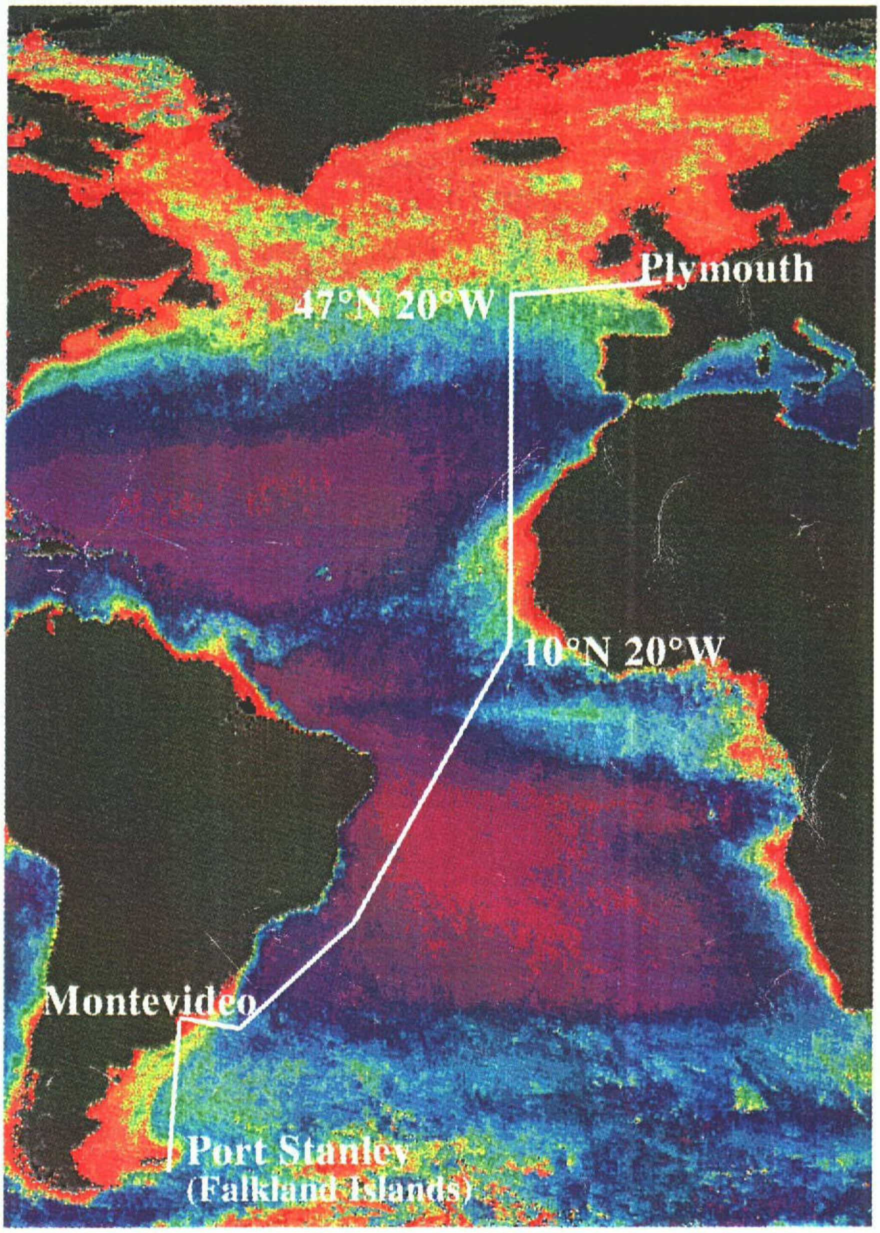
ATLANTIC MERIDIONAL TRANSECT (AMT)



AMT-3 CRUISE REPORT

Atlantic Meridional Transect

AMT-3
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cruise period
16 September - 25 October 1996

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Acknowledgements

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The AMT scientific team are very grateful for the support received from the Director of the British Antarctic Survey (BAS), Dr. Barry Heywood and his staff both at Cambridge and at sea. Particular thanks go Frank Curry, John Hall, David Blake, Graham Hughes, Ian Collinge, Kath Nicholson, Mary Sutton, Prof. Andrew Clark and Dr Julian Priddle at Cambridge and to Graham Butcher who provided computer support on the voyage.

The National Aeronautics and Space Administration (NASA) of the USA supported the programme with equipment and funding from the Sea-viewing, Wide-Field-of view Sensor (SeaWiFS) project.

Finally, though already alluded to, the AMT project and the scientific party on AMT3 would like to extend their gratitude to Captain Jerry Burgan, his officers and men, for their professional, positive support throughout the voyage.

1. Rationale and Objectives

Background

The Atlantic Meridional Transects (AMTs) were conceived as a means of acquiring a time series of oceanographic, biological, chemical and optical data over large latitudinal ranges (50° N to 50° S) and through a number of contrasting oceanographic provinces. The core scientific objectives are to refine our understanding of the role of the ocean biota in the biogeochemical processes, carbon fluxes and ultimately global climate and to develop remotely-sensed measurements of global primary production.

The AMTs take advantage of the twice yearly passage of the NERC vessel, RRS James Clark Ross, operated by the British Antarctic Survey, during its passage to and from Antarctica each year. Since the only ship costs involved are to cover the additional time required for course deviations and station work, the AMT is a highly cost-effective project for fundamental marine science. AMT-3 is the third Atlantic transect in the current series.

Objectives

The AMT forms a significant component of two NERC PRIME Special Topic projects; P19: 'The optical characterisation of zooplankton in relation to ocean physics; discrimination of seasonal, regional and latitudinal variations' (Robins, Harris & Pilgrim) and P20: 'Holistic biological oceanography: mesoscale to basin-scale and seasonal studies of phytoplankton processes linked to functional interpretation of bio-optical signatures and biogeochemistry' (Aiken and Holligan). In addition, through international collaboration, the AMT also forms a component of the calibration and validation of the NASA SeaWiFS and NASDA ADEOS /OCTS programmes as well as providing input to SIMBIOS, a programme to develop the methodology and operational capability to combine data products from various ocean colour missions. In the longer term, the AMT project aims to contribute to the refinement of global (basin scale) primary production and ecosystem models which will be important for our ability to predict climate change. The specific objectives of AMT-3 remained similar to previous transects:

- To improve our understanding of the relationship between physical processes and biological production.
- Identify, define and quantify latitudinal changes in biogeochemical provinces.
- Determine phytoplankton characteristics and photosynthetic parameters.
- Identify nutrient regimes and their role in biogeochemical cycles.
- Characterise plankton community structure, including the accurate determination of carbon values (to JGOFS protocols).
- Relate the partial pressure of CO_2 (pCO_2) in surface waters with the biological production.
- Acquire data for the calibration of remotely sensed observations (primary validation).

- Secondary validation of remotely sensed products (e.g. chlorophyll concentration).
- Interpret basin-scale remote sensing observations.
- Develop models that enable the interpretation of satellite imagery in terms of total water column properties.

2. Cruise Personnel

Plymouth Marine Laboratory:

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British Antarctic Survey:

GRAHAM BUTCHER

NB Full postal addresses, phone and e.mail numbers are given in Appendix A

3. Cruise itinerary, track and sampling strategy

Itinerary

16 September	-joined ship in Grimsby
17	-commenced installation of scientific equipment
20	-depart Humber Estuary
21	-called Portsmouth for fuel; sailed 18:00
22	-Station 1 (practice) SDY 266
24	-nearest approach to 47N x 20W; Station 3, SDY 268
30	-end science (EEZ); Station 9, SDY 274
02 October	-start science; Station 10, SDY 276
16	-end science off R.Plate; Station 27, SDY 290
21	-depart R.Plate (Montevideo)
23	-resume science; station 297
25	-(am) final Station 30, SDY 299; move to Mare Harbour
25	-(pm) arrive Stanley
30	-flight to UK *via* Ascension Is.

NB A full list of stations, times and corresponding sequential day of the year (SDY) are given in Appendix B

Cruise track and sampling strategy

The *RRS James Clark Ross* left Grimsby on the Humber Estuary on September 20 and sailed for Portsmouth to load aviation fuel. Thereafter a course *via* the Western Approaches was taken towards the first major waypoint (see Figure 1) at 47°N 20°W. At this station the course was then altered to due south, with only minor deviations, as required, to stay outside of territorial waters off Madeira, Africa and the Cape Verdes. At the latitude of 10°N the ship altered to a south-westerly course for the R. Plate entrance in Uruguay arriving in Montevideo on October 17 to load stores and make repairs. On leaving Montevideo, the course was generally southerly to the Falklands arriving in Port Stanley on October 25.

The scientific work fell into two main components: 1) a conventional station, generally once a day to make CTD profiles, take bottle samples and make optical measurements; 2) continuous or intermittent underway measurements on samples drawn for a number of determinants from the pumped surface water supply while on passage between stations.

Operations on stations

At about 10:00hrs each day the vessel stopped for typically 90 minutes and two CTD/rosette casts were made to a maximum depth of 200m. The timing of the station was a compromise between the requirements of the primary production specialists who would ideally sample at dawn and the optical scientists who would prefer to work closer to local noon. Water sample bottles were fired at typically 10 depths on each cast and the sampling depths were chosen primarily by reference to the CTD fluorometer which was installed for this work. The positions of the stations are given in Appendix B and the water bottle sampling depths for each station are given in Appendix C. The samples taken were used for a number of determinations which are described in the individual reports.

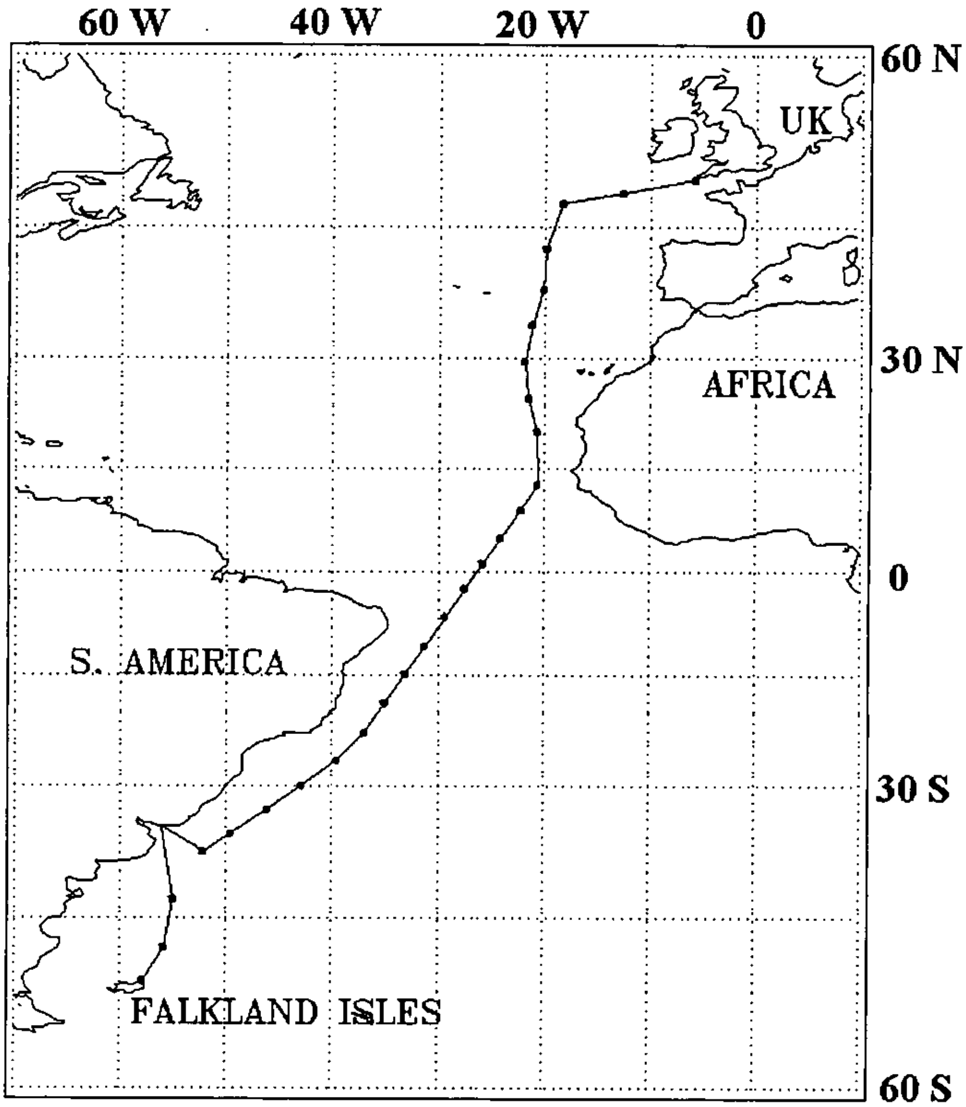


Figure 1. Mercator projection of the Atlantic showing the cruise track for AMT3 and the location of the principal, mid-morning stations.

Simultaneously with the CTD casts, vertical hauls were made to 200m for zooplankton from the forward crane and an optical cast was carried out from the aft telescopic crane. For these the ship was oriented, when possible, with the sun on the starboard side to minimise the effect of ship shade on the optical results. In addition to the wire-deployed light meters, a free-fall light meter and tethered surface reference meter (NASA) were deployed on most stations and a tethered surface up- and down-welling light meter (NASDA) were allowed to drift away from the starboard quarter on each station. Various ancillary samples and observations (e.g. sea and sky photographs) were also taken on each station. The scientific log recording the timing and order of all scientific operations is given as Appendix D. From October 12 - 16, extra optical casts were made during the afternoon to increase data frequency co-incident with the trials of the OCTS/ADEOS satellite trials

Underway measurements

The underway measurements included salinity, temperature and fluorescence which were measured using flow-through sensors connected to the uncontaminated sea water supply drawn from a nominal depth of 7m below the hull. These data were logged continuously to the Level C logging system. The inherent optical properties of the water were monitored using an AC-9 system fed from the seawater supply and logged to PC. In addition, meteorological, environmental and navigational data were also logged continuously to the main computer (Table 1). Dissolved gases (CO_2, CH_4 & N_2O) were extracted from seawater samples taken from the pumped seawater supply and analysed semi-automatically.

At intervals, generally following the daily station through until nightfall, an Undulating Oceanographic Recorder (UOR) instrumented with CTD, F, transmissometer and up- and down-welling light meters, was towed at passage speed.

A number of radiometer systems were deployed, mainly from the foredeck and foremast, to measure sea surface skin temperatures underway for comparison with satellite-derived data and to enable relationships between skin temperatures and bulk surface temperature to be derived (ROSSA).

In support of the radiometric work, a meteorological, radio-sonde balloon was launched daily and a detailed (hourly) log of meteorological and sea state conditions were recorded by the bridge officers and tabulated by Jenny Rust of BAS. A sub-set of this data at four hourly frequency is given in Appendix E.

In addition to the continuous measurements, a number of discrete samples were taken from the pumped supply at various time intervals (see Appendix F). These were analysed for major nutrients, and chlorophyll and samples were taken for iodine/iodate determination and for Bacterial enumeration (see below). Samples were taken from the sea water supply and from CTD bottles for accurate measurement of salinity using the Guildline Autosal precision salinometer on board. These data were used to check the calibration of the Neil Brown conductivity sensors on the CTD and SeaBird sensors on the flow through system. Precision thermometers were deployed with the CTD and used to check the temperature of the effluent from the SeaBird thermosalinometer in order to check the temperature responses.

Stream	Raw or Pro	Samp rate	Variables logged	Comments
sim500	Raw	15 sec	uncdepth, rpow, angfa, angps	
basctd	Raw	1 sec	pres, temp, cond, ch1, deltat	Uncalibrated voltage readings
em_log	Raw	5 sec	speedfa	
dop_log	Raw	1 sec	speedfa, speedps	
gps_trim	Raw	1 sec	lat, lon, pdop, hvel, hdg, svc	
gps_ash	Raw	1 sec	sec, lat, lon, hdg, pitch, roll, mrms, brms, attf	3D GPS - pitch roll etc
oceanlog	Raw	10 sec	atemp, mstemp, sstemp, hum, par, tir, fluor, flow, psy1, psy2, soap, press, cond, temp_h	
gyro	Raw	1 sec	heading	
stcm	Raw	2 sec	x, y, z	3 Component Magnetometer
adcp_raw	Raw	1 sec	rawampl, rawgood, beamno, bindepth	
anemom	Raw	1 sec	wind_dir, wind_spd	
tsshrp	Raw	10 sec	hacc, vacc, heave, roll, pitch	
adcpfrst	Pro	1 sec	bindepth, roll, pitch, heading, temp, velps, velfa, velew, velns, velvert, velerr, ampl, good, bottomew, bottomns, depth	
bestnav	Pro	30 sec	lat, lon, vn, ve, cmg, smg, dist_run, heading	Derived from several instrmts
bestdrf	Pro	30 sec	vn, ve, kvn, kve	same
relmov	Pro	30 sec	vn, ve, pfa, pps, pgyro	same
268ctd1	Pro	1 sec	press, temp, cond, salin, potemp, sigmat, svanom, potemp, sigmap, depth, soundv, dyhigh, stab, sigs, chloro, fluor	2 of these files per day - numbered by Julian days - some readings not calibrated.

Table 1. List of variables logged on the level ABC on-board computer.

4. Specific reports and preliminary results

4.1Water chemistry and bio gases

4.1.1 Total Iron Analyses

Andrew Bowie, University of Plymouth

Introduction

The marine biogeochemistry of iron is complicated by its redox speciation, low solubility and involvement in biological cycles. Fe(III) is the thermodynamically favoured redox state of dissolved iron in seawater, but undergoes rapid hydrolysis to form insoluble mixed oxy-hydroxides. Fe(III) is colloidally stabilised by organic ligands which also photoreduce Fe(III) to Fe(II). This results in a redox loop which is thought to retain dissolved iron at nanomolar levels in seawater. Furthermore, iron is an important trace nutrient for phytoplankton growth and actually limits primary production in certain nutrient-sufficient oceanic waters.

Objectives

To determine the total reducible iron levels in various depths obtained from daily CTD casts and underway samples. The analyses will focus on evidence of Fe delivered from Saharan dust fallout off NW Africa, increased Fe through upwelling regions, and the extent of possible Fe limitation in the Southern Ocean sectors of the transect.

Analytical methodology

Shipboard determinations were performed using an automated flow injection chemiluminescence (FI-CL) analyser. The system is based around the oxidation of luminol, which is catalysed by Fe(II) ions, emitting light. After in-line Fe(III) reduction, iron is preconcentrated and separated from the seawater matrix using a 8-hydroxyquinoline cation-exchange resin column. This allows the elutant Fe to be determined in the sub-nanomolar range in open ocean waters.

Unfiltered seawater samples were acidified to pH 2 with Ultrapur® HCl prior to analysis, and the Fe content determined by standard additions. Identical CTD samples were collected, acidified and stored for subsequent laboratory analysis of total dissolvable (including labile particulate) Fe, together with analysis of other micro-nutrients (e.g. Co, Zn) and aerosol delivered metals (e.g. Al, Pb).

Early Results

No significant problems were encountered and the system performed well in what was its first open-ocean sea trials. Initial difficulties with the injection valve and sample pump were resolved, and the system was stable and reliable from day to day. The detection limit of the analyser was 0.1nmol l^{-1} when 1.1ml of sample was passed through the column. Total Fe levels ranged from the limit of detection, measured in the waters of the southern oligotrophic gyre, up to 5nmol l^{-1} which was observed on the European shelf. A surface water profile of the transect, using samples collected from the CTD 7m depth, is contained in Figure 2. A typical CTD depth profile (2-200m) collected at station #9 (N 20° 05.14', W 20 ° 37.74') is shown in Figure 3.

Although the profiles fluctuate somewhat, early indications indicate that elevated iron concentrations in surface seawater are possible due to high atmospheric input and upwelling. Increased Fe levels, due to sedimentary regeneration, are found on both the continental shelves of the Western Approaches and off East Falkland. A clear increase is noted at 20°N off West Africa, a dual Fe input of aerosol dusts and the Mauritanian upwelling system. Further enrichments are observed at the Equatorial upwelling zone, and at 35°S in the frontal system where the cold Falklands' current mixes with the warm Brazilian current.

The Fe laden atmospheric input will be verified through measurements of Al and Mn on replicate samples collected for laboratory analysis. Other macro-nutrients levels (shipboard auto-analyser data) and micro-nutrients (Co, Zn) will be determined by cathodic stripping voltammetry analyses to correlate with Fe enrichment through upwelling systems. In order to estimate particulate iron levels through the transect, laboratory samples will be subjected to a strong acid leach, determining total dissolvable Fe, and comparisons made with the Coulter multisizer particle data. Finally, any organically bound Fe will be recovered after on-line UV photo-oxidation.

Future improvements to the FI-CL analyser, which will be investigated after the cruise, include adaptations to allow continuous Fe determinations via the JCR's pumped surface seawater supply. The acquisition of an autoanalyser to couple with the Fe monitor will improve sample throughput, and any modification which would allow the Fe(II) and Fe(III) content to be evaluated individually would help clarify iron redox speciation and undoubtedly lead to a greater understanding of iron's role as a micronutrient for primary production.

