 48 31 19N	017 23 12W	ZNET	50,100,200	BIOMASS, GUT CONTENT	APS-20X1,APS-55X1,WP2-100X1 WP2-2OOX4,WP2-500X1
1905G22	1333 48 31 39N	017 23 41W	BOTTLE	2	15NO3	
1905G23	1341 48 31 42N	017 23 48W	BOTTLE	10	15NO3	
1905G24	1349 48 31 44N	017 23 53W	BOTTLE	35	15NO3	
1905C2	1353 1426 48 31 46N	4315 017 23 56W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC,O2,DOC, BP,BN,POC,PON,CBN	LEVEL 1 SHALLOW PORTION
1905C3	1508 1830 48 31 51N	4310 017 24 29W	CTD	400,500,600,700,800,1000,1200, 1500,2000,2500,3000,4236	NUTS,CHL,O2,DOC,BP,BN, POC,PON	LEVEL 1 DEEP PORTION
1905C4	1944 2010 48 31 25N	4310 017 26 48W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	
1905G25	2208 48 31 00N	017 27 42W	BOTTLE	10	MAZ	
1905G26	2222 48 30 55N	017 27 52W	BOTTLE	10	MAZ	
1905Z2	2300 2345 48 30 48N	017 28 22W	ZNET	100	BIOMASS, GUT CONTENT, GRZ EXP	WP2-200X2,WP2-500X2
1905MIZ1A	2325 48 30 42N	017 28 42W	ZNET	35	MIZ	APS-20X1
2005C1	0013 0040 48 31 00N	4260 017 29 22W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
2005G1	0402 48 24 59N	017 41 01W	BOTTLE	2	PP	
2005G2	0405 48 25 00N	017 41 02W	BOTTLE	10	PP	
2005G3	0412 48 25 01N	017 41 05W	BOTTLE	15	PP	
2005G4	0418 48 25 04N	017 41 10W	BOTTLE	20	PP	
2005G5	0426 48 25 03N	017 41 12W	BOTTLE	25	PP	
2005G6	0432 48 25 00N	017 41 11W	BOTTLE	35	PP	
2005C2	0503 0546 48 25 07N	4260 017 41 36W	CTD	8,15,25,30,35,40,60	SI,BP,BN	
2005C3	0624 0710 48 26 14N	4260 017 42 14W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,HPLC(10,30)	NOISY CTD O/P; SOME BOTTLES FIRED ON WIRE DEPTH
2005G6A	0730 48 27 01N	017 41 55W	BOTTLE	10	BDILEX	NO CAST NUMBER LOGGED
2005C4	0915 1005 48 27 18N	017 42 24W	CTD	2,10,20,30,60,100	CHL,PTC,C:N,CARBO, PROTEINS,SZDIS	
2005Z1	1120 1150 48 27 52N	017 44 01W	ZNET	100	BIOMASS, GUT CONTENT	APS-55X1,WP2-200X2
2005G7	1152 48 27 57N	017 44 03W	BOTTLE	10	MAZ	
2005G8	1157 48 27 59N	017 44 04W	BOTTLE	10	MAZ	

Stn. Id	Start End Latitude	Sounding Longitude	Gear	Depths Depths (continued)	Samples Samples (continued)	Comments Comments (continued)
2005C5	1219 1250 48 28 08N	4300 017 44 15W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL,POC,PON	
2005C6	1356 1746 48 29 02N	 017 44 57W	CTD	1000,1500,2000,2500, 3000,3500	RN	
2005C7	1858 1956 48 31 00N	 017 45 41W	CTD	1000(X4)	DOC	
2005C8	2008 2041 48 31 10N	4310 017 46 21W	CTD	2,10,20,30,40,50,60, 75,100,150,200,300	NUTS,CHL	

Table 2. Assay of nutrient standards from Dutch research ship Tyro using RVS Chemlab Auto-Analyser system as deployed on RRS Charles Darwin cruise 46/90, May 16, 1990. All concentrations in $\mu M\ l^{-1}$

NITRATE		PHOSPHATE		SILICATE	
Nominal concentration	Assay	Nominal concentration	Assay	Nominal Concentration	Assay
2.4	2.7	0.24	0.24	1.65	1.61
8.0	8.6	0.45	0.50	5.65	5.01
16.0	17.0	1.08	1.14	8.15	7.50
24.0	26.4	1.72	1.81	15.15	14.46

Table 3. Nutrient concentrations of intercalibration samples collected from Level I CTD cast on Dutch research vessel Tyro, May 16, 1990. Samples analysed using RVS Chemlab Auto-Analyser sytem as deployed on RRS Charles Darwin cruise 46/90. All concentrations in $\mu M\ l^{-1}$. n.d.: not detectable

DEPTH (m)	NITRATE	NITRITE	PHOSPHATE	SILICATE
2	1.2	n.d.	0.28	0.25
10	1.2	0.02	0.28	0.25
20	1.4	0.02	0.33	0.48
30	3.6	0.09	0.52	1.20
40	6.4	0.31	0.85	2.62
50	9.3	0.26	0.82	3.46
60	9.4	0.24	0.82	3.65
75	10.5	0.07	0.85	3.73
100	10.2	0.09	0.87	3.84
150	10.3	n.d.	0.87	3.77
200	10.6	n.d.	0.89	3.92
300	11.2	n.d.	0.94	4.20
400	11.7	n.d.	0.98	4.80
500	13.2	n.d.	1.03	5.36
600	16.1	n.d.	1.07	5.74
700	16.9	n.d.	1.29	8.11
800	19.0	n.d.	1.41	9.56
1000	19.7	n.d.	1.48	10.84
1200	19.7	n.d.	1.48	11.28
1500	19.0	n.d.	1.46	11.06
2000	18.5	n.d.	1.44	12.16
2500	19.0	n.d.	1.48	21.17
3000	21.7	n.d.	1.59	31.33
4820	24.7	n.d.	1.87	42.20