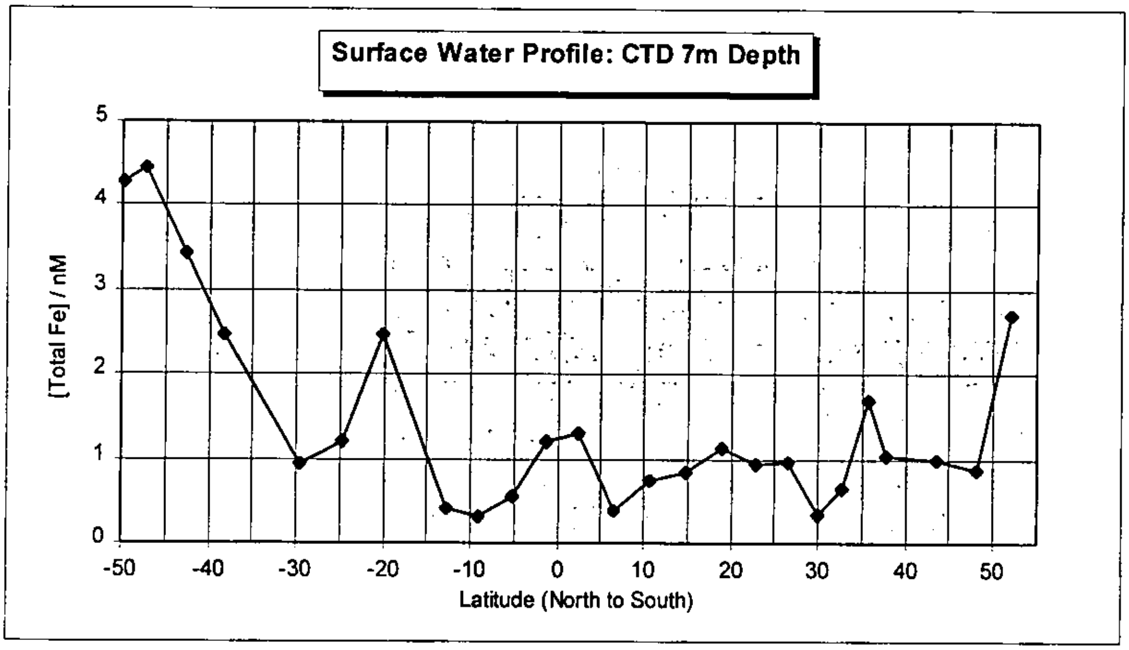


Figure 2: Surface Water Profile, Portsmouth (UK) to Stanley (FI)

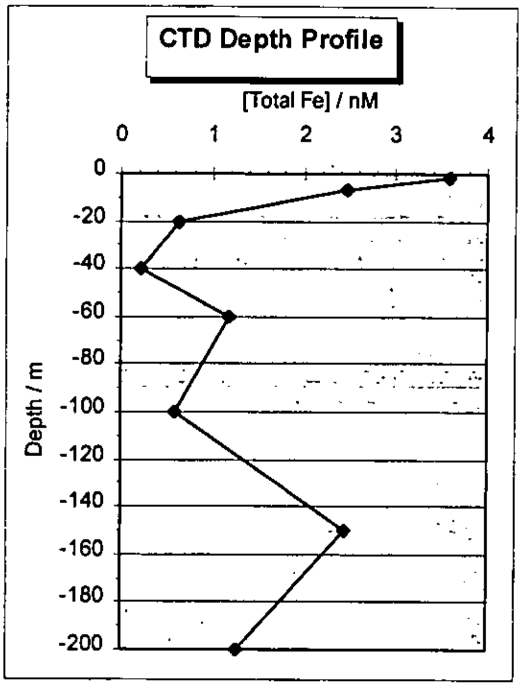


Figure 3: Typical CTD Depth Profile, Station #9, SDY 274

4.1.2 Iodine/Iodate

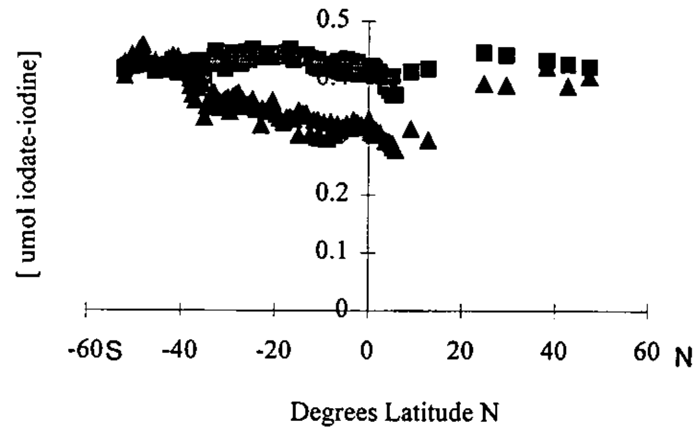
Tony Bale for Victor Truesdale, Oxford Brookes University

Samples for iodine-iodate/iodide analyses were collected for Dr Victor Truesdale of Oxford Brookes University. A 15ml tube was flushed and filled from each of the sample bottles on the 'productivity' CTD cast (see appendix C). Generally, ten depths were sampled between 7m and 200m with extra samples concentrated around the chlorophyll maximum. From about 10°N to 40°S, underway samples were taken from the ships pumped supply at about 4 hourly frequency, the sampling times for these are given in Appendix F which lists all the underway sample events. The samples were stored at 4°C and were transported to Oxford for subsequent analysis.

Generally, iodine is present in the oceans at about 0.5 µmol, as iodide and iodate; in deeper waters there is little iodide. It has been suggested that the ratio of iodide to iodate might indicate something about the redox condition of seawater, but more recent ideas focus upon the iodine cycle resembling that of the nutrients, with uptake and regeneration akin to the N system. The pioneering work of Sugawara and Terada showed that there is a general depletion of total iodine as the tropics are approached from either the N or S in the Pacific. At the same time, iodate is reduced to iodide in the surface waters. There is no other published meridional transect. This study was therefore undertaken to "confirm" this trend, and to check that the Atlantic behaves as the Pacific. The methods used are different to those of Sugawara and Terada, and that is an interesting dimension in itself. Here, total iodine is determined by the catalytic action of iodine on the reaction between Ce(IV) and As(III), and iodate by converting it to I_2 by acid and KI. (The others used precipitation by silver.)

The results shown in Figure 4 illustrate the expected trend clearly. However, the loss of total iodine is less than expected. Indeed, it suggests that the system could be modelled entirely without assimilation as the dominant process. That is, iodate reduction could be non-assimilatory. If this is so the quasi-nutrient status of iodine can be dropped. It is believed that iodate can be reduced in oxic bacterial cultures, so maybe the iodate reduction really reflects bacterial action in the general regeneration of detritus. It will be interesting to examine how well iodine correlates with nutrients, chlorophyll, etc.

Figure 4. Total iodine and iodate/iodine results for AMT3



4.1.3 Inorganic nutrient analyses

Colin Griffiths, Tony Bale, Plymouth Marine laboratory

Objective: To determine the concentration of dissolved nitrate, nitrite, silicate and phosphorus in CTD and underway samples in order to contribute to the definition of biological 'provinces' and to support the primary production measurements.

Methods: The concentrations of nutrients were measured colourimetrically using a 4-channel, Technicon auto-analyser with standard methodologies. All depths from the CTD (typically 10) were measured on each cast, generally within 2 hours of collection. Surface samples taken at approximately 4 hourly intervals were stored at 4°C and analysed with the samples from the following CTD cast. A list of CTD stations and the underway samples are given in Appendices B and F, respectively.

Results: All samples were analysed except for one batch where the phosphate channel was lost temporarily. There were a number of technical problems throughout; these consisted of: 1) noisy colourimeter responses initially, particularly for the silicate channel which was also prone to drift non-linearly. However, this improved with time and became less problematic as the voyage progressed. 2) All the colourimeters blew bulbs, sometimes frequently. There are only a few spare bulbs left. 3) The orange-green pump tubes in the present batch only lasted a few days despite being run for only 4-5 hours a day. All the analytical results are presently stored as colourimeter responses on paper traces and await digitisation before the responses can be converted to quantitative results. At the time of writing, the nitrate and silicate data has been digitised and it is anticipated that the phosphate and nitrite will be completd by the AMT3 workshop. Qualitatively, the surface water nutrient samples and surface mixed-layer samples from the CTD were always below detection except in the shelf waters of the Western Approaches and in the Falklands Current waters. Nutrient values increased with depth and were markedly elevated in the Mauritanian and Equatorial up-welling regions.

4.1.4 Ocean-atmosphere bio gas fluxes

Cliff Law, Plymouth Marine Laboratory

A. Nitrous oxide and Methane

Introduction

The ocean is a source of the biogenic gases nitrous oxide (N_2O) and methane (CH_4) to the atmosphere, accounting for ~ 1-10% of total global emissions. These species are both radiative gases which contribute to the greenhouse effect and influence tropospheric and stratospheric chemistry. Variability in the oceanic source strength results from lateral gradients at the mesoscale and also variability on seasonal timescales. This variability, combined with the relative paucity of actual observational data, significantly reduces the precision of present global ocean-atmosphere flux estimates and hence the quantification of the impact of the ocean upon climate change. Continuous onboard measurement of these gases in air and surface waters during AMT3 will contribute significantly to the oceanic flux database. In addition, the potential for correlation of optical parameters and ocean surface gas concentrations, with the development of algorithms across a range of water mass types, will improve remote predictive capabilities. Prediction of surface concentrations and hence flux fields from satellite imagery will also circumvent the problems and costs associated with obtaining shipboard observational data, and hence contribute significantly to the interpretation and prediction of climate change.

Instrumentation

The analytical system employed during AMT3 was a composite of two systems used previously for the analysis of other trace gas species. It consisted of an equilibrator unit for surface water measurements, and a pumped supply from the ships bridge for air measurement, with chromatographic separation and detection of N_2O by ECD (Electron Capture Detector) and CH_4 by FID (Flame Ionisation Detector). Two gas standards, previously cross-calibrated with NOAA certified standards, were used to cover the sample range for both detectors. The system ran in continuous mode throughout and was supplied with surface water from a depth of 7m via the ships non-toxic system. An analytical routine consisted of one surface water sample, one atmospheric sample, and two standards every 25 minutes.

The system performed well, particularly considering the limited pre-cruise time spent configuring it. Data collection north of 40° N was adversely affected by equilibrator flow problems and contamination and so the data is not presented. Approximately 1000 measurements of both air and surface concentration were obtained between 40° N and Montevideo (35° S) following a change of equilibrator unit, with a break between 13° N and 6° N for further equilibrator tests. Measurements were made between Montevideo and Port

Stanley, although data collection was initially restricted by the increased permeability of the equilibrator. Daily downtime resulting from dessicant changes and data downloading was minimal.

Results

Atmospheric N_2O in the northern hemisphere exhibited a mean concentration of 312.7 +/- 0.8 ppbv (1 S.D.), declining to 312.1 +/- 1.2 ppbv (1 S.D.) south of the intertropical convergence zone (ITCZ) as shown in Figure 5. The position of the ITCZ was not identified as continuous sampling was suspended between 13° N and 6° N, but it has previously been observed between these two latitudes. CH_4 also fell sharply at the ITCZ, from 1791.7 +/- 9 ppbv (1 S.D.) in the NH to 1753 +/- 3.9 ppbv (1 S.D.) in the southern hemisphere.

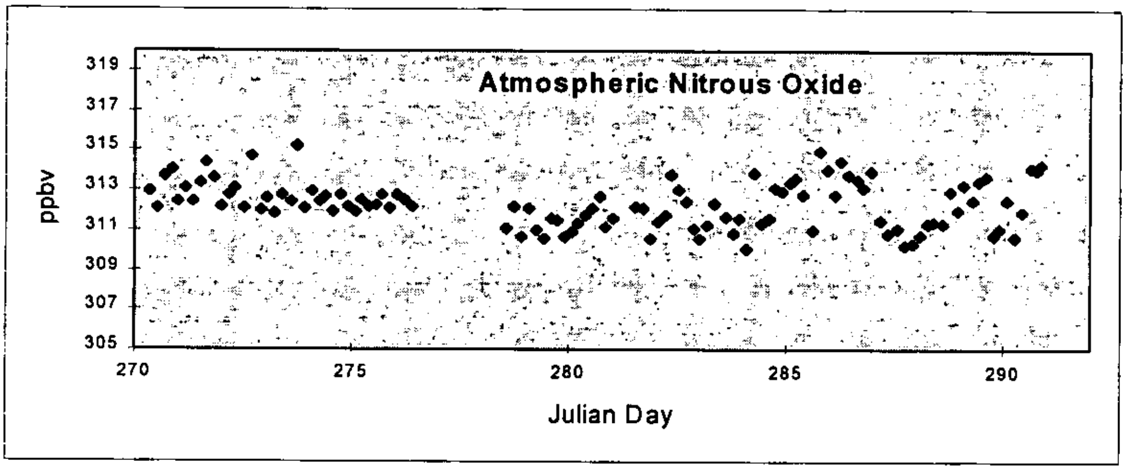


Figure 5a Atmospheric nitrous oxide concentration

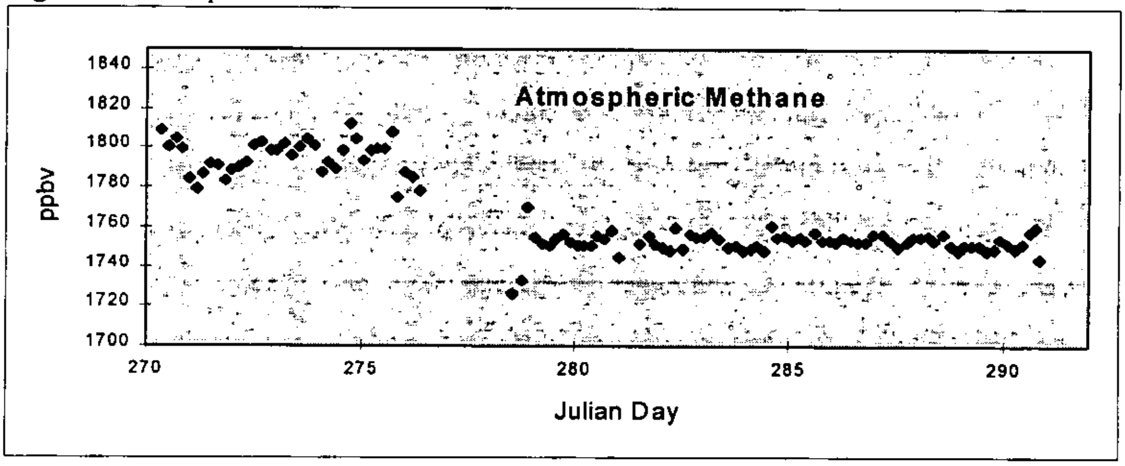


Figure 5b. Atmospheric methan concentration

Figure 6 shows the percentage saturation of surface water relative to atmospheric concentration for each gas. CH_4 was always supersaturated relative to the atmosphere, whereas N_2O showed areas of undersaturation in the North Atlantic Gyre between 30° N and 23° N (A). Strong localised sources were identified for N_2O and CH_4 including the Mauritanian upwelling system (B), Equatorial Upwelling/Front (C), the frontal system between 32° S and 36° S (D) and the River Plate plume (E). The high supersaturations observed in these areas concurs with previous observations from other productive regions. Both gases exhibited strong relationships with fluorescence, chlorophyll and biovolume in some regions, but there was no significant trend throughout. CH_4 often exhibited a sharp increase coincident with elevated fluorescence maxima, but also increased in the relatively oligotrophic waters of the North Atlantic Gyre. The overall mean percentage saturation for N_2O was 103.5%, excluding the Mauritanian upwelling region, which compares favourably with previous global estimates of 102.5%. CH_4 exhibited a mean saturation of 106.2%, excluding the Mauritanian upwelling. It should be noted that these are preliminary data in that they are uncorrected for temperature changes between in situ and the equilibrator, and are also relative to the uncorrected atmospheric data.

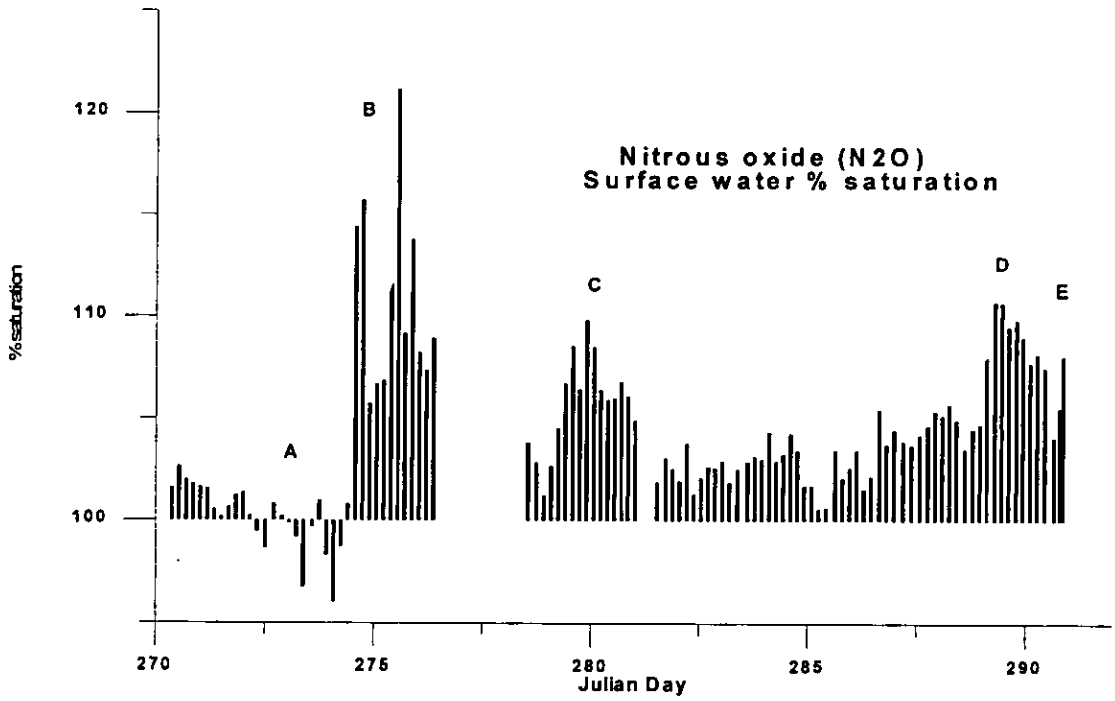


Figure 6a. Surface water saturation values for nitrous oxide

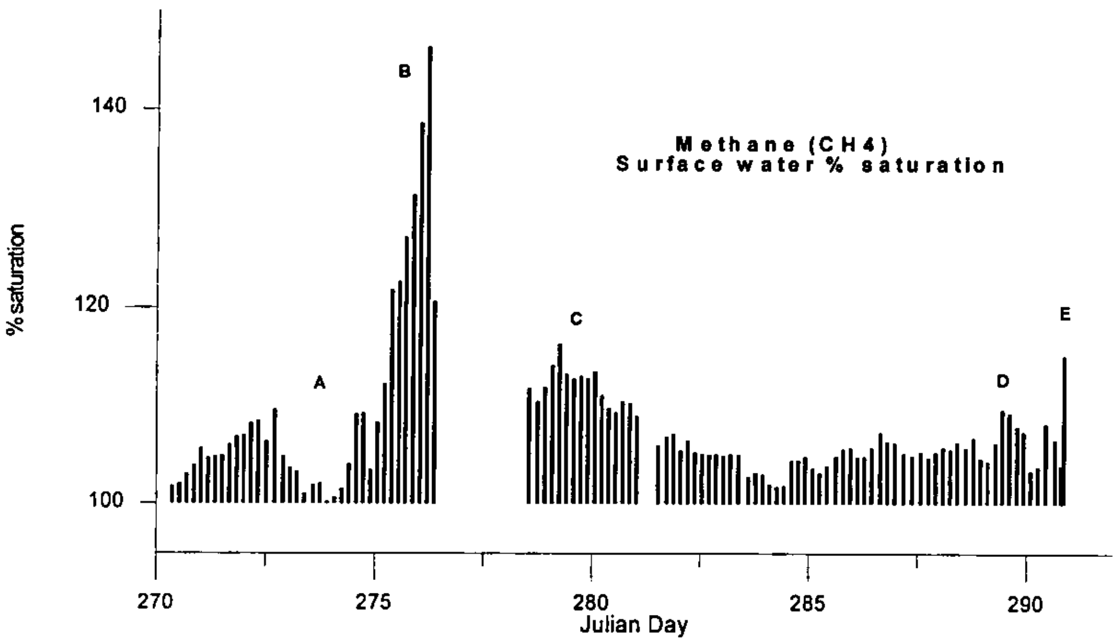


Figure 6b. Surface water saturation values for methane

Carbon dioxide

Introduction

To assess the impact of climate change and global warming, it is vital that the behaviour and cycling of carbon dioxide (CO_2) is understood. Although it is presently unclear whether a terrestrial or oceanic sink for CO_2 is more significant to the global carbon budget, previous studies have shown that the Atlantic, and particularly the North Atlantic, are important buffers to the build-up of pCO_2 in the atmosphere. The AMT cruises provide a perfect opportunity to obtain a large number of measurements with extensive spatial coverage of atmospheric and surface CO_2. This data will expand upon the ΔpCO_2 database for the Atlantic ocean already obtained during other programmes, such as JGOFS and the PML Ship of Opportunities project, and will contribute to global carbon cycle models, thereby tightening estimates of the carbon budget and feeding directly into global environmental policy decisions.

Instrumentation

Continuous measurements of atmospheric and surface water CO_2 were made using an autonomous analytical instrument designed at PML, and used previously on AMT1 and AMT2. The computer controlled system consists basically of a series of solenoids which direct gas samples from a percolating packed bed equilibrator, a pumped air supply from the ships bridge and two WMO traceable standards, to an infra-red transmissometer (LiCOR). The system is also equipped with a GPS receiver so that measurements are logged relative to time and position.

Initial problems were experienced due the lack of maintenance and attention given to the system following its use on the previous summer cruise to the Arctic. Initial blockage of the marine air line was cleared and a PTFE trap installed to try to prevent this in future. Water had penetrated in both marine air and equilibrator gas lines, and consequently the system was badly corroded internally. As a result the apparatus required a complete mechanical overhaul during the first few days of the cruise, after which the system ran continuously from 49^{o} N to 35^{o} S. After shutdown for four days in Montevideo the system required further maintenance with replacement of an air pump and a solenoid valve, but data collection continued between 33^{o} S and Port Stanley. Some software problems were experienced during the cruise but these had minor impact on data collection.

Results

Generally the pCO_2 data shows similar trends to AMT1, with variability over shelf and upwelling regions and fronts associated with elevated productivity, increased nutrient availability and enhanced mixing. Undersaturation was observed in the higher latitudes around 45^{o} N, resulting from the relatively more rapid cooling of these waters compared to the rate of re-equilibrium with the atmosphere. Of particular note is the region of undersaturation centred on 5 N (see Figure 7), which was also observed on AMT1. This feature exhibited similar levels of undersaturation on both cruises, of approximately 20-30 μatm, but was more spatially restricted than on AMT1 to 3^{o} N to 7.5^{o} N. Once again this feature was associated with a salinity minimum of < 35 psu. Also apparent in Figure 7 is an area of undersaturation around 10^{o} S, which exhibited a maximum drawdown of 20 μatm. This feature was also observed during AMT1, but was not associated with a salinity minimum; it corresponds to the boundary of the SEC and the S. Atlantic gyre. It should be noted that these are preliminary data and have not been filtered for atmospheric contamination from ships emissions whilst on station.

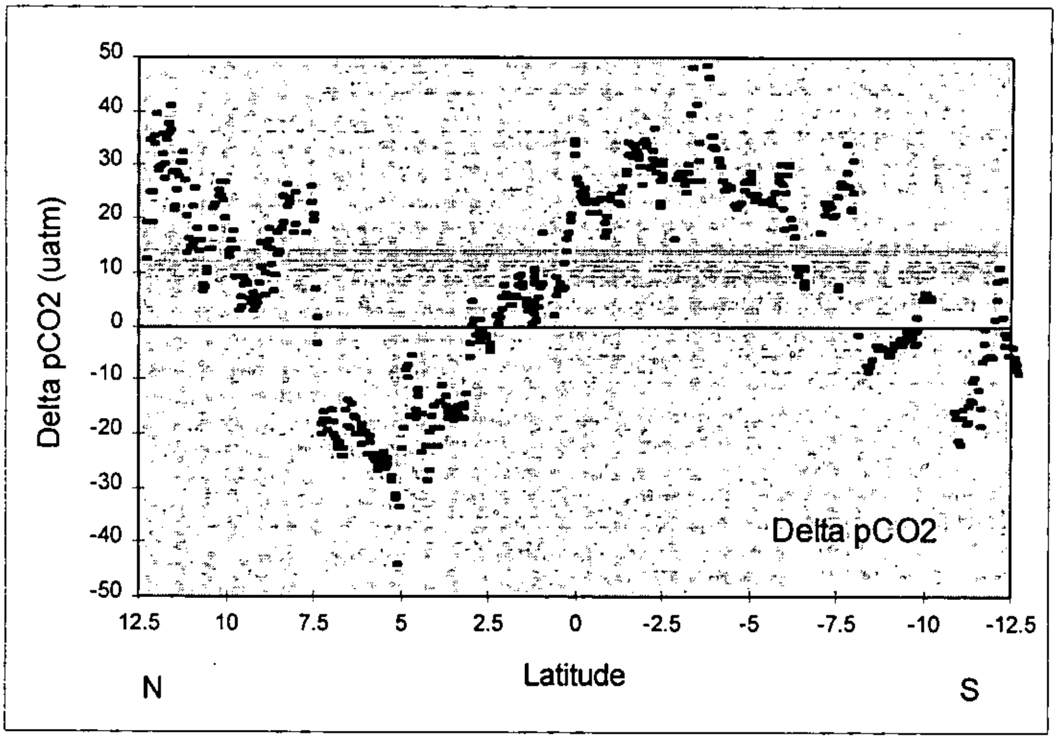


Figure 7a. Delta pCO_2 for the region 12.5° N to 12.5° S

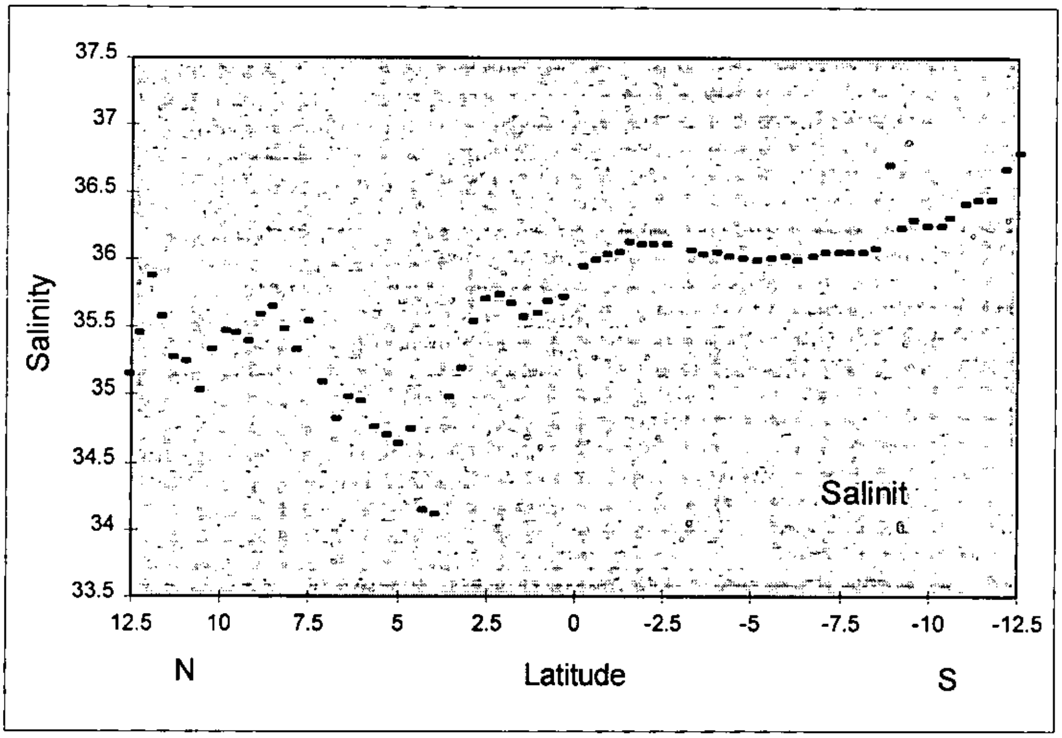


Figure 7b. Surface salinity for the region 12.5° N to 12.5° S

4.2 Bacteria and phytoplankton distributions

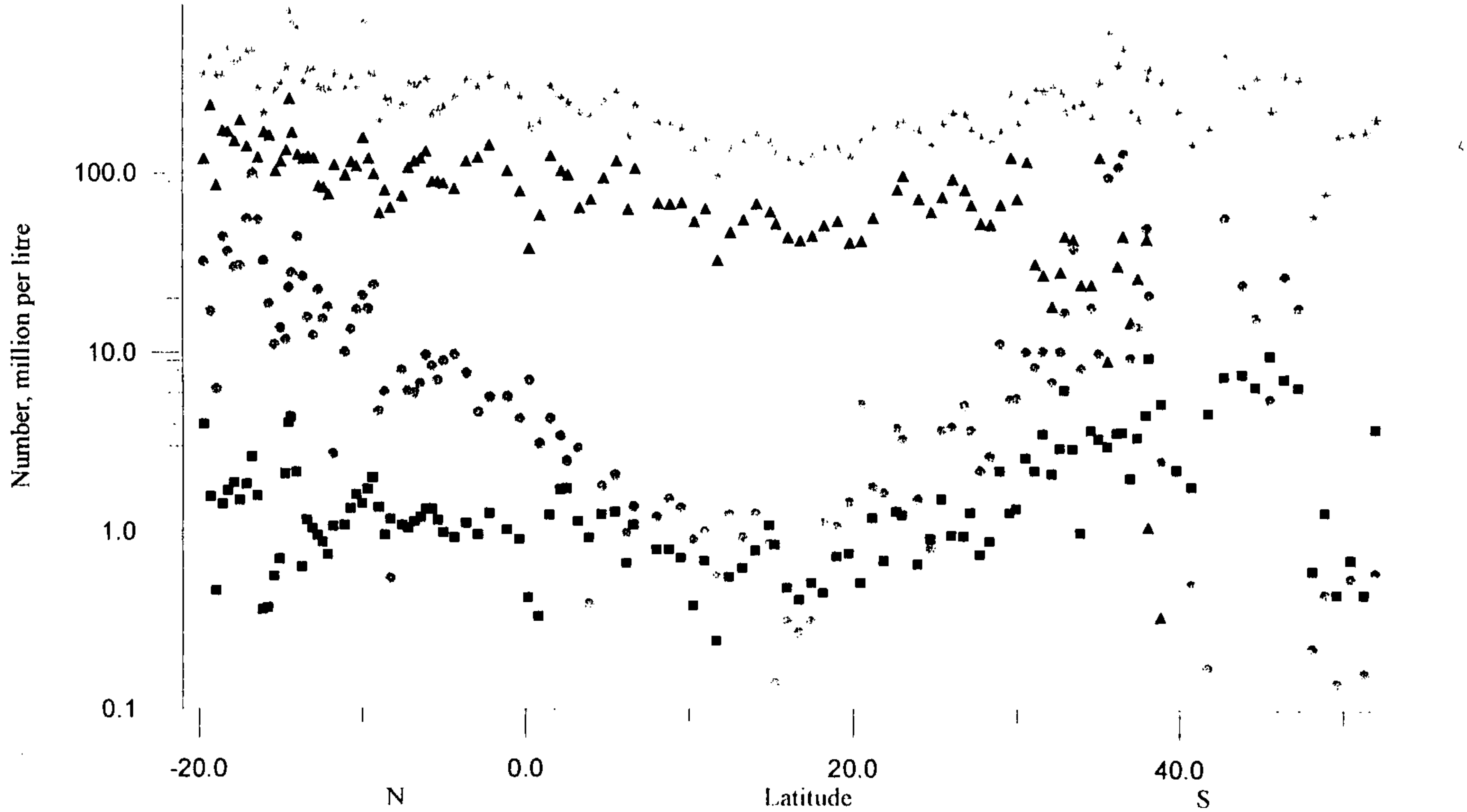
4.2.1 Microbial web studies: bacterial dynamics,
Mike Zubkov, Southampton University

Introduction and objectives
The studies of the microbial web included quantification of the activity of two general groups: bacteria and nanoplanktonic flagellates in terms of vertical distribution, size structure, bacterivory and control of bacterial numbers byprotozoa.

Bacterioplankton size structure, abundance and production
The samples from ten depths were collected daily from the 'productivity' CTD casts to provide vertical distribution of bacterioplankton using flow cytometry (carried out in the laboratory on return from sea). Also the samples collected from these depths were pooled into three integrated samples (on the basis of vertical profiles of temperature, salinity and fluorescence) representative for surface mixed layer, deep chlorophyll maximum layer or layer of hydrophysical gradients and a layer below seasonal thermocline down to 200m. Size fractionation of bacteria was used to estimate the median cell diameter of bacterial populations that inhabited these layers. Samples were filtered through Nuclepore filters with pore size 0.2, 0.4, 0.6, 0.8 and 1μm and filtrate fixed for subsequent analysis by flow cytometry. Bacterioplankton production was estimated using simultaneous uptake of 3H-thymidine and 14C-leucine by bacteria. The integrated samples were inoculated with radioactive precursors and incubated in the dark at in situ temperature.

Abundance of nanoplankton and bacterivory
The samples were collected from the same CTD casts and integrated into three pooled samples to estimate abundance of nanoplankton and common microplankton using epifluorescence technique. Assay of enzymes that cut off glucosamine at acid pH (disrupting bacterial cell wall in protozoan food vacuoles) was employed to estimate the activity of bacterivorous protozoa. These analyses were conducted in conjunction with the measurements of bacterial production. The experiments to study bacterivory were carried out using dilution technique and dual radioactive labelled natural bacterioplankton. Supplementary bacterial numbers, bacterial production and protozoan enzyme activity were monitored in dilution series.

The analysis of all collected material and samples was carried out in the laboratory and the results are summarised in Figure 8.



Concentration of Bacteria total (stars), Prochlorophytes (triangles), Cyanobacteria (circles) and picoeukaryotes (squares) in underway surface samples along the AMT-3 track from 20 N to 52 S.

Fig 8.

Underway surface samples to measure the concentration of picoplankton by flow cytometry were collected at 2 h intervals from 20 to 5 N and at 4 h intervals from there down to the Falkland Islands. There were considerable changes in picoplankton structure and abundance along the the track. In general heterotrophic bacteria and prochlorophytes dominated numerically in tropical waters. The concentration of cyanobacteria gradually decreased to the southern oligotrophic gyre and increased again towards the frontal system between warm Brazil and cold Falklands Currents. The picoeukaryotes showed a roughly similar trend. These data will be compared later with the results of analysis of profile samples.

4.2.2 Pigments and underwater optics, $\delta^{13}C$ in particulate organic material and effect of UV-B radiation on primary productivity.

Koji Suzuki and Yoshihisa Mino, Nagoya University
(supported by NASDA and RESTEC, Japan)

1. Intercalibration exercise on the measurement of phytoplankton pigments and underwater light field by Japanese and British scientists

A new Japanese satellite, ADEOS/OCTS, launched on 17 August 1996, is expected to monitor changes of global biogeochemical cycles. To accomplish this objective, the calibration and validation of remotely sensed data obtained from the satellite is needed at the first priority. However, intercalibration exercises between laboratories on routine shipboard measurements such as algal pigment analysis have seldom been conducted for the accurate "ground truth" of ocean colour satellite data. Therefore, we tried an intercalibration exercise on the measurements of phytoplankton pigments using HPLC as well as measurements of underwater light field with Drs. R. G. Barlow (pigments) and J. Aiken (optics) from Plymouth Marine Laboratory, UK.

Seawater samples were collected from surface to deeper layers (<200 m) using CTD-RMS for algal pigment analysis. The water samples (1.5-4 l) were filtered through Whatman GF/F filters (see Appendix C for details of the CTD bottle depths). The filters obtained were stored in liquid nitrogen until analysis on land.

A spectroradiometer PRR-600 (Biospherical Insts. Co.) and a tethered optical buoy TSRB (Satlantic) transported from Nagoya, was deployed to measure surface irradiance and underwater light field in the almost same time of pigment sampling. The radiometers are calibrated before and after the cruise against a standard lamp which is traceable to NIST standard lamp.

2. Latitudinal variations of $\delta^{13}C$ in particulate organic matter

Many investigations of photosynthetic $\delta^{13}C$ fractionation by marine phytoplankton have been attempted over several decades, because stable isotopic characterisation of marine organic matter can provide useful information on variabilities of biogeochemical processes in surface waters. Recently, interest has focused on the relationship between $\delta^{13}C$ of POM and some factors such as sea surface temperature, concentration of aqueous carbon dioxide [CO_2(aq)] and growth rates of phytoplankton (μ). Therefore, we would like to examine the effect of both CO_2(aq) and m on the $\delta^{13}C$ of POM in the Atlantic ocean, taking advantage of the wide range of environmental variability during the AMT cruise.

Sample collection and storage was conducted as following. All surface water samples were collected from underway sampling system at each stations (see our table).

Suspended POM samples in surface water (15 l) were filtered through Whatman GF/F filters, and the filters were stored frozen until isotope analysis.

DIC samples (125 ml) were poisoned with 0.1 ml of saturated $HgCl_2$ solution, stored in a dark serum bottle at room temperature. The total amount of DIC and its $\delta^{13}C$ will be determined on land.

We determined the growth rate of phytoplankton using dilution technique under simulated in situ incubation, on deck, in running surface seawater. This incubation was conducted in polycarbonate bottles for 24 hrs. After the incubation, samples were filtered onto GF/F filter for Chl *a*. The pigment was extracted in DMF at -20 C in the dark, and was measured by a Turner Designs fluorometer with non-acidification method (Welshmeyer's method). Net growth rate of phytoplankton was estimated from the changes in amounts of Chl *a*.

3. Effect of UV-B radiation on primary productivity with special reference to the production patterns and composition of photosynthetic products in marine phytoplankton

Although the level of biologically harmful UV-B radiation (280-320 nm) arriving at low latitudes is generally higher than that at high latitudes, the UV-B radiation at high latitudes has enhanced because of the depletion of the protective stratospheric ozone. Hence, much attention has recently focused on the biological effect of UV-B radiation. Most studies on the impact of UV-B radiation on phytoplankton have dealt with its effect on photosynthetic rates and on total primary production, but the biochemical implications of such effects have not been well investigated. In addition, its latitudinal variation has never been examined in the open ocean yet.

Therefore, we incubated surface phytoplankton, which were collected from underway sampling system, both in UV-B radiation transparent quartz bottles and in non-transparent polycarbonate bottles on deck during daytime after adding $NaH^{13}CO_3$ as a tracer. The seawater samples were filtered through Whatman GF/F filters, and the filters were stored in liquid nitrogen. The amount of UV-B radiation was continuously measured using a UV-B meter during this cruise. We will estimate the effect of UV-B radiation on the production patterns and composition of photosynthetic products in marine phytoplankton in relation to primary productivity, and its latitudinal variation in the Atlantic Ocean after the cruise.

4.2.3 Phytoplankton abundance, composition and production

Emilio Marañón[1] and Beatriz Mouriño[2]

1 Southampton Oceanography Centre
2 Universidad de Vigo, Spain

Objectives

1.- To describe the latitudinal distribution of size-fractionated phytoplankton abundance and taxonomic composition.

2.- To describe the latitudinal distribution of carbon and nitrogen standing stocks of the microplankton.

3.- To determine the patterns of carbon fixation by phytoplankton in different size fractions (pico-, nano- and net-plankton).

4.- To determine the latitudinal and vertical variability of the photosynthetic parameters of phytoplankton and their relationship with the physical and chemical environmental factors and the taxonomic composition of the microalgal assemblages.

Methods

All sampling and experimental techniques were the same as previously used during AMT-2, and therefore only a brief description will be included here. Phytoplankton stock and rate measurements were conducted on water samples collected from the rosette at 7 depths on each station. Size-fractionated chlorophyll *a* concentration was determined fluorometrically on 90 % acetone extracts on a 10 AU Turner Designs Fluorometer. The fluorometer had been set up to use the non-acidification technique of Welchsmayer (1994) and was calibrated on two occasions during the cruise. In order to compare the results obtained using this technique with the chlorophyll data from AMT-1 and AMT-2, a number of samples were counted every day on both the 10 AU Turner Designs fluorometer and the PML fluorometer used during previous cruises. Correlation between both measurements was high (r^2=0.87) and the slope of the regression line was not significantly different from 1. The results of this inter-calibration exercise indicate that chlorophyll data from AMT-1 and 2 and AMT-3 are perfectly comparable.

Both formaline and Lugol's iodine samples for microplankton species identification and counting were taken from each station at 3 depths: surface (7 m), deep chlorophyll maximum (DCM) and an intermediate depth. These depths were the same as those where photosynthesis-irradiance experiments (see below) were conducted. 1.5 litre samples from 5 depths at each station were filtered in duplicate onto pre-ashed Whatman GF/F filters for particulate organic carbon and nitrogen (POC/N) analyses. Filters were frozen, then dried at 60 °C for 24 hours and finally kept in plastic containers with silica gel at room temperature.

Vertical profiles of size-fractionated primary production were obtained from ^{14}C incubations conducted in an on-deck incubator provided with a range of 10 irradiances from 97 % to 1 % of I_0. Triplicate 70 ml samples were spiked with 10 μCi $NaH^{14}CO_3$ and incubated for 7-8 hours at an irradiance close to that of their original depth, as determined by the optical cast. At the end of the incubations, samples were sequentially filtered through 20 μm, 2 μm and 0.2 μm polycarbonate filters and the radiactivity of each fraction determined on a Beckman liquid scintillation counter after decontamination of the filters in acid fumes.

Photosynthesis-irradiance (P-I) experiments were carried out on a bench incubator equipped with an 100 W halogen lamp which provided a range of light intensities from 5 to 2500 µE m^{-2} s^{-1}. P-I experiments were conducted with water from 3 depths at each station (surface, deep chlorophyll maximum and an intermediate depth) and lasted for 2.5 hours. At the end of the experiments, the samples were filtered through 0.2 µm polycarbonate filters, decontaminated and counted as described above. All the samples and experiments are listed in Appendix J.

Preliminary Results

Total chlorophyll concentration ranged from less than 0.15 mg m^{-3} in the upper mixed layer of the subtropical north Atlantic and the tropical south Atlantic to more than 0.6-0.8 mg m^{-3} in subsurface waters of the temperate regions (Figure 9). The vertical distribution of chlorophyll *a* was characterised by the presence of a deep maximum (>0.3-0.4 mg m^{-3}) during most of the transect. The DCM was deeper in the tropical South Atlantic and shallower in the Mauritania upwelling region.

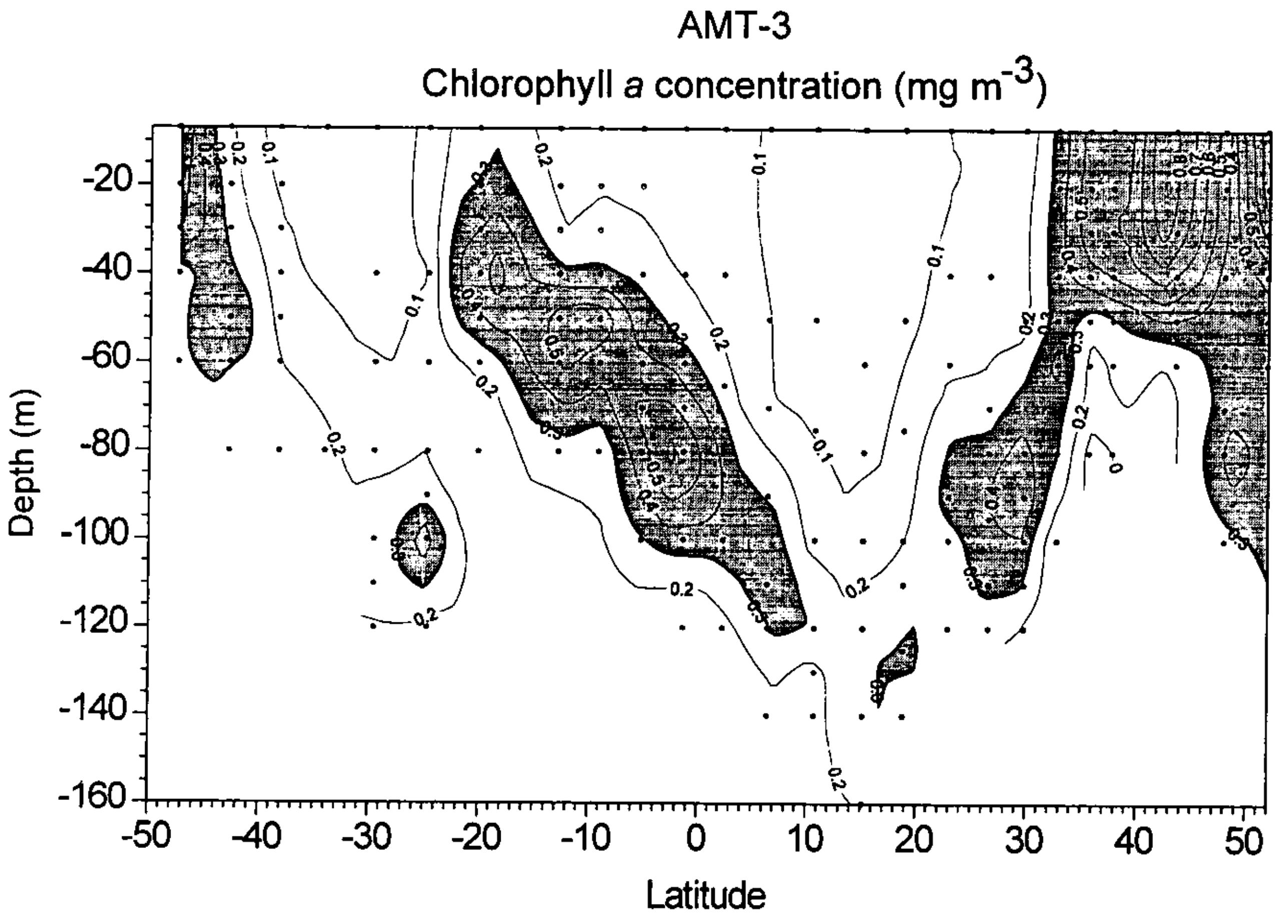


Figure 9.- Latitudinal distribution of chlorophyll *a* concentration (mg m^{-3}) from 47° N to 52° S. Shaded areas indicate chlorophyll *a* concentration >0.3 mg m^{-3}.

The latitudinal distribution of primary production mirrored that of chlorophyll *a* concentration (Figure 10). Highest rates of carbon fixation (>1.5 mgC m^{-3} h^{-1}) were measured in surface waters of the African upwelling region and the temperate South Atlantic. Primary production took low values (<0.40 mgC m^{-3} h^{-1}) throughout the water column in the subtropical North Atlantic and the tropical South

Atlantic. Enhanced photosynthesis was detected in the region from 5° N to 5° S, which was presumably due to an increase in the upward diffusion of nutrients as a result of the equatorial upwelling.