Table 4. Location of Lagrangian experiment marker drogue relative to position of RRS Charles Darwin at 2400 each day and after repositioning of ship to close marker early the following day. Bearings, degrees true; distances in miles

DATE	BEARING at 2400	DISTANCE at 2400	DATE	TIME	BEARING	DISTANCE
1.5.90	358	6.4	2.5.90	0800	225	2.4
2.5.90	286	7.2	3.5.90	0339	119	1.9
3.5.90	206	3.7	4.5.90	0400	127	2.5
4.5.90	178	3.6	5.5.90	0305	127	1.9
5.5.90	227	2.3	6.5.90	0400	139	1.8
6.5.90	267	4.8	7.5.90	0400	170	1.9
7.5.90	256	5.3	8.5.90	0400	312	1.9
8.5.90	124	2.7	9.5.90	0400	192	2.4
9.5.90	040	4.3	10.5.90	0400	166	2.0
10.5.90	223	3.7	11.5.90	0400	154	1.3
11.5.90 (2200)	289	3.6	12.5.90	0558	193	2.17
12.5.90	233	3.9	13.5.90	0400	163	1.8
13.5.90	290	3.0	14.5.90	0400	177	2.0
14.5.90 BUOY OUTSIDE RADAR RANGE ($>$ 8 miles)			15.5.90	0400	233	1.5
15.5.90	098	5.4	16.5.90	0800	149	1.6
16.5.90	198	6.8	17.5.90	0400	185	2.0
17.5.90 (1600)	233	7.4	RECOVERY OF BERTHA			
18.5.90	197	2.4	19.5.90	0400	214	3.0
19.5.90	209	6.7	20.5.90	0400	076	1.6
20.5.90 (2000)	175	5.2				

Table 5. Daily integrated PAR values (Einsteins m^{-2})

DATE	PAR
30.4.90	27.69
1.5.90	43.59
2.5.90	24.25
3.5.90	25.12
4.5.90	23.69
5.5.90	20.18
6.5.90	16.26
7.5.90	12.27
8.5.90	14.51
9.5.90	35.52
10.5.90	21.76
11.5.90	20.63
12.5.90	29.40
13.5.90	65.00
14.5.90	42.51
15.5.90	59.33
16.5.90	34.76
17.5.90	37.32
18.5.90	52.12
19.5.90	48.72
20.5.90	52.64
21.5.90	28.53

Table 6. 12-hourly averaged wind velocity data. Windspeed is in knots and direction in degrees true, corrected for ship's heading and velocity

DATE	TIME	VELOCITY	DIRECTION
29.4.90	0000-1200	27.7	73.6
	1200-0000	11.5	246.8
30.4.90	0000-1200	20.4	44.2
	1200-0000	11.2	53.6
1.5.90	0000-1200	20.1	347.0
	1200-0000	18.6	333.0
2.5.90	0000-1200	15.9	344.8
	1200-0000	15.7	327.9
3.5.90	0000-1200	5.8	308.8
	1200-0000	12.3	265.4
4.5.90	0000-1200	15.0	247.0
	1200-0000	16.4	235.2
5.5.90	0000-1200	16.6	267.1
	1200-0000	18.0	262.4
6.5.90	0000-1200	20.1	267.2
	1200-0000	15.0	283.9
7.5.90	0000-1200	15.1	267.1
	1200-0000	11.8	277.2
8.5.90	0000-1200	7.0	224.7
	1200-0000	3.6	156.3
9.5.90	0000-1200	9.4	50.4
	1200-0000	14.0	42.9
10.5.90	0000-1200	17.5	36.8
	1200-0000	9.5	214.2
11.5.90	0000-1200	NO DATA	
	1200-0000	NO DATA	
12.5.90	0000-1200	27.4	315.5
	1200-0000	25.3	310.7
13.5.90	0000-1200	17.8	338.6
	1200-0000	17.1	522.8
14.5.90	0000-1200	17.9	289.8
	1200-0000	8.6	223.8
15.5.90	0000-1200	15.4	97.5
	1200-0000	19.4	88.6
16.5.90	0000-1200	16.4	128.3
	1200-0000	4.4	287.0
17.5.90	0000-1200	10.3	247.3
	1200-0000	15.3	314.8
18.5.90	0000-1200	12.8	280.8
	1200-0000	19.2	162.6
19.5.90	0000-1200	8.0	269.1
	1200-0000	12.3	213.8
20.5.90	0000-1200	13.5	175.6
	1200-0000	17.6	200.7
21.5.90	0000-1200	35.3	225.6
	1200-0000	29.9	224.9

Table 7. Chlorophyll a and phaeopigment concentrations ($\mu g\ l^{-1}$) for calibration samples from surface (4m) flow-through fluorometer. Values derived using acetone extraction technique and fluorometric assay

DATE	TIME	INST. READING (REL. UNITS)	CHL a	PHAEOPIGMENT
4.5.90	0800	-	0.57	2.95
	1200	-	1.35	2.05
	1600	-	1.62	2.74
	2000	-	0.66	1.28
5.5.90	1000	-	1.01	3.45
	1900	-	0.87	1.80
6.5.90	1000	-	0.74	1.93
	1400	-	1.16	1.73
	1800	-	0.61	3.11
	2200	-	0.52	1.15
7.5.90	1000	-	1.17	1.78
	1500	-	1.31	1.84
	1800	-	0.70	3.08
	2230	-	0.87	2.64
8.5.90	1000	-	0.70	1.24
	1400	-	1.27	1.88
	1930	-	1.35	2.05
	2200	-	1.35	2.00
9.5.90	1115	-	1.31	1.78
	1425	-	1.27	1.93
	2000	-	1.40	1.80
	2230	-	1.92	3.22
10.5.90	1020	49	1.27	1.93
	1410	41	0.94	1.47
	1700	50	1.38	1.77
	2000	60	1.84	3.93
11.5.90	1100	53	1.35	2.11
	1400	50	1.75	3.23
	1700	36	1.97	3.28
	2145	51	2.01	4.23
12.5.90	1000	51	1.27	1.88
	1400	37	0.70	1.50
	1900	53	1.40	2.12
	2200	48	2.27	3.97
13.5.90	1114	27	0.87	1.28
	1300	29	1.18	1.70
	1800	36	1.22	2.03
	2200	67	2.05	3.82
14.5.90	1100	58	1.84	3.67
	1400	45	2.10	3.15
	2000	63	2.23	3.54
	2230	48	2.19	3.06
15.5.90	1000	60	2.32	4.29
	1745	57	2.62	4.46
	2230	86	2.62	3.93

Table 7 (contd.)