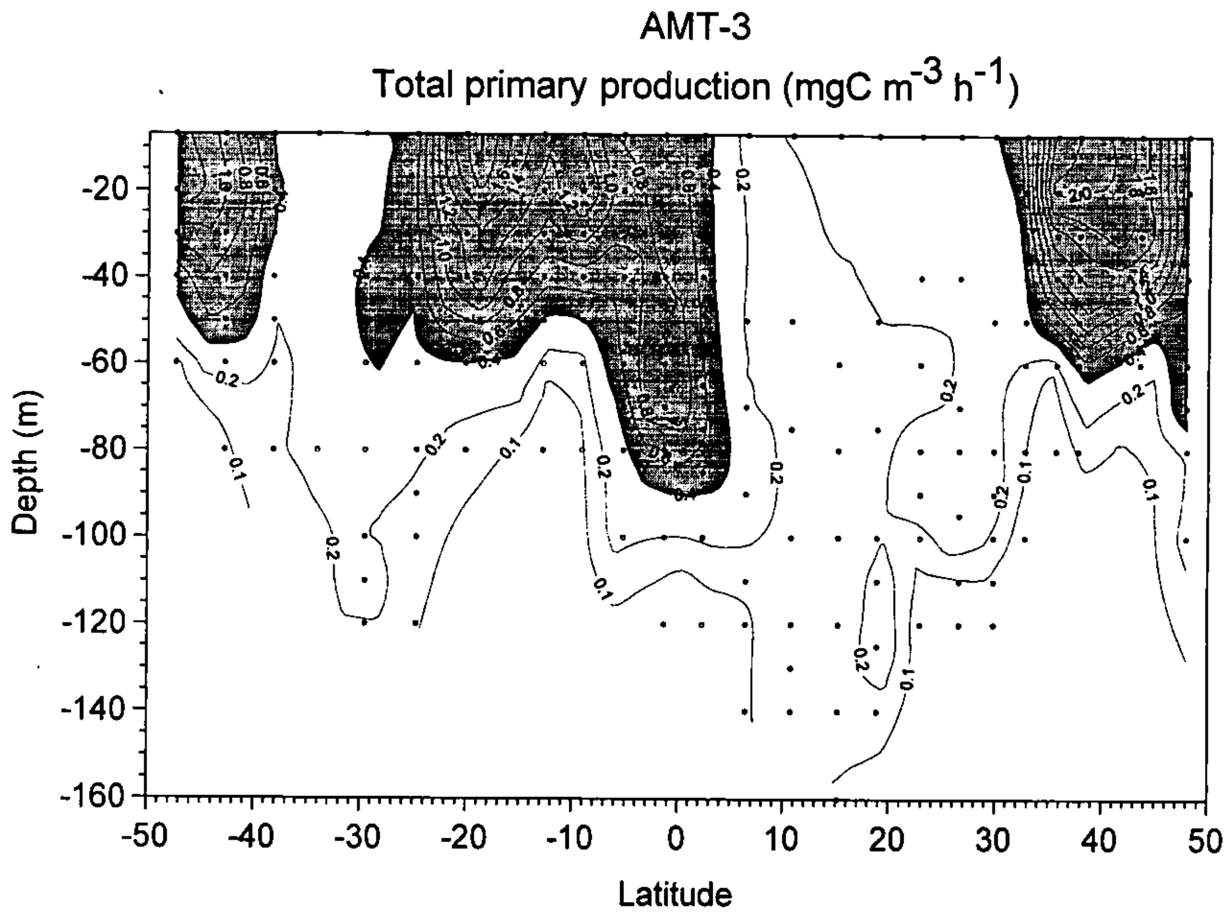


Figure 10.- Latitudinal distribution of total primary production (mgC m^{-3} h^{-1}) from 47° N to 48° S. Shaded areas indicate primary production >0.4 mgC m^{-3} h^{-1}.

Picoplankton was the dominant size fraction in terms of productivity during most of the cruise, usually accounting for 40-70 % of total production (Figure 11). Maximum contribution (>70 %) of picoplankton to total production took place in the equatorial and South tropical regions. Lower relative picoplankton productivity was not always associated with increased total carbon fixation rates. Reduced picoplankton productivity rates were found in the upper mixed layer of the subtropical North Atlantic and the region between 10° and 20° S.

Photosynthesis in the intermediate size fraction (2-20 μm) was generally lower than 0.2 mgC m^{-3} h^{-1}, representing 20-40 % of total primary production (Figure 12). A higher contribution (>50 %) of nanoplankton to total productivity in subsurface waters at subequatorial and equatorial stations was actually due to a reduction in picoplankton productivity.

Net-plankton (>20 μm) production was very low throughout the cruise, generally accounting for less than 10-20 % of total primary production (Figure 13). The highest contribution (>50 %) of netplankton to total production ocurred in subsurface waters at the southernmost station, coinciding with moderate levels of total phytoplankton biomass and production.

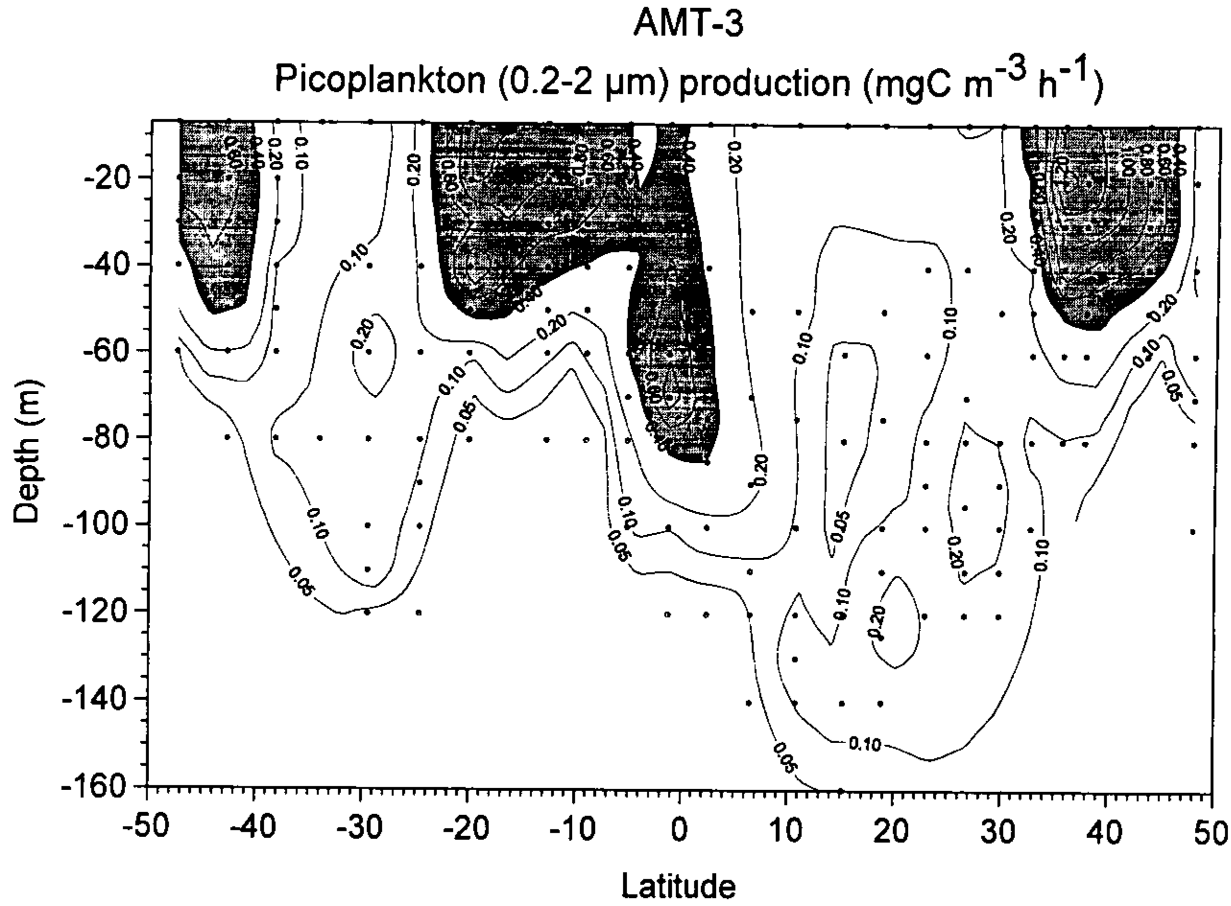


Figure 11.- Latitudinal distribution of picoplankton production (mgC m^{-3} h^{-1}) from 47° N to 48° S. Shaded areas indicate production >0.4 mgC m^{-3} h^{-1}.

Figure 14 illustrates the way in which the vertical physical structure of the water column affects the photoadaptation parameters of the phytoplankton assemblages. At an equatorial station, microalgae from the upper mixed layer (samples from 7 and 40 m) showed the same light-saturated photosynthesis rate (P^Bmax), whereas microalgae from below the thermocline (sample from 80 m) exhibited a much lower P^Bmax and strong photoinhibition (Figure 14A). It is interesting to note that samples from 7 and 40 m depicted a different light response in terms of inital slope and photoinhibition, even though both belonged to the upper mixed layer. This suggests that vertical mixing within the upper mixed layer in equatorial regions may not be so quick as to hamper the development of photoacclimation responses by phytoplankton.

A different pattern was found at a temperate station where all the phytoplankton biomass was concentrated in the upper mixed layer (Figure 14B). No photoinhibition was evident at any depth and differences in P^Bmax between assemblages were comparatively small, reflecting the effects of rapid vertical mixing.

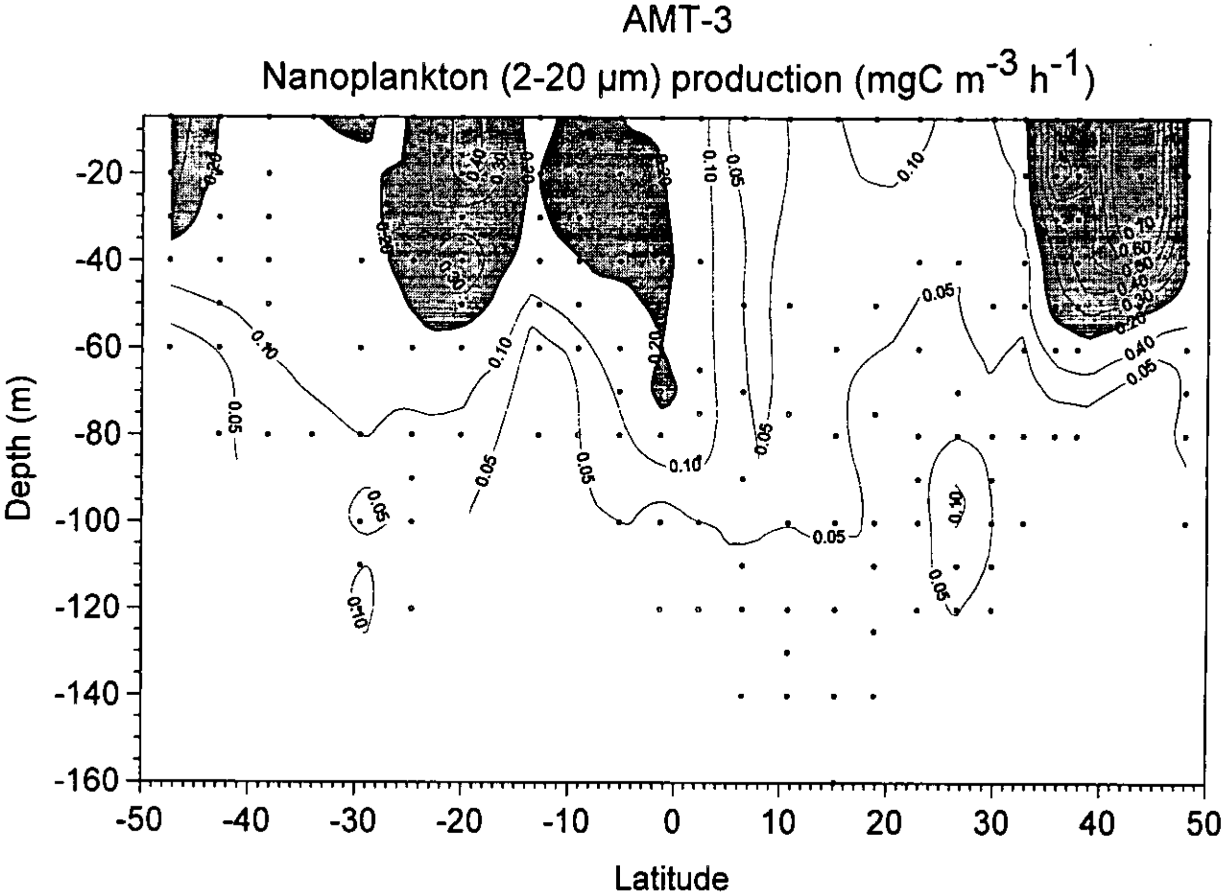


Figure 12. Latitudinal distribution of nanoplankton production (mgC m^{-3} h^{-1}) from 47° N to 48° S. Shaded areas indicate production >0.2 mgC m^{-3} h^{-1}.

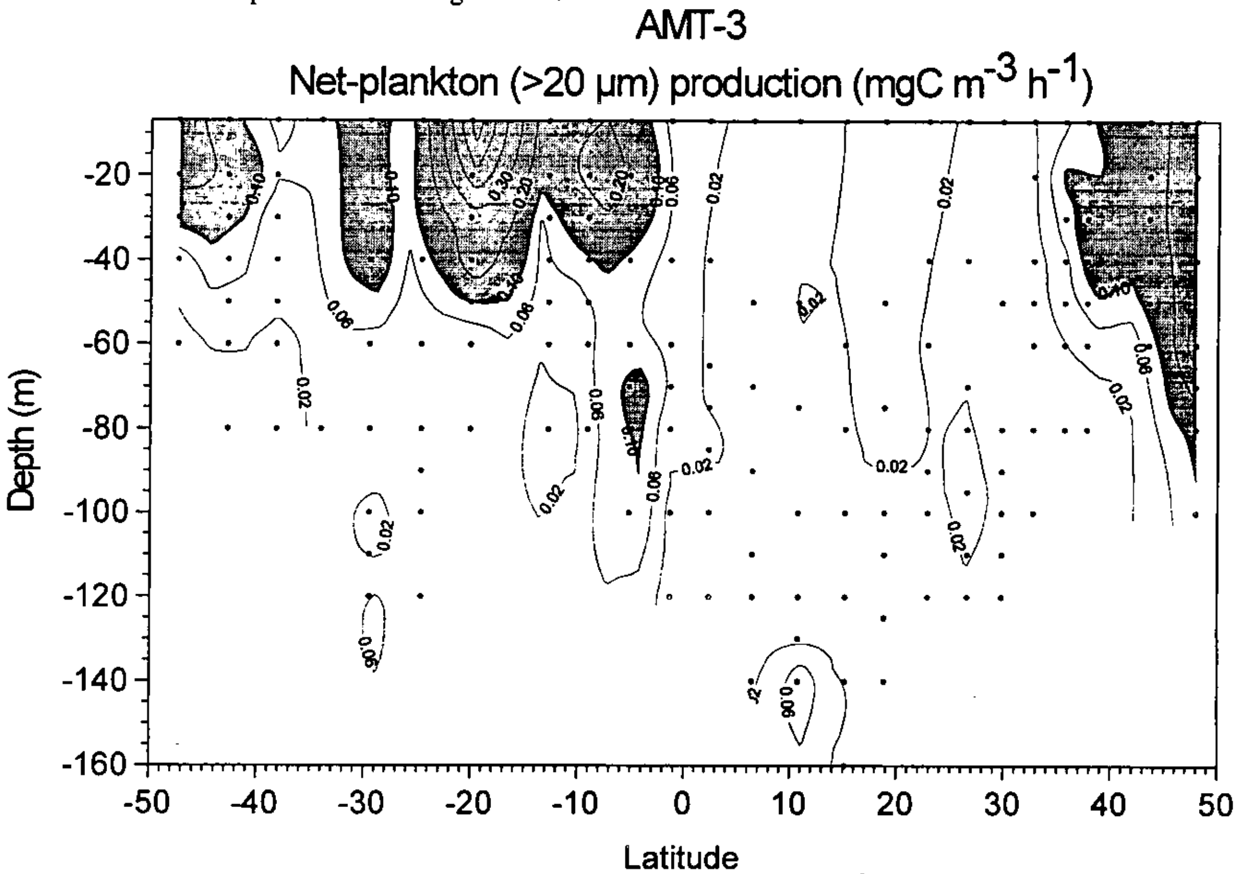
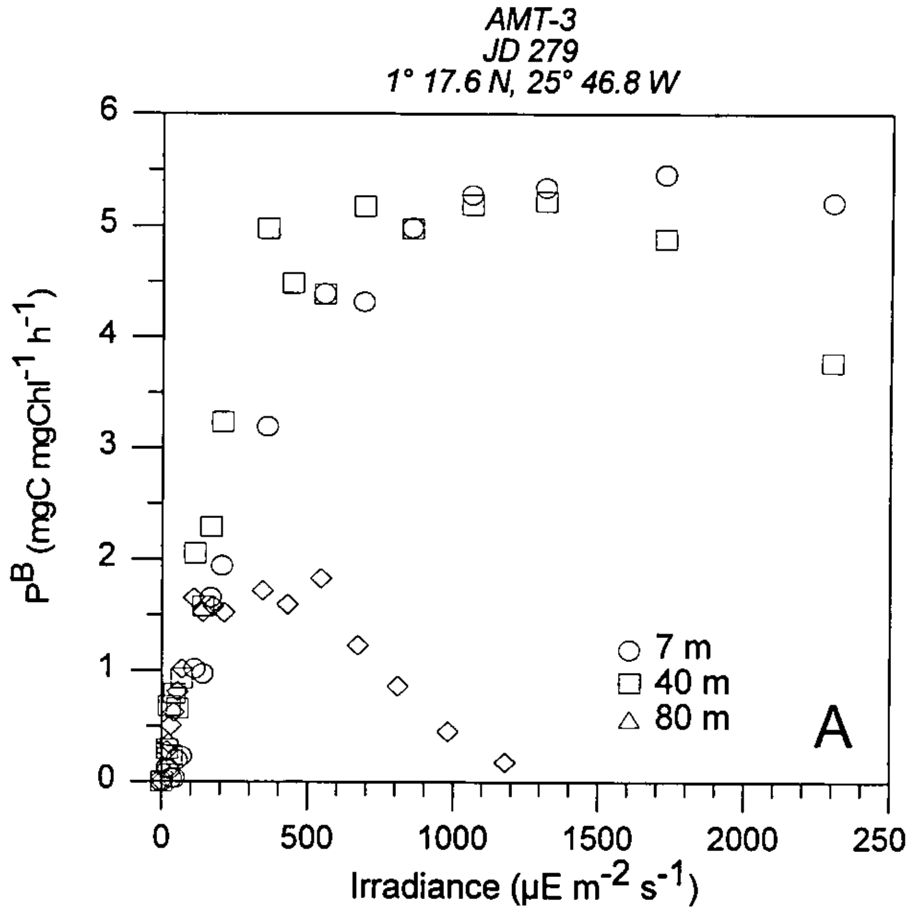


Figure 13. Latitudinal distribution of net-plankton production (mgC m^{-3} h^{-1}) from 47 °N to 48 °S. Shaded areas indicate production >0.1 mgC m^{-3} h^{-1}.



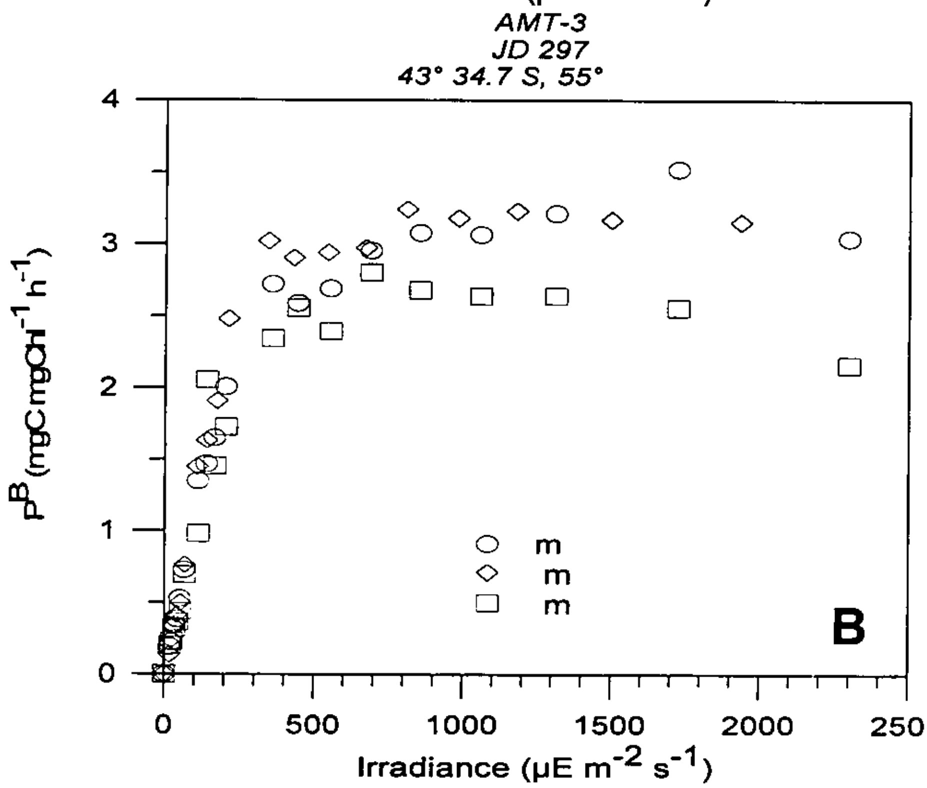


Figure 14. - Photosynthesis *vs* irradiance curves from 3 different depths at A) an equatorial and B) a temperate station during AMT-3. Note differences in the scale of the Y-axis between A and B.

4.2.4 Phytoplankton pigment distributions

Ray Barlow, Plymouth Marine Laboratory

OBJECTIVES

1) To investigate the distribution of chlorophyll and carotenoid biomarker pigments along the AMT in order to determine the basin scale variations in phytoplankton biomass and community structure.

2) To provide an accurate pigment data base for the calibration of fluorescence and optical sensors, and the development of ocean colour remote sensing algorithms for phytoplankton biomass and primary production estimates.

METHODS

Underway surface sampling for pigments was conducted every 2 hours by drawing water from the non-toxic sea water supply and filtering 0.5-2 l for HPLC analysis, and duplicate 0.25 l for on board chlorophyll measurements. For vertical profiles,a 2.1 l sample was drawn from each of the 9 depths down to 200m for HPLC analysis, and 0.25 l from 5 depths for on board chlorophyll analysis. All HPLC samples were filtered through GF/F filters and stored frozen in liquid nitrogen for analysis of water column samples at PML and surface samples in San Diego (Chuck Trees). Duplicate samples were collected from the surface 7m depth and the chlorophyll maximum depth for HPLC analysis in San Diego. Chlorophyll samples were filtered through GF/F filters, immediately extracted for 12-18 hours in 90% acetone, and the chlorophyll fluorescence measured with a Turner Designs 10-AU fluorometer using the method of Welschmeyer (*Limnol. Oceanogr.*, **39**, 1985-1992, 1994). The fluorometer was calibrated with Sigma chlorophyll *a* standard. Detailed pigment analysis will be conducted using reverse phase HPLC to determine the concentrations of a range of light-harvesting and light-protecting chlorophylls, carotenoids and phaeopigments.

PRELIMINARY RESULTS

Details of the underway surface pigment sampling, temperature, fluorescence, salinity and corrected chlorophyll concentrations are presented in Appendix F and the daily station pigment log and corrected chlorophyll concentrations are summarized in Appendix G

There were considerable variations in surface chlorophyll along the AMT track (Figure 15), ranging from 7 mg m^{-3} at 49-50°N and at 50°S to levels of <0.1 mg m^{-3} in the oligotrophic gyres in both the northern and southern hemispheres. Chlorophyll concentrations increased substantially in the frontal systems associated with the West African upwelling influence (22°N-14°N) and smaller increases were observed at 4°N and at the equator. Further increases in chlorophyll levels were again observed between 30°S and 40°S in the frontal systems between the southern extremety of the warm Brazil Current and the northern limit of the cold Falklands Current. South of 40°S, there was considerable fluctuation in the chlorophyll *a*, indicating the patchiness of the phytoplankton distribution during the spring in these southerly water masses.