16.5.90	1110	44	2.53	4.39
	1430	75	2.88	2.99
	2325	103	2.84	4.24
17.5.90	1115	56	2.10	2.88
	1500	21	0.83	1.84
	1925	23	0.57	0.90
	2300	20	1.01	1.25
18.5.90	1300	34	1.84	3.41
	2000	30	1.20	2.44
	2200	74	1.79	3.14
19.5.90	1930	58	1.79	2.88
	2130	60	1.70	2.86
20.5.90	0900	37	1.17	2.13
	2045	52	1.88	3.16

Table 8. Temporal changes in Chlorophyll *a* concentration (µg/l) at 10m and 30m as recorded using HPLC analysis

Date	Time	10m	30m
1 May	0730	1.218	1.386
2 May	1000	1.328	1.335
	1930	1.832	1.451
3 May	0730	1.458	1.298
	1830	1.637	1.664
4 May	0645	1.696	0.834
	1715	1.348	0.971
5 May	0630	1.513	0.762
	1715	1.644	0.848
6 May	0700	1.740	1.303
	1830	1.966	1.340
7 May	0700	1.953	0.811
8 May	0645	1.973	1.087
	1830	2.042	1.698
9 May	0645	2.196	0.953
10 May	0700	2.155	0.456
	1715	2.512	1.256
11 May	0645	2.335	0.579
	1730	1.870	0.519
12 May	0700	2.710	0.543
13 May	0645	2.627	2.463
	1830	2.174	1.933
14 May	0715	3.275	2.932
	1900	3.652	1.691
15 May	0630	3.692	1.823
16 May	1815	3.657	2.832
17 May	0630	3.487	0.249
	1715	1.747	2.179
19 May	0700	1.163	0.187
	2000	2.263	0.950
20 May	0700	2.000	1.772
	2030	1.727	2.367

Table 9. Size fractionated distribution of HPLC Chlorophyll *a* (µg/l)

Date	Depth	Size	Vol filtered (l)	Chl *a*	% Chl *a*	Filtering Procedure
4 May	10m	GFF	1	1.295	100.0	One filter only
		5µm		0.646	48.0	
		1-5µm	1	0.568	42.2	Stacked filters
		1µm		0.131	9.7	
4 May	35m	GFF	1	0.846	100.0	One filter only
		5µm		0.259	48.3	
		1-5µm	1	0.100	18.7	Stacked filters
		1µm		0.177	33.0	
10 May	10m	5µm		0.960	49.4	
		1-5µm	1	0.761	39.1	Stacked filters
		5µm		0.224	11.5	
		5µm	1	0.494		One filter only
		0.2µm	1	2.213		One filter only
12 May	10m	5µm		0.641	29.5	Filtrate through
		1-5µm	1	1.202	55.3	each filter
		1µm		0.331	15.2	independently
	10m	5µm		0.553	48.0	
		1-5µm	1	0.306	26.6	Stacked filters
		1µm		0.293	25.4	

Table 10. Tyro/Darwin intercalibration - HPLC Chlorophyll *a* concentrations (µg/l)

Depth	Chl *a*
2m	3.194
10m	3.044
15m	2.353
20m	1.187
25m	0.251
35m	0.069

Table 11. Times of commencement and completion of deployment of productivity rigs and recovery times. Process measurements made also indicated.

DATE	COMMENCEMENT OF DEPLOYMENT	COMPLETION OF DEPLOYMENT	RECOVERY TIME & DATE	PROCESS MEASUREMENTS
1.5.90	0557	0649	0435 (2.5.90)	PP, $^{15}NO_3$, O_2P, TCO_2P, DOC
2.5.90	0735	0745	0203 (3.5.90)	PP, DOC
3.5.90	0546	0628	0222 (4.5.90)	PP, $^{15}NO_3$, O_2P, DOC
4.5.90	0545	0557	0202 (5.5.90)	PP, DOC
5.5.90	0545	0600	0211 (6.5.90)	PP, DOC
6.5.90	0615	0625	0157 (7.5.90)	PP, NO_x
7.5.90	0602	0636	0217 (8.5.90)	PP, $^{15}NO_3$, O_2P, TCO_2P, DOC
8.5.90	0600	0617	0209 (9.5.90)	PP, NO_x
9.5.90	0550	0620	0223 (10.5.90)	PP, $^{15}NO_3$, O_2P, TCO_2P, NO_x
10.5.90	0618	0631	0157 (11.5.90)	PP
11.5.90	0547	0618	0248 (12.5.90)	PP, $^{15}NO_3$, DOC
12.5.90	0610	0624	2135 (12.5.90)	PP, DOC, NO_x
13.5.90	0540	0550	0155 (14.5.90)	PP, NO_x
14.5.90	0553	0625	0155 (15.5.90)	PP, $^{15}NO_2$, O_2P
15.5.90	0545	0556	2230 (15.5.90)	PP, DOC, NO_x
16.5.90	1045	1145	2012 (16.5.90)	PP, $^{15}NO_3$, O_2P, DOC
	(TYRO INTERCALIBRATION)			
17.5.90	0540	0605	0230 (18.5.90)	PP, $^{15}NO_2$, O_2P, DOC
19.5.90	0557	0625	0220 (20.5.90)	PP, $^{15}NO_3$, DOC, NO_x
20.5.90	0554	0605	2200 (20.5.90)	PP

Table 12. Detailed sampling schedule of O_2 and TCO_2 measurements and productivity experiments carried out during Darwin cruise 46/90.

DATE	STN. NO.	DEPTH	COMMENT
1.5.90		2,10,20,35,75m	O_2 24hr in situ productivity
		2,10,20m	TCO_2 24hr in situ productivity
	015/CO_2	2-300m	O_2 profile CTD 07.00
2.5.90	025/CO_3	2-300m	Level 1 O_2, TCO_2
	025/CO_4	400-4000m	Level 1 O_2, TCO_2
3.5.90		2,10,20,35,75m	O_2 24hr in situ productivity
4.5.90	045/CO_3	0-300m	O_2 profile 06:00
	045/CO_4	0-300m	09:00
	045/CO_5	0-300m	13:00
	045/CO_7	0-300m	17:00
	045/CO_9	0-300m	21.00
5.5.90	055/CO_3	0-300m	O_2 profile 08:00
	055/CO_6	0-300m	O_2 profile 21:00
6.5.90	065/CO_4	0-300m	Level 1 O_2, TCO_2
	065/CO_5	400-4000m	Level 1 O_2
7.5.90		2,10,20,35,75m	O_2 24hr in situ productivity
		2m	TCO_2 24hr in situ productivity
	075/CO_3	2m	O_2, TCO_2
8.5.90	085/CO_5	2m	O_2, TCO_2
9.5.90		2,10,20,35,75m	O_2 24hr in situ productivity
		2m	TCO_2 24hr in situ productivity
	095/CO_3	0-300m	Level 1 O_2, TCO_2
	095/CO_4	400-4000m	Level 1 O_2, TCO_2*
10.5.90	105/CO_4	2m	O_2, TCO_2 12:00
11.5.90		2m	6hr on deck. Diel experiment
			04:00 O_2
			08:00 O_2, TCO_2
			12:00 O_2, TCO_2
			16:00 O_2
12.5.90	125/CO_4	0-300m	Level 1 O_2
	125/CO_5	400-4000m	Level 1 O_2
13.5.90	135/CO_3	2m	O_2, TCO_2 12:00
14.5.90		2,10,20,35,75m	O_2 24hr in situ productivity
		2m	TCO_2 24hr in situ productivity
16.5.90		2,10,20,35m	Intercalibration with Tyro
			12 hr in situ productivity

Table 12 (contd.)

	CTD Tyro	2-300m	Level 1 O_2, TCO_2*
	CTD Tyro	400-4000	Level 1 O_2, TCO_2*
17.5.90		2,10,20,35m	O_2 24hr in situ Productivity 6hr on deck. Diel experiment 08:00 O_2, TCO_2 12:00 O_2, TCO_2 14:00 O_2, TCO_2 16:00 O_2

Table 13. Detailed sampling schedule for ^{15}N new and regenerated productivity determinations carried out during Darwin cruise 46/90

DATE	SAMPLING TIMES	SAMPLE TYPE	DEPTHS SAMPLED (m)	EXPERIMENT/COMMENTS
29.4.90	11.20	NT(O)	2	Shakedown Station. Comparison
	11.20	GF(O)	2	between surface GF sample + NT SW supply
1.5.90	03.45-04.35	GF(I)	2,10,15 20,25,30	Productivity rig 1 (^{15}N natural abundance, all depths)
	15.30	NT(O)	2	
2.5.90	06.35	GF(O)	2	
	14.00	NT(O)	2	Close to level 1 CTD station
3.5.90	03.50-04.30	GF(I)	2,10,15 20,25,35	Productivity rig 2 (^{15}N nat. abund., 2,15,25m)
	15.10	NT(O)	2	
4.5.90	08.05	GF(O)	2	Diel experiment (32hr)
	12.05-12.30	GF(O)	2,35,50	
	16.20	GF(O)	2	
5.5.90	04.10	GF(O)	2	
	08.10	GF(O)	2	
	12.10-12.30	GF(O)	2,23,50	
	16.10	GF(O)	2	
	16.10	NT(O)	2	
6.5.90	12.30	NT(O)	2	
7.5.90	04.10-04.35	GF(I)	2,10,15 20,25,35	Productivity rig 3 (^{15}N nat. abun. 2,15,25m)
	13.15	NT(O)	2	
8.5.90	04.05-04.15	GF(O)	2,10,35	
9.5.90	03.45-04.20	GF(I)	2,10,15 20,25,35	Productivity rig 4 (^{15}N nat. abun. 2,15,25m)
	14.40-11.50	GF(O)	2,10,35	
10.5.90	04.10-04.50	GF(O)	2,10,35	
11.5.90	03.40-04.10	GF(I)	2,10,15 20,25,35	Productivity rig 5 (^{15}N nat. abun., all depths)
	08.05-08.15	GF(O)	2,10,35	Diel experiment (32 hr)
	12.10	GF(O)	2	
	16.05-16.20	GF(O)	2,10,35	
	20.10	GF(O)	2	
12.5.90	04.20-04.55	GF(O)	2,10,35	
	12.00-12.10	GF(O)	2,10,35	
13.5.90	11.40-11.50	GF(O)	2,10,35	

14.5.90	03.45-04.30	GF(I)	2,10,15 20,25,35	Productivity rig 6
	13.05-13.15	GF(O)	2,10,35	
15.5.90	04.10-04.20	GF(O)	2,10,35	
16.5.90	08.50-09.55	GF(I)	2,10,15 20,25,35	Productivity rig 7 Tyro intercalibration exercise
17.5.90	04.15-04.45	GF(I)	2,10,15 20,25,35	Productivity rig 8 (^{15}N nat. abun., all depths)
	08.05-08.25	GF(O)	2,10,35	Diel experiment (^{15}N nat. abun.,
	13.00	GF(O)	2	all samples + depths) (24hr)
	16.15-16.35	GF(O)	2,10,35	
18.5.90				No sampling, retrieve Bertha
19.5.90	03.45-04.35	GF(I)	2,10,15 20,25,35	Productivity rig 9 (^{15}N nat. abun., 2,10,35m)
	13.40	GF(O)	2	
20.5.90	11.50-11.55	GF(O)	2,2	Comparison of 2 Go-Flo bottles fired at same depth