The vertical distribution of chlorophyll along the transect is illustrated in Figure 16, and it may be noted that the bulk of the chlorophyll was located in the upper 30m at 50-40°N. The chlorophyll maximum was then observed to occur at progressively deeper depths to reach 140m at 15°S in the southern oligotrophic gyre. The chlorophyll maximum shallowed progressively through the more southerly latitudes and at 40-50°S most of the chlorophyll was again located in the upper 30m (Figure 16).

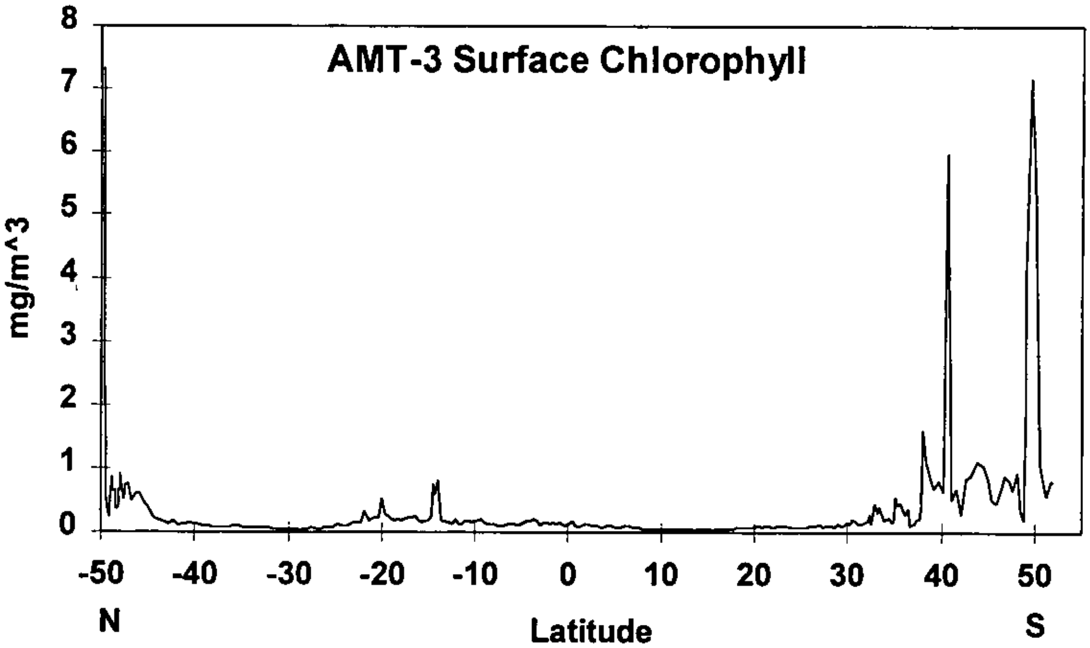


Figure 15. Underway surface chlorophyll *a* concentration along the AMT transect.

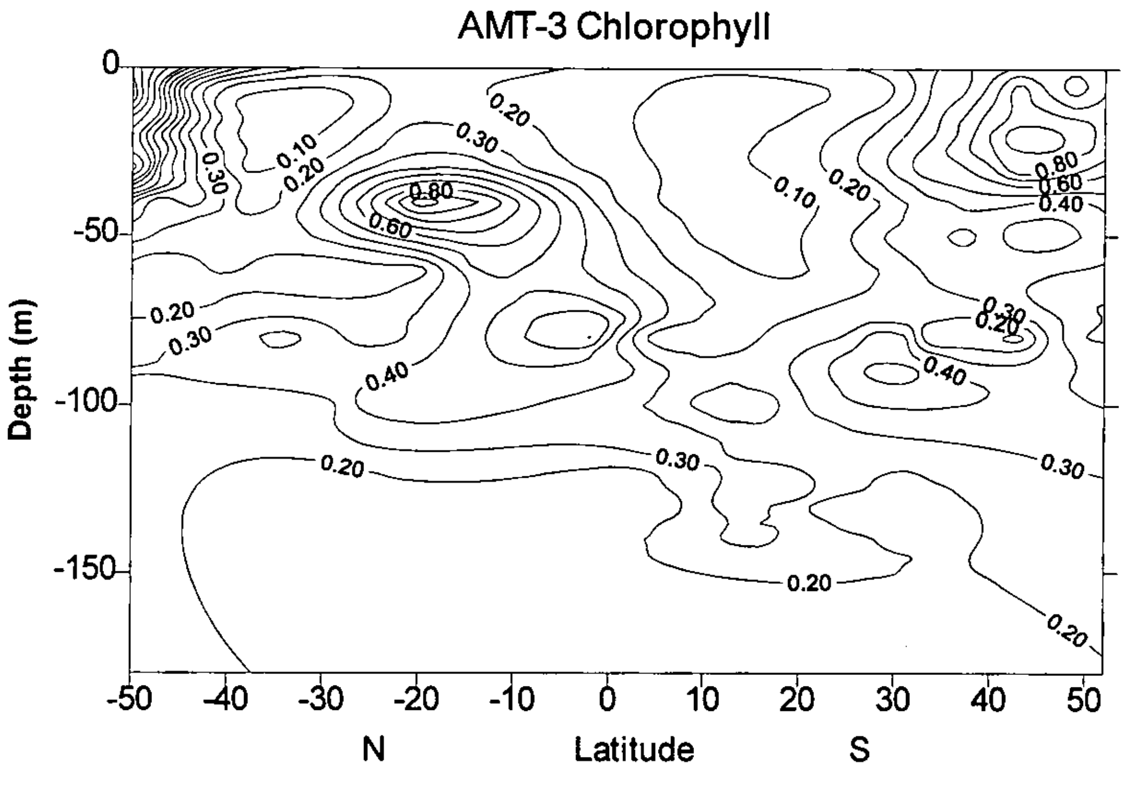


Figure 16. Vertical distribution of chlorophyll *a* (mg m^{-3}) along the AMT transect.

4.3 Zooplankton

4.3.1 Particulates and zooplankton carbon

Ignacio Huskin, Universidad de Oviedo

Particulates

Samples for CNH analyses were obtained from two diferent depths: surface (7m) and chlorophyll maximun, as determined by *in situ* fluorescence. Water from the two depths was filtered through membrane filters of 2, 5 and 10µm and a 200µm gauze. Filtrate from each size fraction was filtered in triplicate onto pre-ashed Whatman GF/F filters to produce a series of replicate samples of the four size fractions (<2,<5,<10,<200µm). Filters were mantained for 48 hours in the oven (60°C) and then compacted in pre-ashed aluminium foil for CNH analysis.

Zooplankton

At each station, a WP2 plankton net (200µm) was deployed to 200m. The sample was split into two halves, one half was used for OPC analysis and the other half for size fractionated carbon. The diferent size fractions were obtained by screening the sample through 2000,1000,5000 and 500µm sieves to create fractions of 200-500,500-1000,1000-2000 and >2000µm. Subsamples of each size fraction were filtered onto pre-ashed Whatman GF/C filters (in triplicate). Filters were mantained for 48 hours at 60°C and then compacted in aluminium foil. The remainder of the sample was preserved with borax buffered formaldehyde (4%) for later taxonomic identification.

Ingestion rates

Ingestion rates were obtained using the gut fluorescence method. At each station, one WP2 plankton net (200µm) was deployed to 200 m. The sample was immediately screened to obtain three different size fractions (200-500, 500-1000, 1000µm). Subsamples of each fraction were filtered onto paper filters and frozen for further determination of initial gut contents in each fraction. The remainder of one of the three fractions (one diferent fraction each day) were used for gut evacuation experiments. Copepods were introduced in a cold box filled with filtered sea water from the station (7m) and subsamples were taken every 5 minutes during the first half an hour. Two extra subsamples were taken at 45 and 60 minutes. Subsamples were filtered onto paper filters and frozen for further gut content analysis.

A fixed number of copepods were taken from the frozen filters to extract gut contents. The copepod number used was:15 for the large fraction, 25 for the medium fraction and 50 for the small fraction. Three replicates were taken at each time. Chlorophyll was extracted from the copepods guts using 5ml acetone (90%) in 20ml vials during 24 hours at -20°C. Copepod gut fluorescence was determined using a Turner Fluorometer. Plots of each gut evacuation experiments were obtained (copepod gut contents against time). Data were fitted to an exponential curve and the inverse of the slope was assumed to be the gut passage time. Finally, ingestion rates were obtained dividing the initial gut content by the gut passage time.

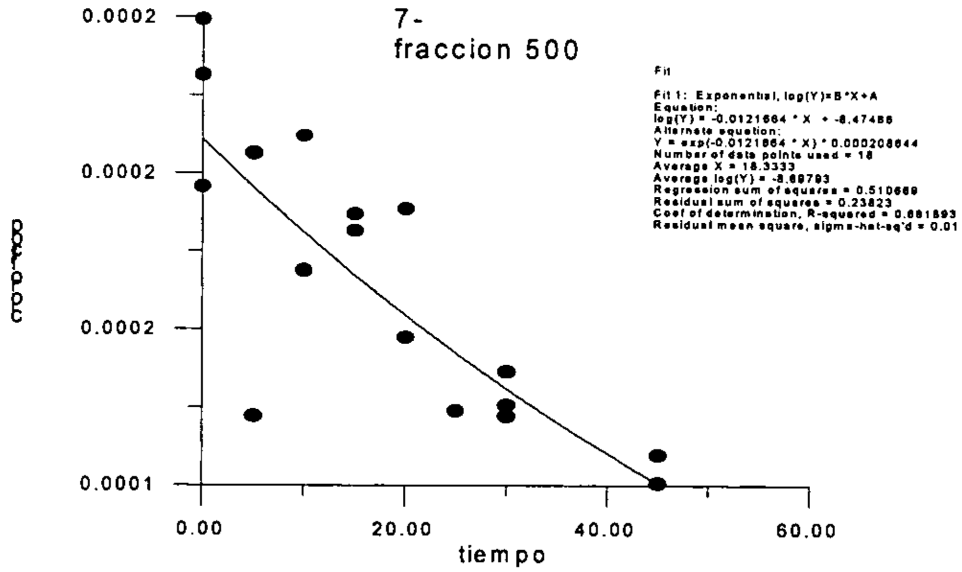


Figure 17. Example of gut evacuation experiment: date 7-10, fraction 500-1000µm

4.3.2 Optical Plankton Counter and Video Zooplankton Analyser

Chris Gallienne, Plymouth Marine Laboratory

Equipment:

The optical plankton counter (OPC) can produce reliable, real time abundance and size distributions of mesozooplankton (250µm - 16mm equivalent spherical diameter - ESD). The device uses a collimated beam of light received by a sensor. When this beam is occluded by a particle, the sensor response is a pulse whose size is proportional to the cross-sectional diameter of the particle. This pulse is digitised, and the digital size mathematically converted to equivalent spherical diameter using a semi-empirical formula.

The OPC was deployed as for AMTs 1 & 2, both for continuous underway sampling from the ship's uncontaminated supply, and for processing samples from the 200m integrated vertical net samples from daily stations. The seawater intakes were fitted with steel, 6mm mesh filters, as on AMTs 1 & 2.

The video zooplankton analyser (ViZA) is a video based system for acquiring images of the water volume passing through the OPC, and using computer automated pattern recognition techniques to attempt to classify organisms to major taxonomic groupings. The OPC is able to give reliable abundance and size distribution data, but is unable to tell us anything about shape, and therefore the species community structure. The ViZA device is being developed under PRIME project P19 in order to add this dimension to the survey.

Methods

At each daily station, three WP-2 (200µm mesh) net casts were made. The first, using a double net to 200m, the second using a single net to 200m and the third using a single net to 20m. The sample from the double net was used for gut evacuation experiments. The single

200m net was split and processed as for AMT 1 & 2, using a Folsom splitter. Half of the sample was passed through the OPC, and collected and preserved for subsequent microscopic taxonomy analysis.

The OPC was used in continuous flow-through mode during the whole cruise, using the uncontaminated seawater supply. This was interrupted only briefly at local dusk and dawn to change data files, and for about two hours each day on station to process the net samples. For about an hour on each of seven days a 200μm mesh filter was connected to the flow outlet to collect the sample passed through the OPC. This was preserved for subsequent analysis to validate the OPC data.

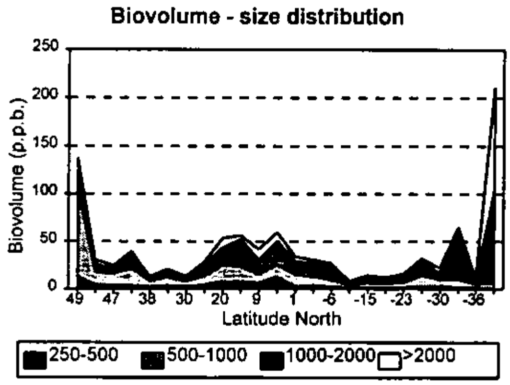
The ViZA system was also used continuously in underway mode, and also for the processing of each of the vertical net samples, the sample water passing through the OPC and ViZA flow cells in series. A burst water connection flooded the video camera, causing some damage on day 275. The initial damage was successfully repaired by day 278, when ViZA sampling continued, but image quality gradually deteriorated until day 282 when the camera failed completely. Fourteen days of ViZA data are available for analysis, however.

Results

OPC

Figure 18 shows the biovolume in parts per billion in each of the four JGOFS size classes for each daily 200m net cast throughout the cruise. Figure 19 shows total biovolume plotted in parts per billion, with the same data for AMT1 plotted for comparison.

Biovolume was generally distributed similarly to AMT1, with the exception of a peak of about 40 ppb at 43°N, which did not appear on AMT1. The double peak around the West African upwelling system was of similar magnitude to AMT1, but centred further south at 9° N rather than 19°N on AMT1. As with AMT1 the plot shows a ridge of enhanced biovolume stretching from the African system across the equator to about 7°S, at about 30 ppb in both cases. Biovolume minima in the Brazil basin were about 10 ppb in both cases. A peak at about 33-36°S of about 70 ppb also appears in both data sets. Size distributions are generally similar in both data sets, although the 1000-2000μm. size class in the African system was less dominant than on AMT1.



Figures 18. Bio-volume size along transect

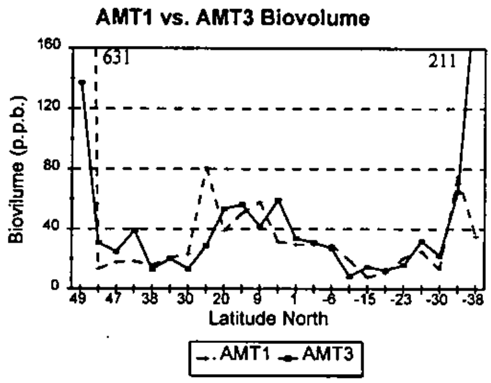
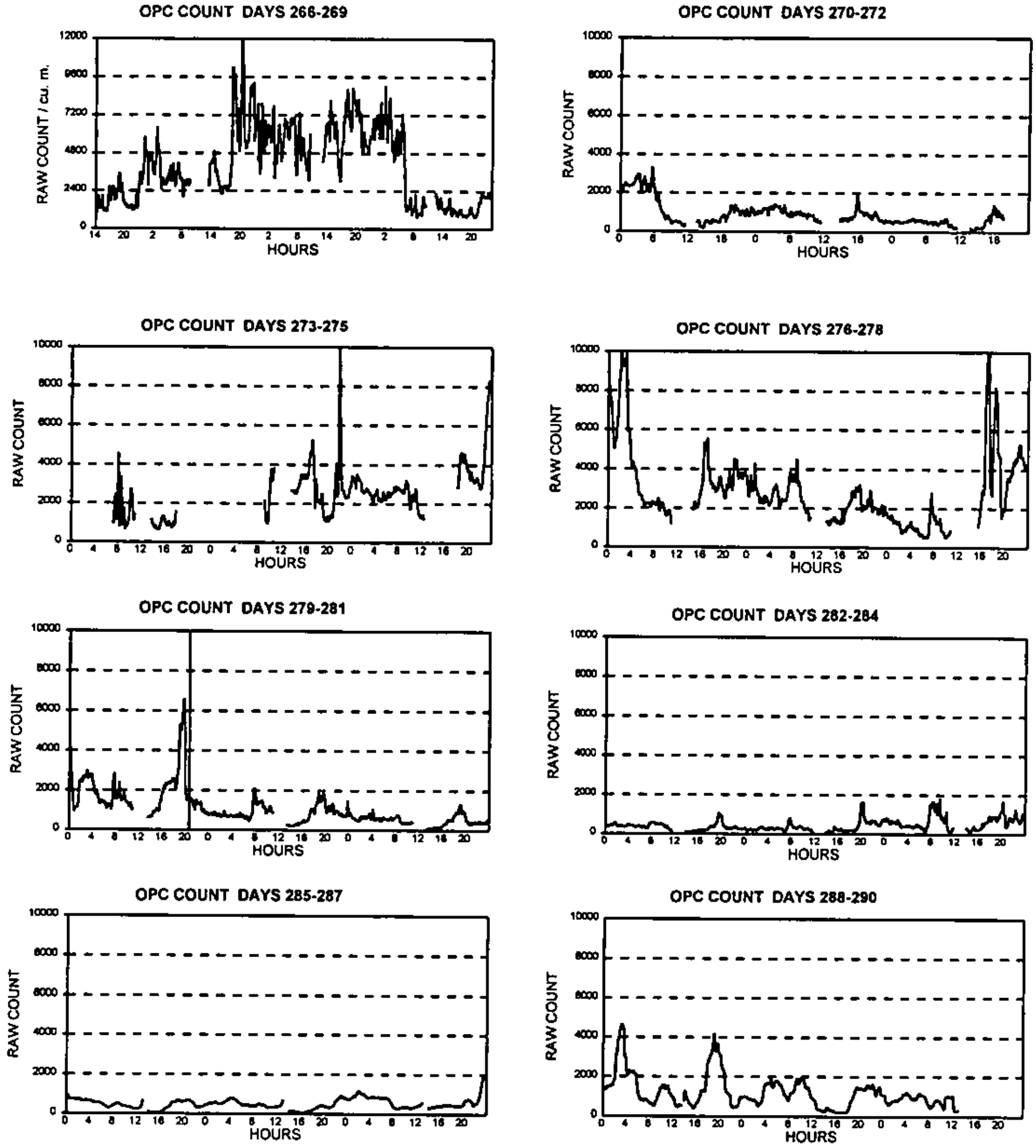


Figure 19. Total volume for AMTs 1 and 3



Figures 20a to h show zooplankton abundance in raw particle counts per cubic metre in underway mode for the whole cruise.

High zooplankton counts during days 266-269 (20a) show the influence of the coastal environment, declining to much lower counts in the 'blue' waters of the Canary Basin on days 270-272 (20b). Counts are higher again across the West African upwelling area and the equator, marked by the vertical line on day 279 (20e). Counts are very low on days 280 to 287 (20f) across the Brazil Basin, and increase again in the more coastal environment approaching the River Plate estuary on days 288 - 290 (20h).

As on previous AMT cruises, there is evidence of increases in counts at dusk and dawn, particularly between 5°N and 20°S (days 278 - 284), which may offer some support to the theory of 'midnight sinking'.

Midnight sinking is a phenomenon associated with diel vertical migration is the appearance of peak abundances at the surface at dusk and dawn, with lower surface counts between these peaks. It has been suggested (Raymont, 1963) that this may be due to species seeking 'optimum' light levels. As light levels fall below this optimum, these species rise to the surface. Further reduction in light level to a point at which vertical position makes no difference results in the cessation of active swimming in response to light levels, and the natural tendency of zooplankton to sink passively takes over. As dawn approaches, and light levels again increase above this threshold, these species again rise in an attempt to reach this optimum light level. Shortly after dawn the surface light level exceeds this optimum, and the zooplankton again actively descend to deeper waters.

ViZA

The data from the ViZA system for the fourteen days before the failure of the video camera are available and are currently being processed. The ViZA system is still under development, and these data will be used to assess the current performance of the system. It is intended that this assessment and analysis should be completed during the two months subsequent to the end of the cruise, and these data will then be available

4.4 Physical Oceanography

4.4.1 Salinity and temperature calibrations

Colin Griffiths and Tony Bale, Plymouth Marine laboratory

The precision of the Neil Brown CTD unit was checked by reference to salinity bottle values collected on each CTD cast (typically at three depths) and with certified, ISO reversing digital thermometers. Likewise the SeaBird, flow-through thermosalinograph interfaced to the Ocean Logger was checked with salinity bottles taken from the salinometer outlet and by measuring the temperature of the effluent water, also with an ISO precision digital thermometer.

The salinity bottles were analysed for conductivity using a Guildline, AUTOSAL, precision salionometer standardised against IAPSO (Ocean Scientific Ltd.) standard seawater according to the operating instructions. Salinity was calulated from the conductivity ratio at the temperature of the measurements using the algorithm developed by A. Bennett (B.I. O.) which is consistent with the UNESCO salinity tables.

CTD thermosalinograph

A total of 98 thermometer readings and 54 salinity bottle analyses were used to check values produced by the Neil Brown CTD unit. The errors are plotted against time for the duration of the cruise in Figure 21a-b. Although calibration work for oceanographic purposes would not normally be carried out on surface samples where large variations in temperature over small vertical distances can give rise to imprecise readings, the average temperature error was only -11.9 mdeg C (standard deviation 29.4 mdeg C) and showed no significant trend with either time over 33 days or with the temperature of the measurement. Likewise, the salinity measurements undertaken on-board indicated that the salinity values generated by the CTD instrument were reading very slightly high with an average error of +0.0033 ppt (standard deviation = 0.0082 ppt) and that there was also no trend with either time or salinity.

SeaBird (Ocean Logger) thermosalinograph

Eighteen values of temperature by thermometer and salinity by Autosal were compared with the SeaBird values of temperature and salinity (derived from conductivity and temperature), respectively. The errors are plotted against time for the leg UK to Montevideo in Figure 21c-d. The average temperature error was -0.4 mdeg C (standard deviation 29.7mdeg C) and the average salinity error was -0.008 ppt (standard deviation 0.011 ppt) with no significant drift over time or trends with temperature or salinity.

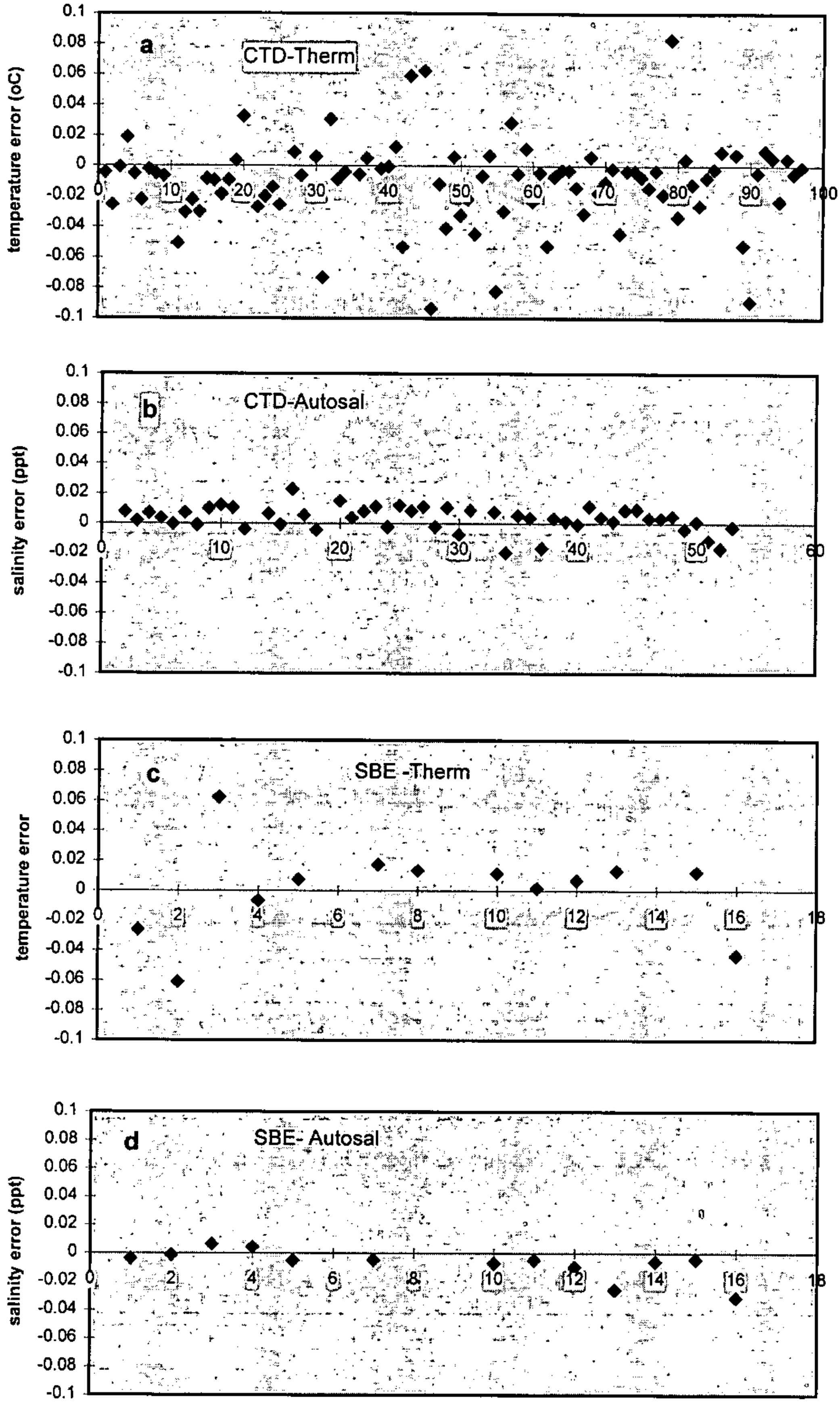


Figure 21a-d. salinity and temp errors with time (AMT3 all data)

4.4.2 CTD operations

Colin Griffiths, Plymouth Marine Laboratory

Measurements of conductivity and temperature with depth were made by profiling a Neil Brown Mk IIIB CTD (Instrument Systems, Inc.) when the ship was stationary. Also fitted to the CTD was a PML (Aiken, 1981) fluorometer. The CTD package contained a rosette sampling system fitted with 12 x 10l General Oceanics water bottles.There was one station each day mid morning. At each station the CTD profiled to 200m on the first cast for 'Productivity etc..' and typically to 200m on the second cast for 'Pigments', (see Appendix C). Data was logged on a PC and onto the Level ABC system which reduced the 8Hz sampling to 1 Hz averages. Processing and presentation was peformed on the level C system using RVS software. Use was made of the downcast fluorescence profile to determine the bottle firing strategy on the upcast for each profile.

Calibrations were obtained from bottles 1, 5 and 11, (typically 200m, mid depth and 7m) on the first cast using digital reversing thermometers manufactured by Sensoren-Instrumente Systeme and by taking salinity samples which were analysed onboard with a Guildline, Autolab salinometer.

4.4.3 Expendable Bathythermographs (XBT) profiles

Colin Griffiths, Plymouth Marine Laboratory

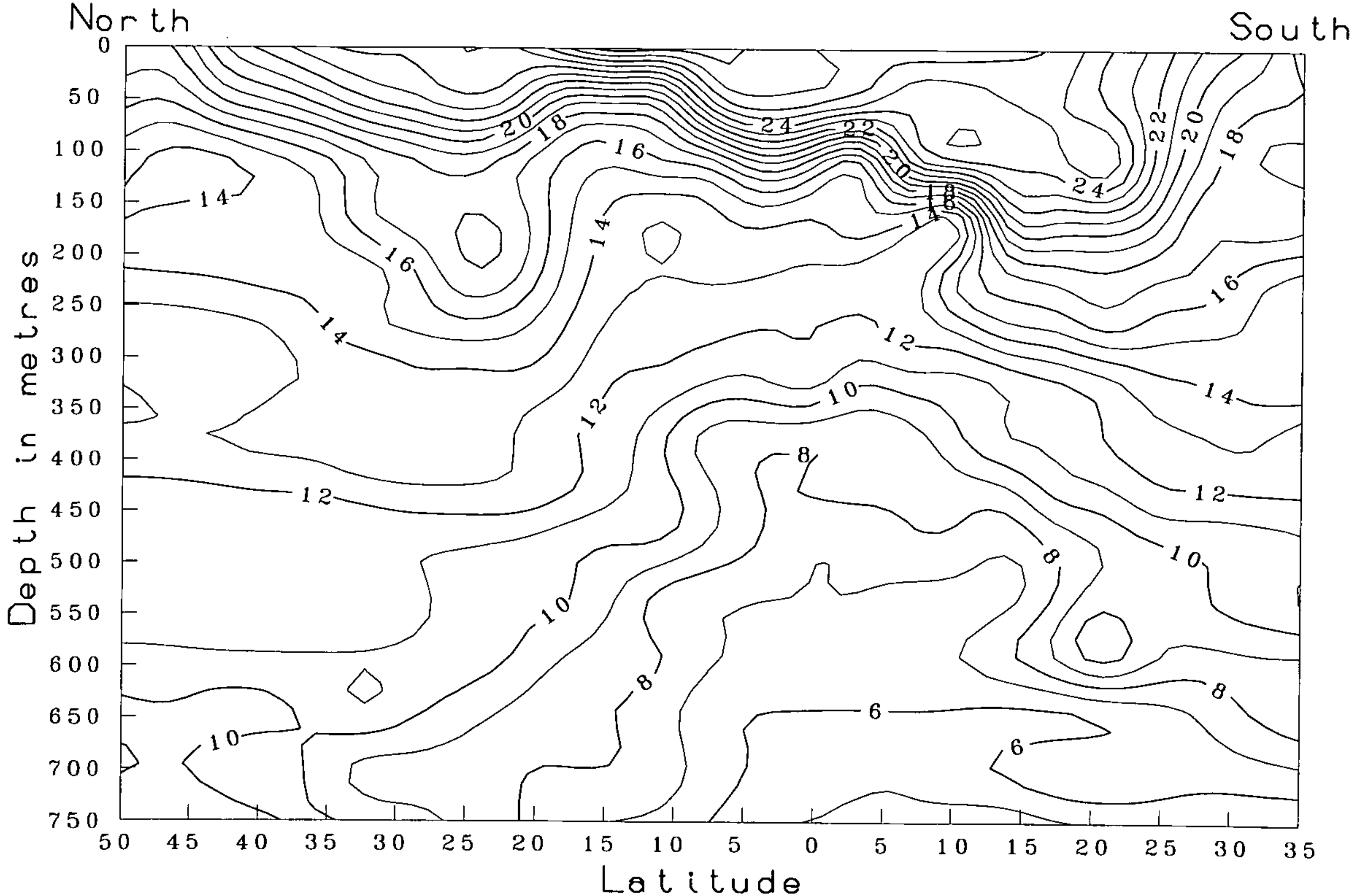
During the cruise a total of 36 Sippican T5 XBT's and 108 Sparton T7 XBT's were deployed. Temperature profiles were obtained down to a depth of 1830m for the T5's and 760m for the T7's. XBT's were deployed at regular intervals during the cruise, typically 0000 ,0600, 1200 and 1800 local time. T5's were deployed at noon as we were leaving station, T7's were deployed the rest of the time. Problems were encountered with the launching system on 10th October. The problem was traced to a damaged cable within the hand launcher. At certain times the sampling rate was increased; this was aided by the AVHRR composite images trnasmitted to the ship. A contour plot of the temperature structure (surface to 750m) on the UK to Montevideo leg is given in Figure 22.

4.4.4 Acoustic Doppler Current Profiler (ADCP)

Colin Griffiths, Plymouth Marine Laboratory

Acoustic doppler current pofiling (ADCP) uses the doppler shift of the signals reflected from four, pulsed acoustic beams radiating out and downwards at angles of 45^{o} to each other to derive sub-surface currents. The method relies on particulate material in the water to reflect the acoustic signals and the acoustic frequency employed on AMT3 (250 kHz) is optimal for scattering from particles of the dimensions of zooplankton. Contained within the backscattered signal data, therefore, is information on the number density (signal strength) of zooplankton in the surface waters. The ADCP data obtained during AMT3 was logged and archived for subsequent processing. Distinct migration patterns on diel timescales were observed as the zooplankton migrated to great depths during the day and returned to surface waters (within the depth range of the ACDP) by night. The combintion of ship speed and very low particle numbers during the day time meant that signal returns were unuseable for large parts of the transect within the oligotrophic gyres.

Fig 22. AMT3 XBT section UK-Montevideo



4.5 Optical Oceanography

4.5.1 Ocean Colour Optics

Stanford Hooker, NASA Goddard Space Flight Centre

Introduction

As with many of the other types of measurements collected during AMT-3, optical data was collected underway and on station. The UOR, which was fitted with Satlantic\footnote[1] radiometers, and a Wetlabs nine-channel absorption and attenuation meter (AC-9) provided the former; whereas, the latter were provided by three different multispectral profilers: the SeaWiFS Optical Profiling System (SeaOPS) and the SeaWiFS Free-Falling Advanced Light Level Sensors (SeaFALLS), which are both based on Satlantic radiance and irradiance sensors, as well as the Profiling Reflectance Radiometer-600 (PRR-600) made by Biospherical Instruments, Inc. (BSI). Underway and station surface irradiance was provided by SeaOPS and a photosynthetically available radiation (PAR) sensor; the latter was JCR equipment. Monitoring of the calibration of the UOR, SeaOPS, and SeaFALLS radiometers was provided by the SeaWiFS Quality Monitor (SQM).

A summary of the bio-optical sampling used to interpret the biogeochemical fields was as follows:

a) Discrete vertical profiles of the *in situ* light field using the SeaOPS, SeaFALLS, and PRR-600 multispectral instruments;
b) Synoptic measurements of near-surface optical properties using the UOR light sensors and beam transmissometer; and
c) Underway measurements of the underlying inherent optical properties of absorption and attenuation using the AC-9 instrument.

The UOR, SeaOPS, SeaFALLS, and PRR-600 light sensors all measured optical properties at SeaWiFS wavelengths. The AC-9 was coupled to the uncontaminated seawater supply and its data can be used to interpret and model the optical measurements made by the light sensors. Additionally, the AC-9 provided the interpretation of the other underway measures when *in situ* optical observations were unavailable. For the light measurements, the diffuse attenuation coefficient Kd of the water was used as a quick-look product to determine the efficacy of the sensors.

Profiling Rig

A custom-built profiling rig was used to carry SeaOPS, the PRR-600, a CTD package with fluorometer and tilt and roll sensors (CTDFTR), a transmissometer, and an underwater PAR sensor. This rig was the same one used during AMT-1 and AMT-2. The positioning of the equipment on the rig was developed with a geometry that ensured all radiance sensors did not view any part of the support. The narrow geometry of the rig was designed to provide the minimum optical cross section. The field of view of the irradiance sensors was only influenced by the 7mm wire and careful attention was paid to the balance of the rig, even though SeaOPS and the CTDFTR have tilt and roll sensors. The rig was trimmed with lead weights in air, accounting for the in-water weights of the sensors; after final assembly of the rig, visual checks for correct trim were carried out *in situ*.

[1] Identification of commercial equipment does not imply recommendation or endorsement, nor does it imply the equipment identified is necessarily the best available.

The profiling rig was deployed from a stern crane with a reach of about 8--9 m over the side of the ship. The typical lowering and raising speed of the winch used was approximately 1 m in 5 s or 20 cm per s. Since the crane was on the starboard side of the ship, the sun was kept on the starboard side during all stations except during adverse weather conditions. In addition, sea- and sky-state digital photographs were taken at the bottom of the down cast whenever the optical instruments were deployed.

Data was logged on a Macintosh Quadra 700 using software developed at the University of Miami Rosenstiel School for Marine and Atmospheric Science (RSMAS) and GSFC. The software, called Combined Operations (C-OPS), is written in LabVIEW and is used to control both the in-air and in-water SeaOPS data streams. The primary task of C-OPS is to integrate the RS-232 outputs from the DECK-100 and to control the logging and display of these data streams as a function of the data collection activity being undertaken: dark data (caps on the radiometers), upcast, downcast, bottom soak, surface soak, along track, etc. All of the telemetry channels are displayed in real time and the operator can select from a variety of plotting options to visualize the data being collected.

C-OPS file naming is handled automatically, so all an operator has to do is to select what data streams are to be recorded and then set the execution mode of the data collection activity. Each tab-delimited file has a single header, identifying what is recorded in each column, and all data records are time stamped. The files are written in ASCII and are easily viewed with a simple text editor or ingested into a commercial off-the-shelf (COTS) spreadsheet software package.

SeaOPS

SeaOPS is composed of an above-water and in-water set of sensors comprising five subsystems. The in-water sensors are a downward-looking radiance sensor which measures upwelling radiance, Lu, and an upward-looking irradiance sensor which measures downwelling irradiance, Ed. The former is a Satlantic ocean color radiance (OCR-200) sensor (S/N 021), and the latter a Satlantic ocean color irradiance (OCI-200) sensor (S/N 029). The two units send their analog signals to an underwater data unit, a Satlantic DATA-100 (S/N 004), that converts the analog signals to RS-485 serial communications. The above water unit, a Satlantic Multichannel Visible Detector System (MVDS), measures the incident solar irradiance, Es. The MVDS unit (S/N 009), is composed of an OCI-200 irradiance sensor (S/N 030) packaged with an analog-to-digital (A/D) module that converts the analog output of the OCI-200 unit to RS-485 serial communications.

All of the SeaOPS radiometers take measurements in the same six spectral bands (approximately 412, 443, 490, 509, 555, 665, and 683 nm) which have been selected to support SeaWiFS calibration and validation activities (McClain et al. 1992). During AMT-1, the underwater SeaOPS sensors were deployed on a T-shaped frame with the OCI-200 and OCR-200 sensors on one side of the frameand a PRR-600 on the other side (Robins et al. 1996); this strategy was repeated for AMT-3.

The RS-485 signals from the MVDS and the DATA-100 are combined in a Satlantic deck box, the DECK-100 (S/N 008), and converted to RS-232 communications for computer logging. The DECK-100 also provides the (computer controlled) direct current (DC) power for all the sensors and is designed to avoid instrument damage due to improper power-up sequences over varying cable lengths. For AMT-3, the MVDS cable length was approximately 200 m whereas the DATA-100 cable length was about 260 m (250 m on the winch and 10 m from the winch to the DECK-100). The unit also acts as a useful diagnostic should telemetry problems be encountered. Details of the station operations are contained in Appendix I

SQM

The validation of ocean color satellite sensors requires a quantification of the uncertainties associated with *in situ* radiometric measurements. Presently, there is no convenient way to check or monitor the calibration of a field radiometer while it is being deployed. Consequently, individual investigators have relied either on the manufacturer's calibration data or on pre- and post-cruise calibrations of their instruments. The severe environmental changes encountered by a radiometer during shipment or a long cruise, however, calls in to question whether either one of these practices is satisfactory which in turn raises the concern of the data quality achieved during field deployments.

In response to a demand for an onboard calibration capability the NASA Goddard Space Flight Center (GSFC) and the National Institute of Standards and Technology (NIST) jointly designed and constructed a prototype of a portable light source to illuminate various radiometers during oceanographic cruises. This device, called the SQM, produces a diffuse and uniform light field and is designed to be flush-mounted to radiance or irradiance sensors with a spectral range from 380--900 nm. The uniformity of this source is less that 2% over an area of 6 inches in diameter. To account for changes in the illuminance of the SQM, three temperature-controlled photodiodes measure the exit aperture light level: one has a responsivity in the blue part of the spectrum, another in the red part of the spectrum, and the third has a broad-band response.

The SQM has two banks of halogen lamps with eight lamps in each bank. The first bank is populated with Gilway model 187 (4.2 V and 1.05 A) lamps and the second with Welch Allyn model 01160 (5.0 V and 3.45 A) lamps. The power supply for the lamps is via two highly regulated Hewlett Packard (HP) model 6030A power supplies. Both power supplies are controlled with voltage sources provided by a computer-controlled 16 bit digital-to-analog (D/A) board. The output current values from the power supplies are monitored by measuring the voltages across two precision 0.5 ohm shunt resistors with a HP 3457 digital voltmeter (DVM). The DVM voltages are acquired over an HP interface bus (HPIB), and the program controlling the D/A boards and acquiring the signals converts the resistance values to current and adjusts the output of the power supplies to ensure a constant current supply to the lamps.

Data logging for the SQM involves two computer systems: one for the device under test (DUT) and one for the SQM. Three of the DUTs were fiducials, that is, dummy radiometers with different reflective surfaces: a white one, a black one, and a black one with a glass face (made of the same glass used in the Satlantic radiometers). The purpose of the fiducials is to be able to collect data with them before and after actual radiometers as another way of tracking the short- and long-term characteristics of the SQM light chamber as determined by the internal photodiodes.

Whenever the DUT was a field radiometer, a computer system was needed to acquire and log the data from the radiometer. For AMT-3, the UOR and SeaOPS radiometers were logged using the C-OPS software running on a Macintosh 180c PowerBook computer, and the SeaFALLS radiometers were logged using ProVIEW and the Compaq computer normally used for that purpose.

The SQM software is written in Visual Basic and is hosted on a Toshiba PC laptop. The SQM computer controls the HP 6030A power supplies and acquires seven other signals from the HP 3457 DVM: three photodiode voltages from inside the SQM, two thermistor (temperature) voltages from the two shunts, and two voltages across the two shunts. The latter are converted into currents, since the resistance of the shunts is known. All of this information is time stamped and logged into a tab-delimited ASCII file. The file has descriptive headers which record the DUT being used and what the configuration of the SQM was during the experiment.

SeaFALLS
SeaFALLS is composed of two subsytems both manufactured by Satlantic: a SeaWiFS Profiling Multichannel Radiometer (SPMR) and a SeaWiFS Multichannel Surface Reference (SMSR). The latter mesures downwelling irradiance and upwelling radiance as it falls through the water column, while the latter measures downwelling irradiance just below the sea surface. The profiler receives its power and sends its data via an umbilical cable; it is sufficiently buoyant in water that one person can deploy and recover the profiler. The reference floats just below the surface suspended from a square floating frame; it can also be deployed and recovered by one person. Because both the profiler and the reference can be deployed far away from the ship, any ship-induced disturbances to the *in situ* light field are minimized.

The SPMR and SMSR units utilize 13-channel radiometers with the same wavelengths (approximately 406, 412, 443, 470, 490, 509, 532, 555, 590, 665, 670, 683, and 700 nm) and bandwidths (10 nm). The SeaOPS band set is a subset of this: approximately 412, 443, 490, 509, 555, 665, and 683 nm. SeaFALLS is equipped with OCI-1000 and OCR-1000 radiometers which employ 24-bit A/D converters and are capable of detecting light over a seven decade range (SeaOPS uses OCI-200 and OCR-200 radiometers which use 16-bit A/D converters).

Data telemetry for SeaFALLS is very similar to SeaOPS. A deck unit, a PRO-DCU (S/N 008), supplies the power for both the profiler and reference independently. The output voltage is automatically adjusted for the cable length being used. An internal computer shuts the system down under fault conditions while indicating the type of fault. RS-485 telemetry at 19.2 Kbaud is converted in the deck box to RS-232 for input into a microcomputer, in this case a Compaq laptop personal computer (PC).

The logging and display software used with SeaFALLS was provided by Satlantic and is called ProVIEW. There are several display windows associated with this software which can show all the channels in raw counts or calibrated units. Data is logged in a packed binary format, although ASCII data can be produced using an included utility. Details of the station operations are given in Appendix I.

4.5.2 AC-9 Measurements

Tony Bale, Plymouth Marine laboratory

Objective: 1) To investigate particle-size/light scattering relationships in marine waters for the improvement of models which describe the fundamental behaviour of light in sea waters.
2) To obtain data on the inherent optical properties (IOPs) of water along the Atlantic Meridional Transect to support the development of remote sensing algorithms capable of predicting constituents which influence ocean colour.

Methods

The attenuation of light due to absorption and scattering by species within seawater was measured at 9 wavelengths in the visible spectrum (412, 440, 488, 510, 555, 630, 650, 676 & 715nm) using a Wetlabs AC-9, double beam (a and c) transmissometer. These measurements provide a fundamental link between the optical characteristics of the water and the constituents which influence light behaviour.

The instrument was connected to the ships pumped water supply and was operated continuously between Portsmouth and Stanley apart from the leg into and out of the R. Plate where the supply was switched off. The instrument was operated in a light-tight water jacket maintained at ambient seawater temperature and inclined at an angle of 45^{o} to allow efficient flushing of small bubbles.

Data was logged at a frequency 30 seconds and files were closed twice a day; once on each daily station while the vessel was stopped and again at night when the pure water and air calibration values were checked. Thus, two data files were generated each day; these were named: AC followed by the SDY (Serial Day of Year) number plus A or B to denote the first or second file for each day.

The instrument performance was tracked every night using 0.2mm filtered, deionised water from the Elgastat HPC pure water system which was pumped through the sample line in place of the sea water supply; these files are named WAT SDY.dat. Every 4-6 days the instrument and optical windows were also thoroughly cleaned and air calibration values were obtained (AIR SDY.dat). Pure water calibration values were obtained immediately before and after the air calibration (WAT SDY PR.dat & WAT SDY PO.dat).

This combination of water and air performance checks provided a rigorous control of both the instrument stability and the optical cleanliness of the windows which tend to become slowly contaminated with adsorbed, presumably organic, material.

A complete set of data was obtained for the 9 absorption channels but no attenuation data (c) was taken after day 276 when the source lamp failed on that channel.

4.5.3 Particle Size and Numbers

Tony Bale & David Robins, Plymouth Marine laboratory

Objective To determine particle numbers in the 2-60µm size range to relate to the IOPs measured by AC-9.