Key to symbols used in Table:

NT	Non-toxic seawater supply from pipe in wet-lab
GF	Go-Flo water sample off Kevlar line
(O)	On-board incubation for 6hrs in a temperature-controlled artificial light incubator. Meshes were used to simulate reduced light levels at 10, 35 and 50m
(I)	In situ incubation for 24hr period
^{15}N Nat. abun.	Work carried out by Hilary Kennedy: sampling for ^{15}N natural abundance

Table 14. Mesozooplankton biomass and grazing sampling programme carried out during Darwin cruise 46/90

1.5.90	14.00	NETS		
		WP2-200	(100m)	Biomass
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		Apstein-20	(100m)	Microscopy
		Apstein-20	(50m)	Trial net
		WP2-100	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(200m)	Biomass
	16.00	CTD cast	(100m)	
		Full profile depths: 2/10/20/30/60/100m		
		Chlorophyll a (total, 5, and 10µm)		
		Composition (Lugol and formol)		
		Carbon/Nitrogen (GF/F)		
		Carbohydrates		
		Proteins		
		Size distribution (C. Counts)		
2.5.90	05.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
	10.30	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
	13.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-500	(100m)	Gut Content
		WP2-200	(100m)	Gut Content
		WP2-200	(100m)	Experiment
	18.00	NETS		
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
	18.30	CTD cast		
		Complementary profile: 2/10/20/30/40/50m		
		Particle size distribution		
		Composition (Lugol, formol: 20,40m)		
	22.30	NETS		
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
3.5.90	01.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
		WP2-200	(100m)	Experiment

Table 14 (contd.)

	12.00	CTD cast Complementary profile (as before)		
	14.30	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
		WP2-200	(100m)	Experiment
		WP2-200	(100m)	Experiment
	21.00	Go-Flo Bottles 2 depths (25, 50m) Water collection for experiments		
	22.00	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-55	(50m)	Biomass
		Apstein-20	(100m)	Biomass
		Apstein-20	(50m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
4.5.90	14.30	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-55	(50m)	Biomass
		Apstein-55	(100m)	Biomass
		Apstein-20	(50m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Gut Content
	15.30	CTD cast Full profile (as before)		
	23.15	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Gut Content
		WP2-500	(100m)	Experiment
5.5.90	03.30	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	07.00	NETS		
		WP2-200	(100m)	Gut Content
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content

Table 14 (contd.)

	15.00	CTD cast		
		Complementary profile (as before)		
	18.00	NETS		
		Apstein-20	(50m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
		WP2-200	(50m)	Experiment
	22.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
		WP2-500.	(100m)	Experiment
6.5.90	00.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
		WP2-500	(100m)	Experiment
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-100	(50m)	Experiment
	12.00	CTD cast		
		Complementary profile (as before)		
	21.00	Go-Flo bottles		
		Water collection experiments (10m)		
	22.30	NETS		
		Apstein-55	(55m)	Biomass
		Apstein-55	(100m)	Biomass
		Apstein-20	(50m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
		WP2-500	(100m)	Experiment
7.5.90	13.45	NETS		
		Apstein-55	(50m)	Biomass
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(25m)	Biomass
		WP2-200	(50m)	Gut Content
		WP2-200	(100m)	Gut Content

Table 14 (contd.)

	15.00	CTD cast		
		Full profile (as before)		
8.5.90	00.30	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
	05.45	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
	09.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
	12.00	CTD cast		
		Complementary profile (as before)		
	13.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
	17.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
	21.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(50m)	Gut Content
9.5.90	00.45	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(50m)	Experiment
		WP2-500	(50m)	Experiment
		WP2-500	(50m)	Experiment
		WP2-500	(100m)	Experiment
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	12.00	CTD cast		
		Complementary profile (as before)		
	22.00	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass

Table 14 (contd.)

		WP2-100	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(25m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-500	(100m)	Biomass
		WP2-500D	(100m)	Gut Content
		WP2-500D	(100m)	Experiment (cancelled)
10.5.90	12.45	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500D	(100m)	Gut Content
	14.00	CTD cast		
		Full profile (as before)		
	23.30	NETS		
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(50m)	Gut Content
		WP2-200	(100m)	Gut Content
		WP2-500	(50m)	Gut Content
		WP2-500	(100m)	Gut Content
11.5.90	03.00	NETS		
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Gut Content
		WP2-200	(100m)	Gut Content
	07.00	NETS		
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Gut Content
		WP2-200	(100m)	Gut Content
	11.00	NETS		
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Gut Content
		WP2-200	(100m)	Gut Content
	13.30	CTD cast		
		Complementary profile (as before)		
	18.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(30m)	Gut Content

Table 14 (contd.)

	22.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-200	(30m)	Gut Content
		WP2-500D	(100m)	Experiment
12.5.90	00.00	NETS		
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Gut Content
		WP2-200	(100m)	Gut Content
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	12.15	CTD cast		
		Complementary profile (as before)		
	22.00	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Biomass
		WP2-500D	(100m)	Experiment
		WP2-500D	(100m)	Experiment
13.5.90	10.00	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	11.15	CTD cast		
		Full profile (as before)		
	23.00	NETS		
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(30m)	Gut Content
		WP2-200	(100m)	Gut Content
		WP2-500D	(100m)	Experiment
14.590	03.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	09.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content

Table 14 (contd.)

	12.30	CTD cast Lugol form only		
	13.30	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	18.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	18.00	CTD cast Complementary profile (as before)		
	21.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
15.5.90	00.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500D	(100m)	Experiment
		WP2-500D	(100m)	Experiment
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	12.00	Go-Flo	(10m)	Experiment
	23.00	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(30m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Biomass
		WP2-500D	(100m)	Experiment
		Multinet:	(200-100m)	Biomass
			(100- 50m)	Biomass
			(50- 25m)	Biomass
			(25 - 0m)	Biomass
		(net supplied by R.V. Tyro: 1/2 samples)		
	23.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
17.5.90	03.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	07.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content

Table 14 (contd.)

	07.30	CTD full profile		
	12.15	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	18.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
	22.15	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
18.5.90	00.00	NETS		
		Cancelled (winch broken)		
	11.00	NETS		
		Cancelled (buoys recovery)		
	23.30	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Biomass
		WP2-500D	(100m)	Experiment
		WP2-500D	(100m)	Experiment
19.5.90	12.30	NETS		
		Apstein-55	(100m)	Biomass
		Apstein-20	(100m)	Biomass
		WP2-100	(100m)	Biomass
		WP2-200	(50m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(200m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Biomass
	22.00	Go-Flo bottle		
		Water collection (10m)		
	23.00	NETS		
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content
		WP2-500	(100m)	Experiment
		WP2-500	(100m)	Experiment
20.5.90	09.45	CTD full profile		
	11.00	NETS		
		Apstein-55	(100m)	Biomass
		WP2-200	(100m)	Biomass
		WP2-200	(100m)	Gut Content

Table 15. Detailed schedule of microzooplankton dilution grazing experiments carried out during Darwin cruise 46/90

EXPT. NO.	TYPE	DATE	DEPTH	Go-Flo SAMPLING TIME	CAST	TIME Oh	TIME 12h	TIME 24h	TEMP(°C)
1	GF/F	1.5.90	10m	5:21	0105/G12	09:30		09:30	12.3
2	GF/F	3.5.90	25m	5:00	0305/G12	08:30	20:30	08:30	12.3
3	DIEL GF/F	4.5.90	10m	4:17	0405/G02	04:00	every 4 hrs		12.5
4	FRACT.	5.5.90	25m	5:00	0505/G09	06:00	20:00	08:00	12.49
5	FRACT.	7.5.90	10m	5:20	0705/G12	06:00	21:30	06:00	12.7
6	GF/F NUT.	8.5.90	10m	16:30	0805/G09	19:00		19:00	12.75
7	GF/F RIG	9.5.90	10m	4:48	0905/G13	06:45	21:30	06:45	12.65
8	FRACT.	11.5.90	25m	4:35	1105/G14	05:45	20:00	06:45	12.86
9	GF/F	13.5.90	25m	4:55	1305/G07	10:30	22:00	10:30	12.71
10	FRACT.	15.5.90	25m	4:55	1505/G09	06:00		07:45	12.97
11	GF/F	17.5.90	10m	5:05	1705/G12	08:00	21:00	08:00	13.37
12	FRACT.	19.5.90	25m	5:20	1905/G	08:00	21:00	08:00	13.8

Table 16. Detailed sampling schedule for microzooplankton biomass carried out during Darwin cruise 46/90

DATE	TIME	LAT	LONG	CAST	TYPE	DEPTHS	SAMPLE
1.5.90	07:08	49°51.577	18°52.64	0105/C02	CTD300	9	LUGOLS GLUT FORM SLIDES
2.5.90		49°46.57	18°33.05	0205/C03	Level 1	12	LUGOLS GLUT
3.5.90	07:13	49°56.5	18°31.7	0305/C02	CTD300	9	LUGOLS GLUT
5.5.90	06:23	49°46.5	18°32.8	0505/C02	CTD300	9	LUGOLS GLUT FORM SLIDES
6.5.90		49°39.5	18°33.6	0605/C03	Level 1	12	LUGOLS GLUT
7.5.90				075/C02	CTD300	9	LUGOLS GLUT SLIDES
9.5.90	14:00	49°28.9 49°28.8	18°36.6 18°36.4	095/C02 095/C03	Level 1	12	LUGOLS GLUT FORM SLIDES
11.5.90	06:22	49°22.8	18°20.6	1105/C02	CTD300	9	LUGOLS GLUT SLIDES
13.5.90	18:04	49°08	17°40.1	1305/C04	CTD300	9	LUGOLS GLUT FORM SLIDES
15.5.90	06:11	49°10	17°17.7	1505/C02	CTD300	9	LUGOLS GLUT SLIDES
16.5.90					Level 1 Tyro	12	LUGOLS GLUT
17.5.90	06:10	48°55	17°03	1705/C02	CTD300	9	LUGOLS GLUT FORM SLIDES
19.5.90	16:40 19:52	48°33 48°33	17°19.9 17°19.9	195/C03 195/C04	Level 1 CTD300	3 9	LUGOLS GLUT SLIDES FORM

Table 17. Detailed sampling schedule for microzooplankton Apstein net (20μm) hauls carried out during Darwin cruise 46/90

DATE	DEPTH	TIME
2.5.90	35-0m	2000
4.5.90	35-0m	2100
6.5.90	35-0m	2145
8.5.90	35-0m	1720
11.5.90	35-0m	0012
13.5.90	35-0m	2300
14.5.90	35-0m	1300
17.5.90	35-0m	2000
20.5.90	35-0m	0030

Table 18. Detailed sampling schedule of DOC measurements carried out during Darwin cruise 46/90.

		Cast Serial No.	
(i)	CTD Casts	2904C01	(shakedown station)
		0105C02	
		0305C02	
		0605C03	
		0805C03	
		1105C02	
		1305C01	(catalyst intercomparison)
		2005C05	(single depth only)
(ii)	Primary Productivity Rigs	01-02.5.90	
		03-04.5.90	
		07-08.5.90	
		11-12.5.90	
		17-18.5.90	
		18-19.5.90	
(iii)	Go-Flo Casts	01.05.90	
		02.05.90	
		03.05.90	
		04.05.90	
		05.05.90	
		07.05.90	
		11.05.90	
		12.05.90	
		16.05.90	
		17.05.90	
		19.05.90	