Methods

A standard Coulter multisizer fitted with a 100µm orifice was used to count the particle numbers in the size range 1.9-60.0mm in the surface waters at every station. The sample was taken from the pumped supply while the ship was on station. Calibration of the instrument was checked using 14.02mm latex calibration spheres and the manometer flow time was calibrated relative to the siphon volume so that particle numbers could be calculated from the sampling time interval (generally 30 seconds). System blanks obtained by passing seawater through a 0.2mm pore-sized filtration cartridge were typically less than 60 particles per ml.

Results

The results obtained are shown in Figure 23 and reveal a latitudinal pattern which is closely related to the distribution of surface chlorophyll determined from acetone extracts.

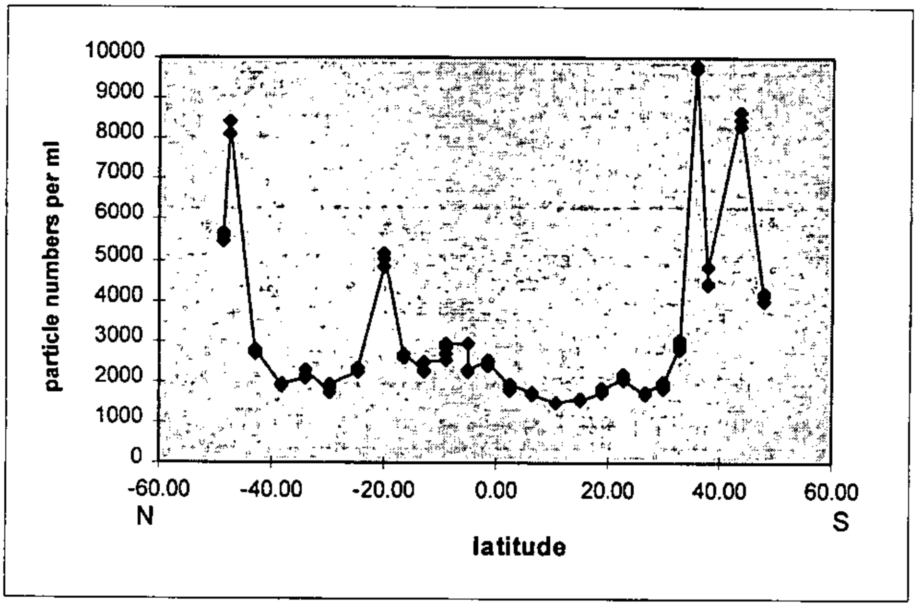


Figure 23 shows particle numbers per ml at each station plotted against latitude.

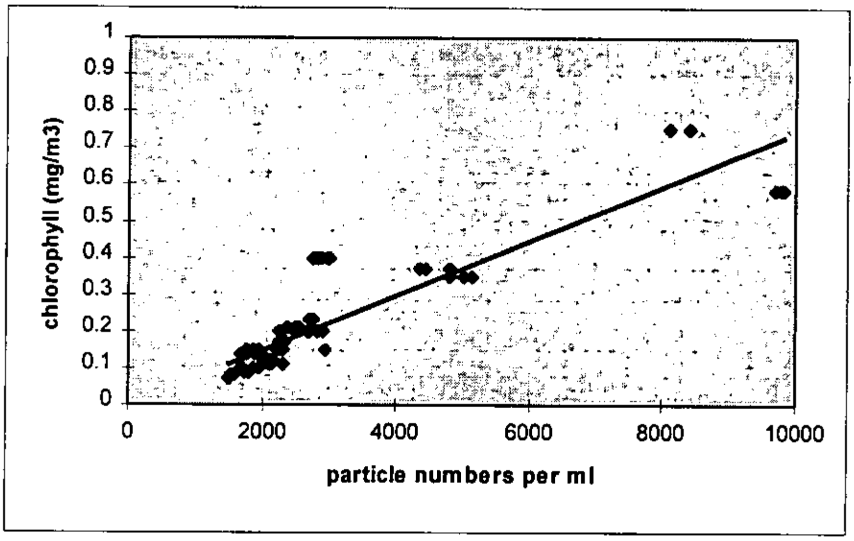


Figure 24 shows the relationship between chlorophyll (R. Barlow) and particle numbers.

4.5.4 UOR report

Jim Aiken, Plymouth Marine Laboratory

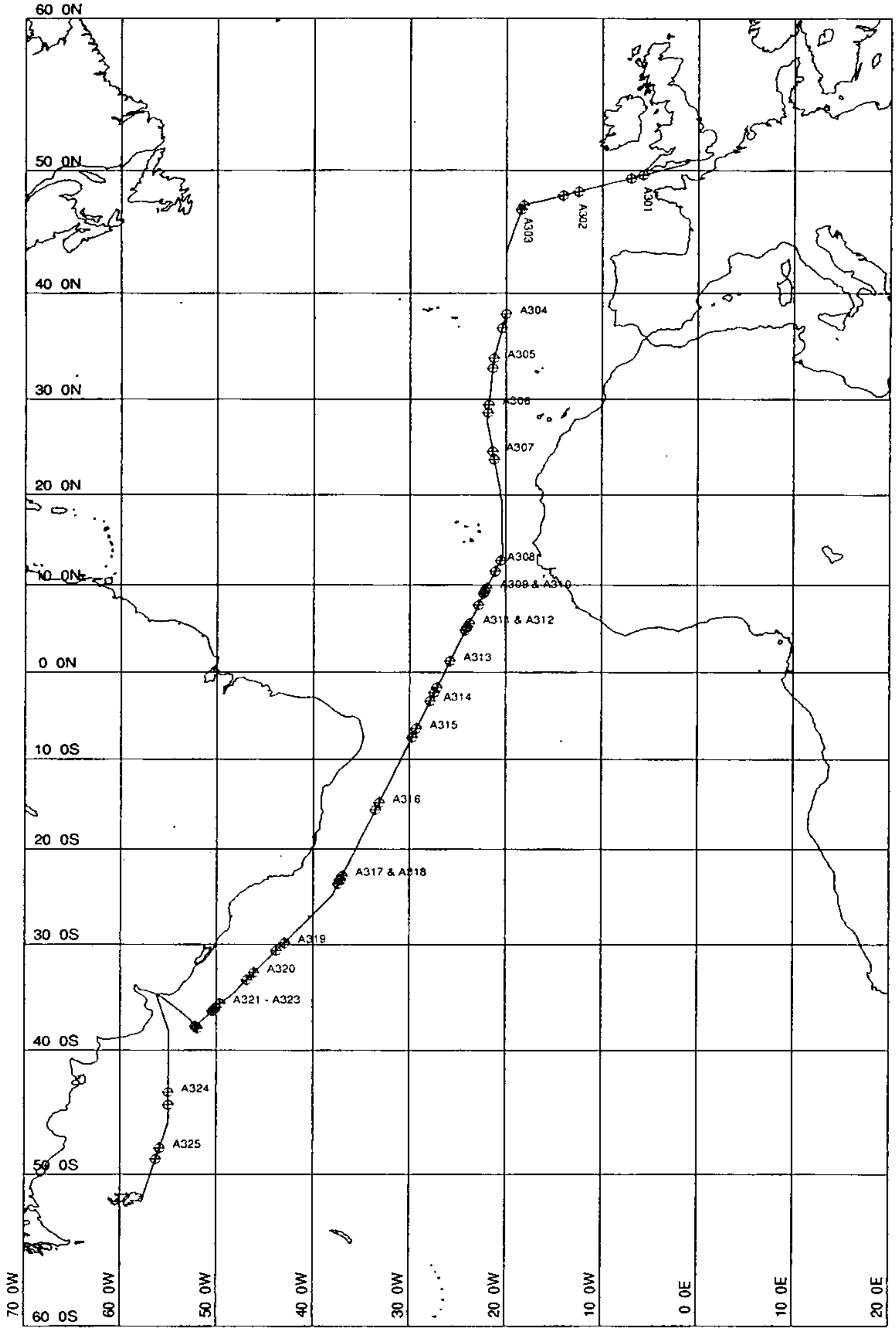
The UOR was towed 25 times, for a total time of 123 h, covering a total distance of 2760 km. Details of the individual tows are given in Appendix H and the positions of the tows are given in Figure 25. Typically, the UOR was towed from the mid-morning station, for 4 to 7 h, through the sunlit period of the day, at a speed of 11-12 knots (20 km/h), with 370 m cable deployed, giving an undulation depth amplitude of 5 to 66 m and an undulation pitch of 3 km. There were 2 long over-night tows; tow A313 (18h 44) across the equatorial upwelling and tow A323 (14h 41) into the station off Montevideo. There were 3 undulation failures due to tailplane jams; the port tailplane bolt was dislodged on 2 occasions and servo S/N 05 was replaced after an unexplained failure on tow A312. The instrumentation package comprised a D, T, C, Fl sensor package (JA5, JA3), Satlantic downwelling irradiance (OCI-200, S/N 001) and upwelling radiance (OCR-200, S/N 001) sensors and PML solid state logger (JA8, JA10); a CI Alphatracka Mk II, 660 nm, 0.25 m transmissometer (S/N 006) was included for tows A308-A312 and A321-end. All sensors worked reliably with minor exceptions: JA5 seawater switch was intermittent causing the chlorophyll sensor signal to float high and was replaced after tow A312; logger JA10 had a damaged plug and was replaced; there was some data loss due to premature battery failure (variable 15 - 18 h) of both AA (sensor electronics) and C cells (chlorophyll flash) due to old batteries from 1995.

Observations were typical for sites and season and comparable to measurements acquired on AMT-1. Temperature stratification persisted throughout the whole of the N. Atlantic from the western approaches to the Equator, with mixed layer depths ranging from 20 to 50 m. There was strong salinity stratification in the equatorial zones (fresher on the surface). In the south equatorial gyre, temperature and salinity stratification disappeared until ca 15° S when weak temperature stratification re-appeared (ca 1 °C). Generally there was greater stratification (1-2 °C) in the Brazilian current than had been observed on AMT-1. On the final section 30° to 37° S, extremely heterogenous mixing of temperature and salinity was observed on the perifery of the confluence of the Brazilian and Falklands current systems.

Chlorophyll concentrations were high in the surface waters in the stratified European shelf seas (1-2 mg m^{-3}) declining in the North Atlantic gyre (0.1 surface, 0.5 sub-surface, thermocline max.); there were regions of high concentrations around the N.W. African upwelling (values up to 1 mg m^{-3}); there were elevated values at the equatorial upwelling, rising to 0.25 mg m^{-3} on the surface; south of the equator surface values were less than 0.1 mg/m3 and only 0.2-0.3 mg m^{-3} at 60-70 m; concentrations of 1-1.5 mg m^{-3} were observed in the heterogeneous waters at 30 to 35° S with surface and sub-surface maximum at diverse frontal and eddy structures. Water transmission measurements were generally consistent with the fluorometer measurements of chlorophyll concentration though free from the surface quenching artefact and hence more representative of the biomass distribution, surface and sub-surface.

It was not possible to assess the quality and accuracy of the Satlantic light sensor measurements whilst at sea, but on a cursory glance the data looked qualatively good; notably the upwelling radiance measurements seemed free from any general artefacts arising from towing; the profiles were generally "clean" and "noise-free" even at the top of the undulation where sun-glitter and UOR pitch and roll were potential sources of noise. The downwelling irradiance measurements showed contrasting characteristics between over-cast, diffuse conditions, when the profiles were clean and noise-free, and under direct sunlight conditions where sun-speckle, sea roughness and UOR pitch and roll all contributed to noisy measurements; the simultaneous measurement of pitch and roll by the UOR logger will allow these data to be screened later, to exclude data with excessive angles (> +/- 10 deg) which render the data quality unacceptable at the standards of SeaWiFS protocols.

Figure 26 shows the contoured vertical sections of a) Temperature (°C; 0.1°), b) Chlorophyll fluoresence (mg.m-3; 0.1), c) Salinity (PSU; 0.05) for UOR tow A313 across the equator from 1° 18.2' N, 25° 46.6'W to 1° 45' S, 27° 08.9'W, showing the effect of the equatorial upwelling, bringing cooler (26.3° C) water to the surface, leading to enhanced chlorophyll concentrations (> 0.4 mg.m-3); note the increase of salinity from 35.85 to 36.2 across the front.



MERCATOR PROJECTION

SCALE 1 TO 55661934 (NATURAL SCALE AT LAT. -0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE -0

GRID NO 1

— Track plotted from bestnav

Fig 25. Ship's track showing UOR deployment during AMT3

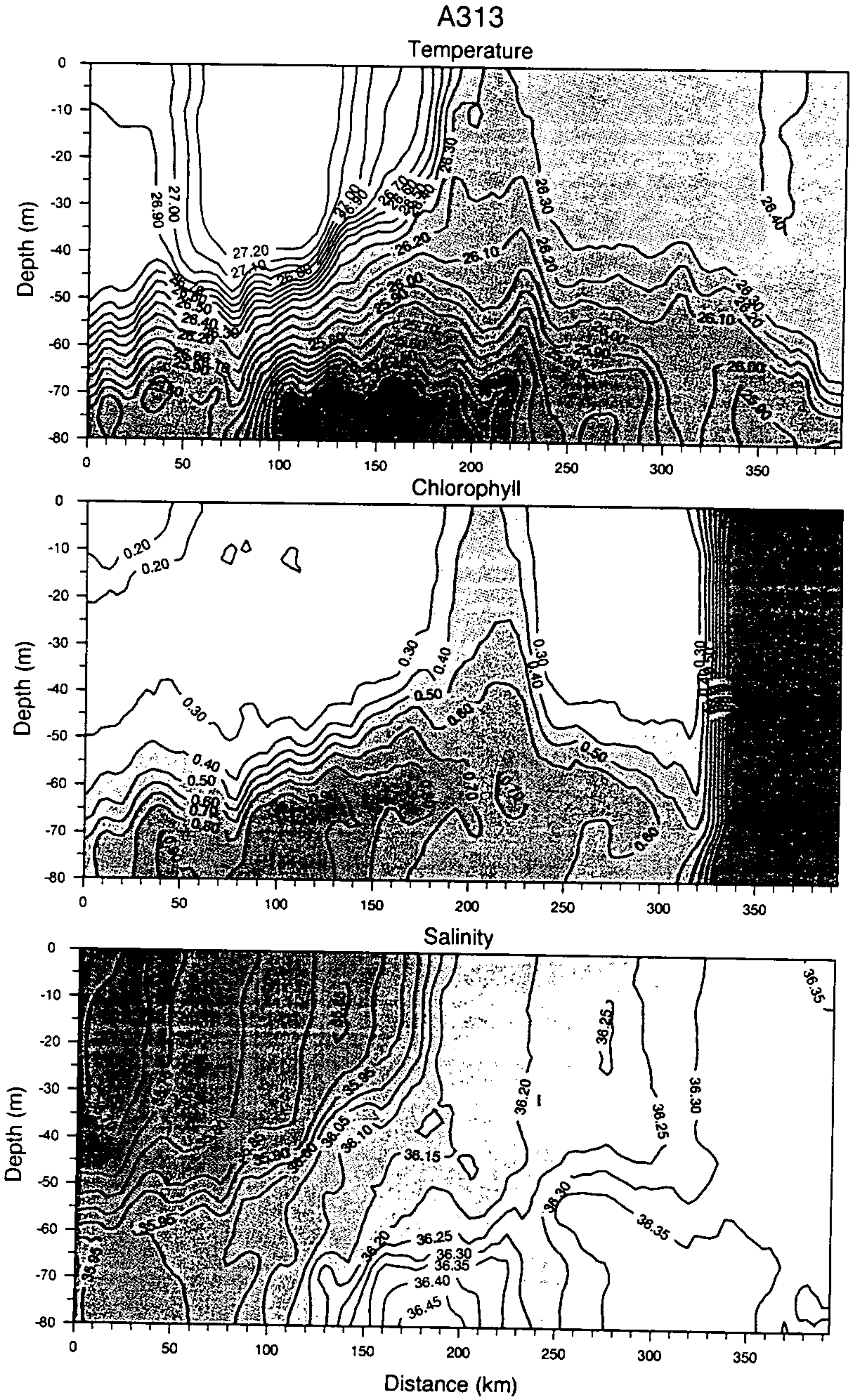


Figure 26 Contoured vertical sections of a) Temperature (°C; 0.1°) b)Chlorophyll fluorescence (mg.m-3; 0.1), c) Salinity (PSU; 0.05) for UOR tow A313 across the equator.

4.6 Sea Surface Temperature

4.6.1 Radiometric Observations of the Sea Surface and Atmosphere (ROSSA) 1996

C J Donlon, University of Colorado/Southampton Oceanography Centre/BAS
T J Nightingale, Rutherford Appleton Laboratory, UK

Experiment Summary

The ROSSA experiment has operated within the framework of AMT-3 and the measurements made complement the biochemical measurements made by the AMT team. ROSSA is concerned with both the accurate validation of precision satellite sea surface temperature observations (such as those made by the ERS-2 Along Track Scanning Radiometer, the NOAA Advanced Very High Resolution Radiometer and the ADEOS Ocean Colour Temperature Scanner), and also the investigation of the small scale processes which in combination, are thought to govern the magnitude and variability of the SSST when referenced to a sub-surface bulk sea surface temperature (BSST). Such processes include the momentum flux (wind stress), the longwave, sensible, solar and latent heat fluxes which in combination define the thermal state of the air sea interface.

Instrument	Parameter	Location	Accuracy
TASCO THI-500L	Skin SST	Forward mast	0.15 +/-0.1K
TASCO THI-500L	Sky temperature	Forward mast	0.21 +/-0.1K
SISTeR	Skin SST	Forward mast	0.1 +/-0.05K
TH ?	Skin SST	Monkey Island	0.1 +/- 0.05 K
Thermal Camera	Skin SST (2D)	Monkey Island	0.1 +/- 0.1K
OPHIR MISTRC radiometer	Skin SST	Bow	Faulty for whole trip
Trailing thermistor	Bulk SST @ 0.1m	Port flank	0.05 +/- 0.005
Eppley Pyranometer	Solar Flux	Bird table (forward mast using gimbals)	0.5%
Eppley Pygeometer	Longwave flux	Bird table (forward mast using gimbals)	0.5%
IOS Psychrometer	Humidity & air temperature	Forward mast	Better than 0.05K
X band radar	Roughness	Forward mast	

Table 1. Summary of instruments installed on the RRS James Clark Ross for ROSSA 1996.

Instrumentation

Table 1 summarises the measurements made during ROSSA 1996. Two, solid state, single channel TASCO-THI-500 radiometers were attached to the forward mast of the JCR where one instrument views the sky and a second the sea surface. These data were logged to a Campbell Scientific CR-10 data logger at the base of the JCR mast. Storage capacity was 12 hours and the system required 2 daily backups. Figure 27 shows the coverage of THI-500 data obtained during ROSSA 1996. A sky and a sea view is necessary to return a true SSST as the emissivity of water is less than unity. Consequently a small portion of the measured sea signal is in fact sky signal (at typically much lower temperatures than those returned from the sea surface) is reflected at the sea surface into the sea view radiometer. By measuring the downwelling sky term using an identical radiometer to the sea measurement, the sea measurements can be corrected for the effect of changing sky temperatures due to the passage of clouds. Figure 28 shows typical traces from the sky and sea viewing instruments. This figure shows in the sky radiometer trace a relatively clear sky (low temperatures) which is perturbed by the passage of 2 cloud banks (higher temperatures). Calibrations for this instrument were performed at the CASOTS workshop/meeting held in Southampton in June 1996 using precision black body units operated inside temperature controlled rooms. These experiments showed that the TASCO instrument remains very linear over the typical temperature range expected during the AMT cruises. There was no appreciable shift in offset or gain as the temperature of the instrument/logger was modified. Calibrations were again performed in Montevideo, and prior to arrival in Stanley.

The Scanning Infrared Sea surface Temperature Radiometer (SISTeR) designed and built by Tim Nightingale (RAL) was deployed during ROSSA 1996 using a specially designed mount plate attached to the JCR front mast. This instrument uses a scanning mirror arrangement to view the sea surface, the sky, a hot calibration source and finally, a cool calibration source. This is the first deployment of the instrument under oceanic conditions. After some initial problems, the SISTeR radiometer began to deliver what appear to be the best radiometric SSST measurements on September 25th. The instrument was monitored carefully throughout the experiment as the current design required protection from rain and sea water spray in poor weather conditions. This was achieved by constructing a door arrangement that could effectively protect the instrument aperture from serious water ingress. On extremely poor days, the entire instrument was wrapped in a plastic bag. These data from the core SSST observations for the ROSSA 1996 experiment and as a calibration source for the TASCO radiometers which will be used (if possible) to 'patch up' the SISTeR data record during spells of potentially poor weather when the SISTeR instrument was non operational. Figure 29 shows the SISTeR data transects collected during ROSSA 1996. The break after the 18th October is due to a mid experiment calibration using a precision black body radiance source. This was required as the scan mirror of the instrument was contaminated and required replacement. Contamination was originally thought to be salt build up on the mirror but careful inspection soon demonstrated that this was not the case. It would appear that the aluminium substrate used to take a rhodium mirror coating had corroded and 'burst' through the mirror. A second mirror was fitted and a calibration performed. This was checked again on October 13th. Calibrations were performed in Montevideo and the mirror inspected which showed less contamination than the predecessor. In future a new mirror design will be implemented on this instrument.

OPHIR MISTRC

This multichannel infrared radiometer was installed successfully on the bow of the JCR using a mount plate engineered at the University of Colorado, USA. Unfortunately, serious problems with the connecting cables that run from the radiometer to the main electronics unit meant that the OPHIR radiometer was unusable for the majority of the experiment. The error reported from the instrument concerned the chopper motor speeds for the optical heads. The instrument carries two independent optical trains one for shortwave and a second for longwave SSST observations. Both chopper drives seemed to be inactive and after several days, the cable in question was finally traced to a +5v return for the optical head chopper motor drives. This was eventually reconnected with great difficulty and the instrument powered up once again. The chopper motors screamed a hellish noise and failed to turn. Consequently, the OPHIR radiometer has been repackaged for shipping back to the USA where a full investigation will be conducted. The advantage of the MISTRC radiometer over the other instruments used during ROSSA 1996 is that it had several short and longwave channels utilising both polarised and unpolarised radiation in an attempt to minimise sky radiance contamination.

Trailing thermistor
Following the recommendations of the CASOTS meeting on sea surface skin temperature (SOC, June 1996), a bulk SST was required at a depth of 0.1 m or less. This was achieved using a specially designed thermistor arrangement which was trailed from the port side of the ship. Initially the thermistor cable alone was used to trail the instrument which was only marginally successful. A heavy weight was attached to the cable which worked well for 2 days at which point the instrument cable parted. A second arrangement was made using a steel cable to carry the weights to which the thermistor cable was attached. This worked well for all of the cruise although several re-termination's at the sensor head were required due to steel wire ends rubbing on the thermistor cable. This instrument was brought inboard during poor weather. The sensor output was taken to the BAS Ocean Logger RhoPoint connection box and logged continuously via the Ocean Logger system.

Eppley Pyanometer and Pyrgeometer radiation sensors
These instruments were mounted on the radiation sensor table of the JCR on the forward mast using specially designed gimbal mounts. Data was logged via a MAC 17 serial data logger to a Toshiba portable laptop PC. This system has functioned reliably for the entire experiment and a typical data trace from the Solarimeter (0.3 -3μm) and the Pygeomeeter (5 - 50μm) is shown in Figure 30. These data will be used to compute the fluxes of long and shortwave radiation at the air-sea interface.