(iv)	Diel Sampling	CTD	Go-Flo
	04.05.90	0405C03	08:13hrs
		0405C04	12:00hrs
		0405C05	16:10hrs
		0405C08	22:10hrs
		0405C09	
		0505C01	
	11.05.90	1105C03	08:00hrs
		1105C04	12:00hrs
		1105C06	16:00hrs
			20:00hrs
	17.05.90	1705C02	08:00hrs
		1705C04	13:06hrs
		1705C06	16:10hrs
		1705C07	
(v)	JGOFS Level 1 CTD	0205C03/4	
		0605C04/5	
		0905C03/4	
		1205C04/5	
		1605C01/2	
		1905C02/3	

Table 19. Schedule of SAPS casts carried out during Darwin cruise 46/90

SAP CAST	STATION NUMBER	LAT N LONG W	DEPTH (m)	FILTER TYPE	LITRES FILTERED	PUMPING TIME HOURS	COMMENTS
1	0405S01	49 50.8	15	GF/F	206	0.5	O.K.
		18 31.9	50	GF/F	357	0.5	O.K.*
			125	GF/F	921	1	O.K.
			200	GF/F	838	1	SPLIT
2	0305S01	49 56.4	350	GF/F	1399	2	SPLIT
		18 31.9	450	GF/F	1708	2	O.K.
			600	GF/F	1771	2	O.K.
			800	GF/F	1653	2	O.K.
3	0705S01	49 32.7	1500	GF/F	1932	3	O.K.
		18 32.8	1500	NUCLEP	1287	3	O.K.
			2000	GF/F	2389	3	O.K.
			2000	NUCLEP	1812	3	SPLIT
4	0105S01	49 50.3	2500	GF/F	3200	3	SPLIT
		18 44.9	2995	NUCLEP	2285	3	SPLIT
			3000	GF/F	30	3	NOGO
			3500	GF/F	1523	3	SPLIT
			4000	GF/F	261	3	LOW
5	1005S01	49 27.2	30	NUCLEP	93	0.5	O.K.*
		18 23.7	30	GF/F	290	0.5	SPLIT*
			15	NUCLEP	37	0.5	O.K.*
			15	GF/F	138	0.5	SPLIT*
6	1005S02	49 26.9	50	GF/F	691	1	O.K.*
		18 27.3	50	NUCLEP	286	1	O.K.
			100	GF/F	857	1	O.K.*
			100	NUCLEP	322	1	O.K.
7	1405S01	49 17.7	350	GF/F	1332	2	SPLIT
		17 25.6	350	NUCLEP	602	2	O.K.
			500	GF/F	780	2	SPLIT*
			500	NUCLEP	2402	2	SPLIT
8	1305S01	49 07.9	750	GF/F	1457	2	SPLIT
		17 45.2	750	NUCLEP	2427	2	SPLIT
			1000	GF/F	1687	2	SPLIT
			1000	NUCLEP	2524	2	SPLIT
9	1705S01	48 53.8	15	GF/F	164	1	O.K.*
		17 01.0	50	GF/F	863	1	O.K.*
			125	GF/F	729	1	O.K.*
			200	GF/F	1002	1	O.K.*
10	1905S01	48 32.6	350	GF/F	1387	2	O.K.
		17 19.5	450	GF/F	1781	2	O.K.
			600	GF/F	1600	2	O.K.*
			800	GF/F	1803	2	O.K.

* Non homogenous distribution

Table 20. Sampling schedule for stable isotopes, Darwin cruise 46/90

(a) CTD Bottle Casts

CAST	LATITUDE	LONGITUDE	DEPTHS
0205C01	49 57.3N	18 35.3W	5, 15, 25, 35, 50, 60 and 80m
0405C02	49 53.5N	18 32.6W	5, 15, 25, 35, 50, 60 and 80m
0605C02	49 39.5N	18 83.6W	5, 15, 30, 35, 40, 50 and 80m
0805C02	49 29.8N	18 37.2W	5, 15, 20, 25, 30, 40, 60 and 100m
1005C02	49 29.2N	18 28.0W	5, 15, 25, 30, 35, 40 and 60m
1205C02	49 18.8N	18 07.7W	5, 20, 25, 30, 35, 40 and 60m
1405C02	49 10.4N	17 33.5W	5, 15, 30, 35, 40, 45 and 60m
1505C03	49 00.8N	17 16.8W	5, 15, 25, 30, 40 and 60m
2005C02	48 25.0N	17 41.1W	5, 15, 25, 30, 35, 40 and 60m

(b) Go-Flo Bottles

CAST	LATITUDE	LONGITUDE	DEPTHS
0105G01	49 51.8N	18 53.0W	2, 10, 15, 20, 25 and 35m
0305G01	49 56.6N	18 32.2W	2, 15 and 25m
0705G01	49 35.1N	18 37.2W	2, 15 and 25m
0905G01	49 31.7N	18 34.6W	2, 15 and 25m
1105G01	49 21.3N	18 20.5W	2, 10, 15, 20, 25 and 35m
1705G01	48 55.2N	17 03.8W	2, 10 and 35m
1705G10	48 54.4N	17 02.2W	2, 10 and 15m
1705G20	48 53.7N	17 00.3W	2m
1705G30	48 53.2N	16 58.1W	2, 10 and 15m
1905G01	48 33.7N	17 19.5W	2, 10 and 25m

Table 21. Sampling schedule for radionuclide analysis for Darwin cruise 46/90

(a) CTD Bottle Casts

CAST	LATITUDE	LONGITUDE	DEPTH (m)	SAMPLE VOLUME (l)	SPIKE ADDTN
0105C03	49 52.0N	18 51.0W	1000	20.2	
			1500	20	
			2000	20	
			2500	19.5	
			3000	19	
			3500	20.2	
0405C06	49 52.1N	18 30.9W	2	20.5	
			25	20	
			50	19.75	
			100	19.75	
			350	19.75	
			500	20.5	
0805C04	49 31.0N	18 37.7W	2	19.8	15.30
			25	19.9	08.05.90
			50	19.8	
			100	19.7	
			350	19.8	
			500	20	
1105C05	49 19.2N	18 15.5W	2	19.6	07.20
			25	19.5	12.05.90
			50	19.7	
			100	19.6	
			350	20	
			500	19.8	
1405C06	49 18.5N	17 25.8W	2	19.9	00.02
			25	18.8	15.05.90
			50	20	
			100	19.7	
			350	20	
			500	20.5	
1705C05	48 53.5N	16 58.9W	2	19.8	0705
			25	20	18.05.90
			50	20.1	
			100	19.9	
			350	20	
			500	20	
2005C06	48 30.1N	17 45.6W	1000		2200
			1500	19.9	20.05.90
			2000	19.9	
			2500	19.5	
			3000	20.1	
			3500	20	

Table 21 (contd.)

(b) Underway Samples

Filter i.d.	1	2
Co-ordinates (Start)	49 56.7N 18 33.5W	49 51.1N 18 32.0W
Co-ordinates (Finish)	49 56.3N 18 31.5W	49 43.2N 18 30.4W
Time (Start)	09.50 2.5.90	19.52 4.5.90
Time (Finish)	10.25 3.5.90	19.45 5.5.90
Flow meter (Start)	21163.3	36144.4
Flow meter (Finish)	25487.3	40225.6
Average flow rate	3.0 l per min	2.8 l per min
Litres filtered	4324	4081

Filter i.d.	3	4
Co-ordinates (Start)	49 31.8N 18 32.9W	49 18.1N 18 02.8W
Co-ordinates (Finish)	49 31.4N 18 39.5W	49 07.7N 17 48.2W
Time (Start)	17.17 7.5.90	11.15 12.5.90
Time (Finish)	20.59 8.5.90	11.24 13.5.90
Flow meter (Start)	54734.3	85686.2
Flow meter (Finish)	58902.4	89839.6
Average flow rate	2.9 l per min	2.9 l per min

Filter i.d.	5	6
Co-ordinates (Start)	49 01.9N 17 04.3W	48 31.6N 17 19.6W
Co-ordinates (Finish)	48 54.8N 17 03.3W	48 27.6N 17 43.7W
Time (Start)	08.45 19.5.90	08.45 19.5.90
Time (Finish)	07.20 17.5.90	11.47 20.5.90
Flow meter (Start)	113117.2	137577.1
Flow meter (Finish)	117912.1	141496.0
Average flow rate	3.33 l per min	2.4 l per min
Litres filtered	4795	3919

Table 22. Sampling schedule for Level 1 POC/PON determinations for Darwin cruise 46/90

CAST	DEPTH	SAMPLE I.D.	LATITUDE	LONGITUDE
0105C04	100m	213-219	49 52.5N	18 48.8W
0205C03	300m	220-231	49 56.3N	18 32.4W
0205C04	BTTM	232-244	49 55.6N	18 30.0W
0305C03	100m	245-251	49 56.2N	18 29.9W
0405C08	100m	252-258	49 52.3N	18 31.6W
0505C04	100m	261-267	49 44.7N	18 30.6W
0605C06	300m	268-280	49 36.0N	18 28.5W
0605C05	BTTM	281-293	49 37.9N	18 29.8W
0705C03	100m	294-300	49 32.6N	18 34.6W
0805C05	100m	301-307	49 31.3N	18 36.9W
0905C03	300m	308-318	49 29.2N	18 36.5W
0905C04	BTTM	319-323	49 28.9N	18 36.4W
1005C04	100m	324-331	49 27.1N	18 26.3W
1105C04	100m	332-338	49 20.1N	18 18.5W
1205C04	300m	339-349	49 18.3N	17 59.6W
1205C05	BTTM	350-354	49 16.8N	17 56.6W
1305C03	100m	355-362	49 08.0N	17 46.7W
1405C04	100m	363-369	49 13.7N	17 27.3W
1605C01	BTTM	370-381	49 01.1N	17 02.9W
1605C02	300m	382-393	49 00.9N	17 02.2W
1905C0	300m	401-410	48 31.6N	17 23.3W
1905C0	BTTM	394-400	48 31.7N	17 25.9W
2005C0	100m	411-415	48 27.9N	17 43.9W

APPENDIX I

LIST OF SCIENTIFIC PERSONNEL

Queen's University of Belfast

Dr Graham Savidge	Principal Scientist
Mr Philip Boyd	^{14}C Primary Production; Nitrate Uptake
Miss Linda Gilpin	Multi-nutrient Uptake
Mr Paul McArdle	Nutrient Analysis

PML

Dr Ray Barlow	HPLC Pigments and Biomarkers
Miss Elaine Edwards	Microzooplankton
Mr Bob Head	Mesozooplankton
Miss Carmen Morales	Mesozooplankton
Mr Axel Miller	Dissolved Organic Carbon

University College of Wales Bangor

Dr Hilary Kennedy	Stand Alone Pumps, POC/PON, Stable Isotopes and Radionuclides
Miss Emily Wood	O_2 and TCO_2 Production

BAS

Dr Ray Leakey	Planktonic Ciliates

IOSDL

Miss Moragh Stirling	Bacterial Production

SURRC

Dr Sarah Bury	^{15}N New and Regenerated Production

RVS

Dr Ed Cooper	Computing
Mr Philip Taylor	Systems Engineer
Mr Tony Poole	Mechanical Engineer
Mr John Strangward	Mechanical Engineer

APPENDIX II

CREW LIST FOR RRS CHARLES DARWIN CRUISE 46/90

P.J. MacDermott	Master
R.J. Chamberlain	Chief Officer
S. Sykes	2nd Officer
R. Warner	3rd Officer
D.E. Anderson	Chief Engineer
G.A. Robertson	2nd Engineer
V.E.D. Lovell	3rd Engineer
P.G. Parker	Electrician
J. Baker	Radio Officer
M. Trevaskis	C.P.O. Deck
M.A. Harrison	Seaman
G. Crabb	Seaman
D.G. Buffery	Seaman
P.H.C. Dean	Seaman
A.G. Scriven	Seaman
D.J. Hanlon	Motorman
C. Hubbard	Cook Steward
P.J. Bishop	Ship's Cook
J.A. Orsborn	2nd Steward
D.E. Jenkins	Steward
B. Griffiths	Steward