IOS Psychrometer
An IOS WOCE standard psychrometer was installed to the JCR mast hand rail using a stub scaffold pole to ensure that contamination of the PRT sensors by convection from the ships decks was minimised. The instruments output was logged to the BAS Oceanlogger system using standard RhoPoint interfaces. These were configured by Paul Woodroffe prior to sailing from Grimsby.

Radiosonde system
In conjunction with the UK meteorological office and BAS, a radiosonde release was made each day at approximately 10:30 local time. The system comprised of a VHF aerial, receiver unit and Vaiasala PP11 data processor unit. Figure 31 shows the positions of all radiosonde releases made during ROSSA 1996. 5 sondes were unusable due to incorrect pressure sensor readings, no carrier frequency or no data frequency. Figure 32 plots a typical radiosonde ascent showing the temperature and humidity profile of the atmosphere up to the 30 hPa pressure level (~9 - 10km). These data will be used together with the SSST and satellite SST observations to derive atmospheric correction algorithms for use with satellite SSST observations. All data were reported to the UKMO in near real time *via* the ships radio officer. Thanks go to Jenny Rust for organisation and operation of the radiosonde system.

Marine Radar system
This was deployed from the JCR mast island to view the sea surface at an angle of 45 degrees. The radar was an X band (10 cm) unit sampled at 512 Hz to standard PC via a 16 bit A/D data acquisition board. Unfortunately for the majority of the experiment, this system was unavailable due to the lack of a configuration file. This was forwarded 2 days before the Montevideo port call and the system brought on line. Although only a short data set was collected, remembering sea conditions for the majority of the experiment had been very light indeed, the wind steadily increased from 1 -2 Kt to 35 Kt overnight. SISTeR radiometer data and radar data were simultaneously collected during this period (15th - 17th October 1996). Several data sets were also obtained while alongside in Montevideo. This system was deployed to measure sea surface roughness and to specifically correlate temperature

changes with roughness characteristics. This system will undergo full calibration on return to the USA at the University of Michigan.

4.6.2, Sea Surface Radiometry

Yasunori Terayama, Saga University and NASDA

Purpose of the work

By using the satellite image data, we can know the sea surface temperature on wide area. But the image data include the influence of atmosphere, aerosol, antenna pattern of the satellite and problem of sensor resolution etc. When the method which remove these influence is used, we need the truth data at a point of the satellite observation. So, we can compare with the superiority of some methods, and can estimate more truthfully sea surface temperature. The purpose of this work on the AMT3 cruise is to collect these truth SST data.

Methods

I obtain the truth SST data with two equipments, and get the measurement on atomosphere with a sunphotometer. These three equipments is the following.

Thermal Infrared Camera(TH3100)

This Camera(TIC) can obtain the sea surface temperature image on the looking area. The TIC is composed of camera part and control part made by NEC SANEI controled by GP-IB interface. On GP-IB interface, SUN workstaion send the control command, and the interface is used also to get the SST data and condition data with GMT. TIC is put on the top floor of ship, shot the sea surface of the ship's left side. This TIC has about 50sec interval time, keep on running during clear day and night.

Handy type thermotracer(KEYENCE IT2-60)

This thermotracer(TH) can obtain value of SST.It is connected to a data logger,the SST data is send with GMT time data. This TH has 3sec interval time, and keep on running all day and night.

Sunphotometer (EKO MS-120)

This sunphotometer can obtain the data of wavelength from 368nm to 862nm. It is run by my hand operate, measure at clear day without cloud.

Data type (TOTAL:about 1GByte)

TIC:text and 8bit image raw data saved DDS Tape for Windows 95

text part:Condition data with GMT and TIC's sensitivity,etc

image part:256*207, 8-bit image data (truth SST is calculated by using before condition data)

TH:text data with GMT

Sun:text data with GMT

ROSSA 1996: SOOSR transects
RRS James Clark Ross September - October 1996

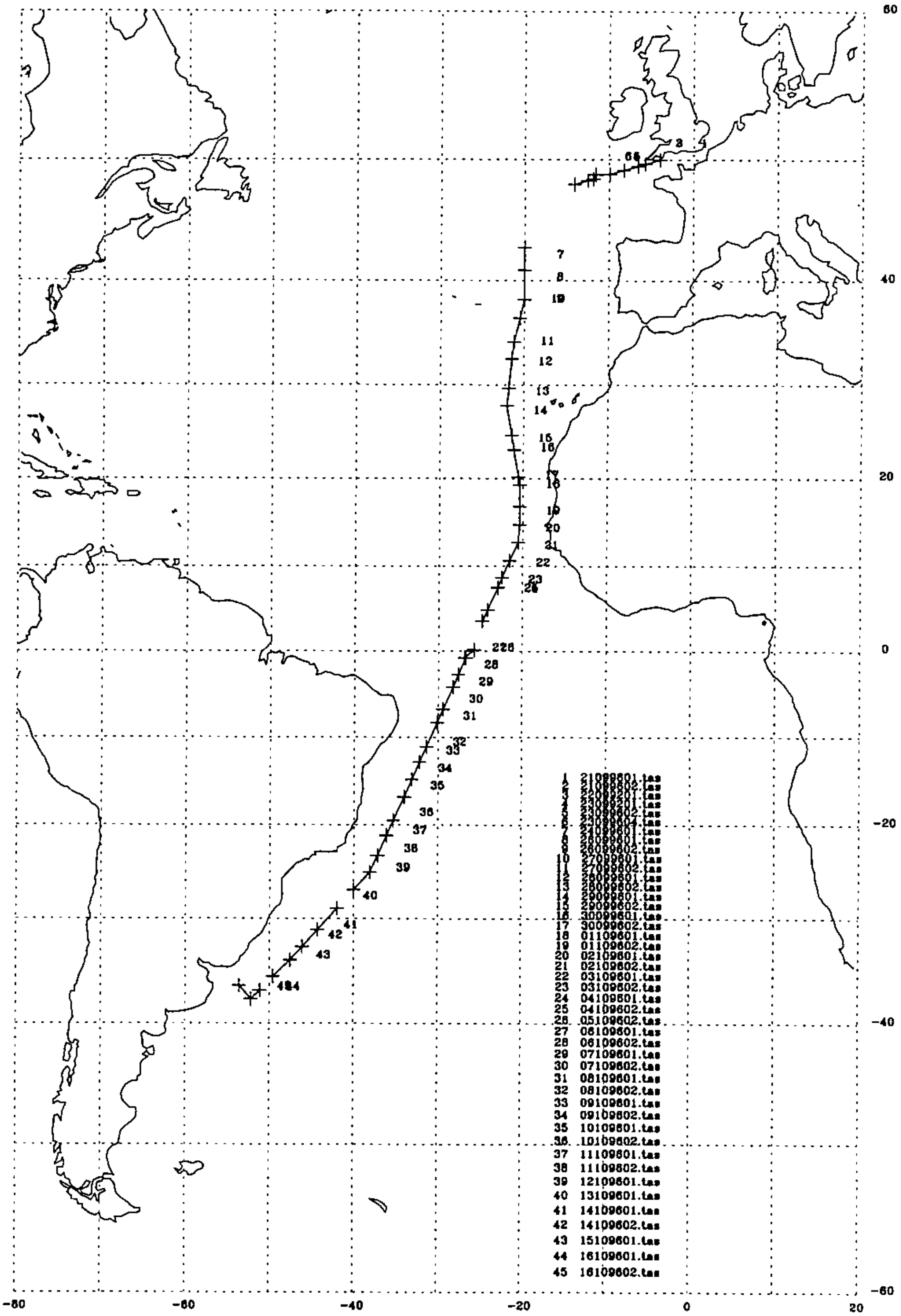
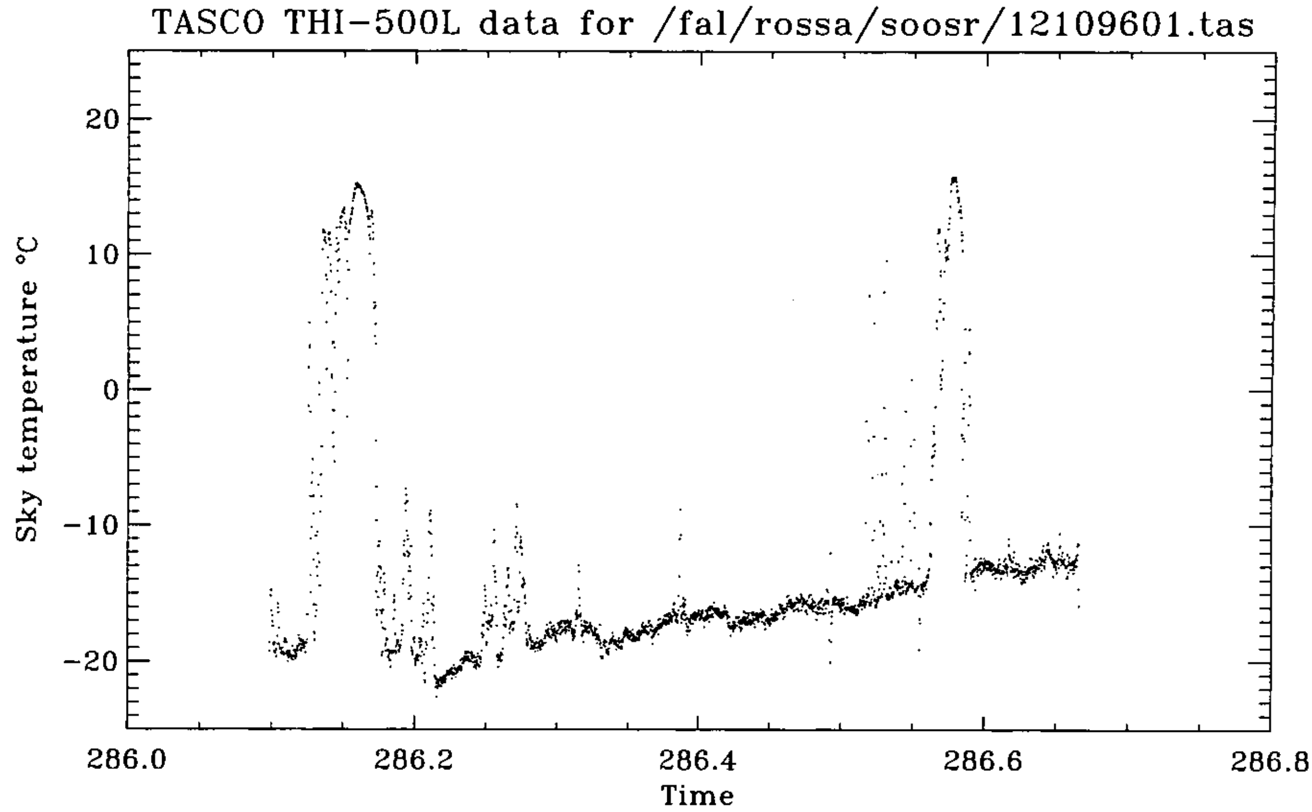


Fig 27.

C J Donlon: RRS James Clark Ross, ROSSA September – October 1996.


TASCO THI-500L data for /fal/rossa/soosr/12109601.tas
Sky temperature °C
20
10
0
−10
−20
286.0
286.2
286.4
286.6
286.8
Time

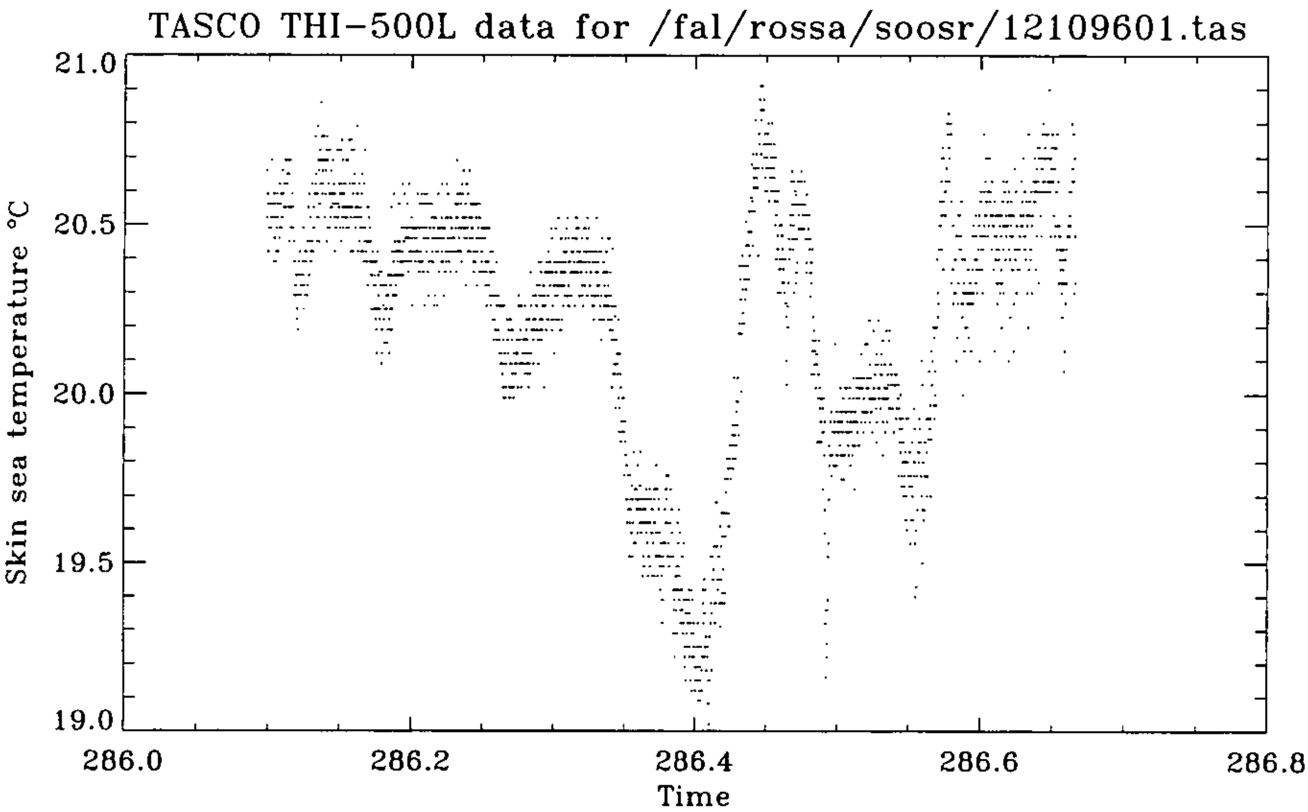

TASCO THI-500L data for /fal/rossa/soosr/12109601.tas
Skin sea temperature °C
21.0
20.5
20.0
19.5
19.0
286.0
286.2
286.4
286.6
286.8
Time

Fig 28.

ROSSA 1996: SISTeR transects
RRS James Clark Ross September - October 1996

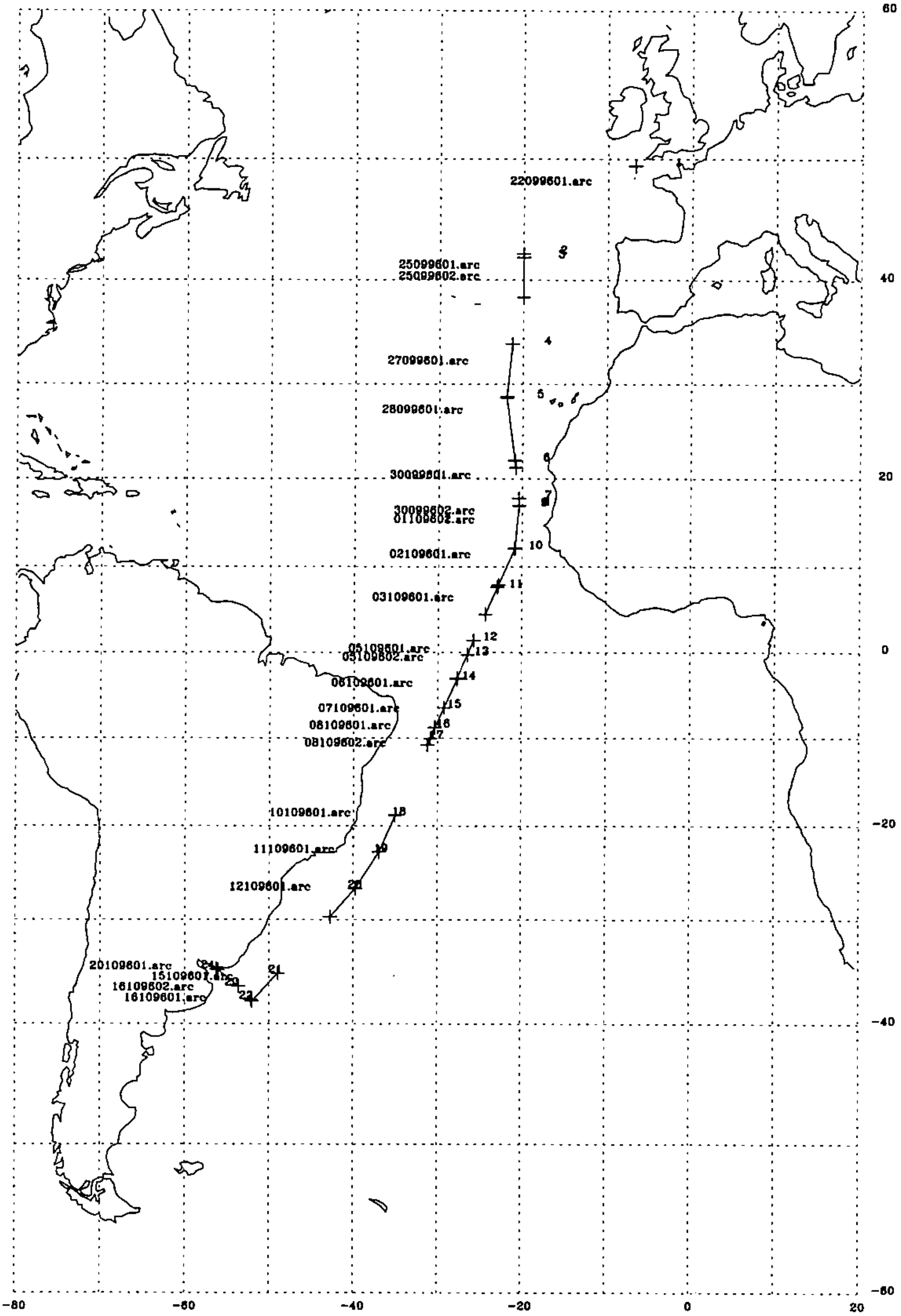


Fig 29.

C J Donlon: RRS James Clark Ross, ROSSA September - October 1996.

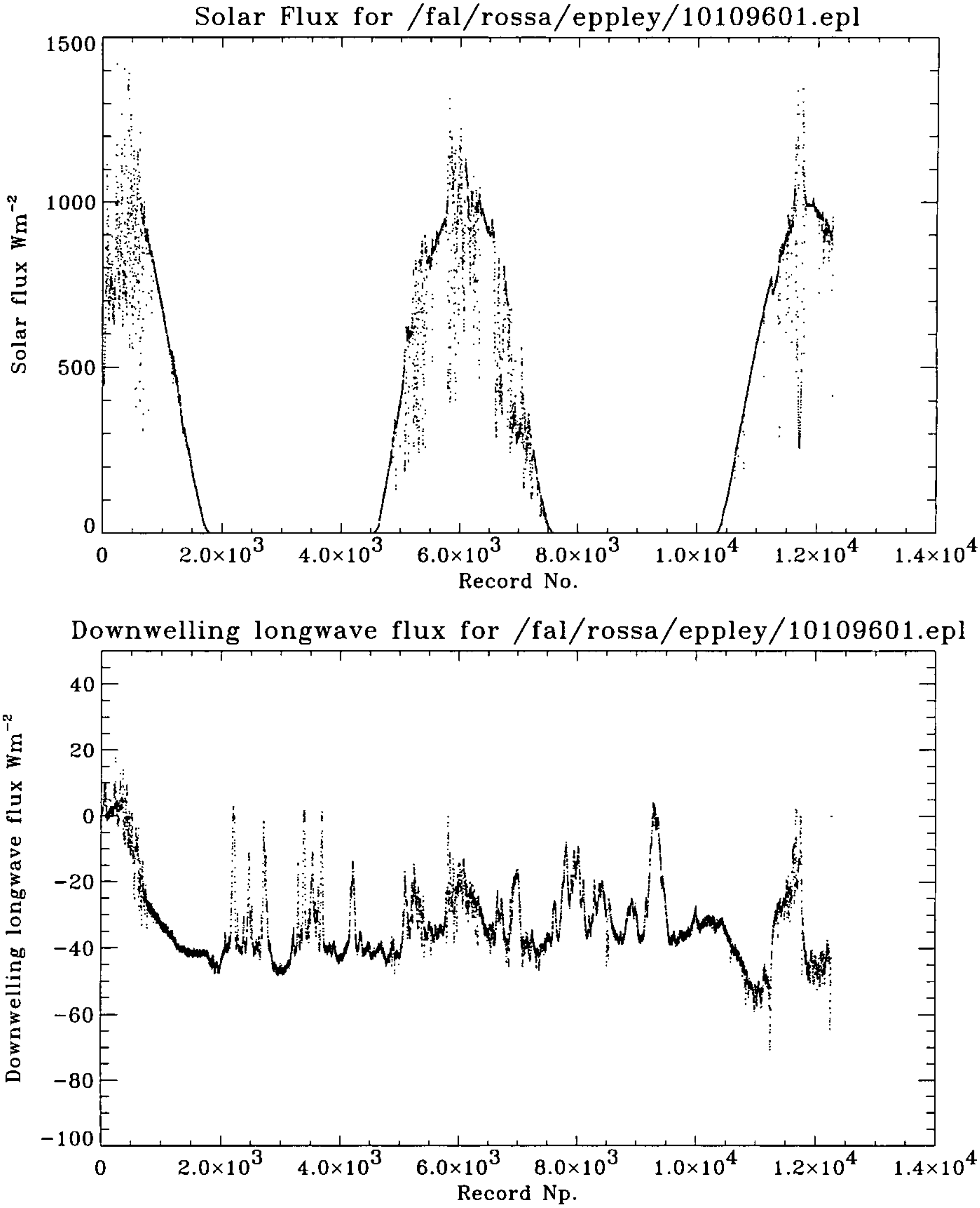

Solar Flux for /fal/rossa/eppley/10109601.epl
1500
1000
500
0
Solar flux Wm^{-2}
0
2.0×10^{3}
4.0×10^{3}
6.0×10^{3}
8.0×10^{3}
1.0×10^{4}
1.2×10^{4}
1.4×10^{4}
Record No.
Downwelling longwave flux for /fal/rossa/eppley/10109601.epl
40
20
0
-20
-40
-60
-80
-100
Downwelling longwave flux Wm^{-2}
0
2.0×10^{3}
4.0×10^{3}
6.0×10^{3}
8.0×10^{3}
1.0×10^{4}
1.2×10^{4}
1.4×10^{4}
Record Np.

Fig 30

ROSSA 1996: Radiosonde release positions.
RRS James Clark Ross September – October 1996

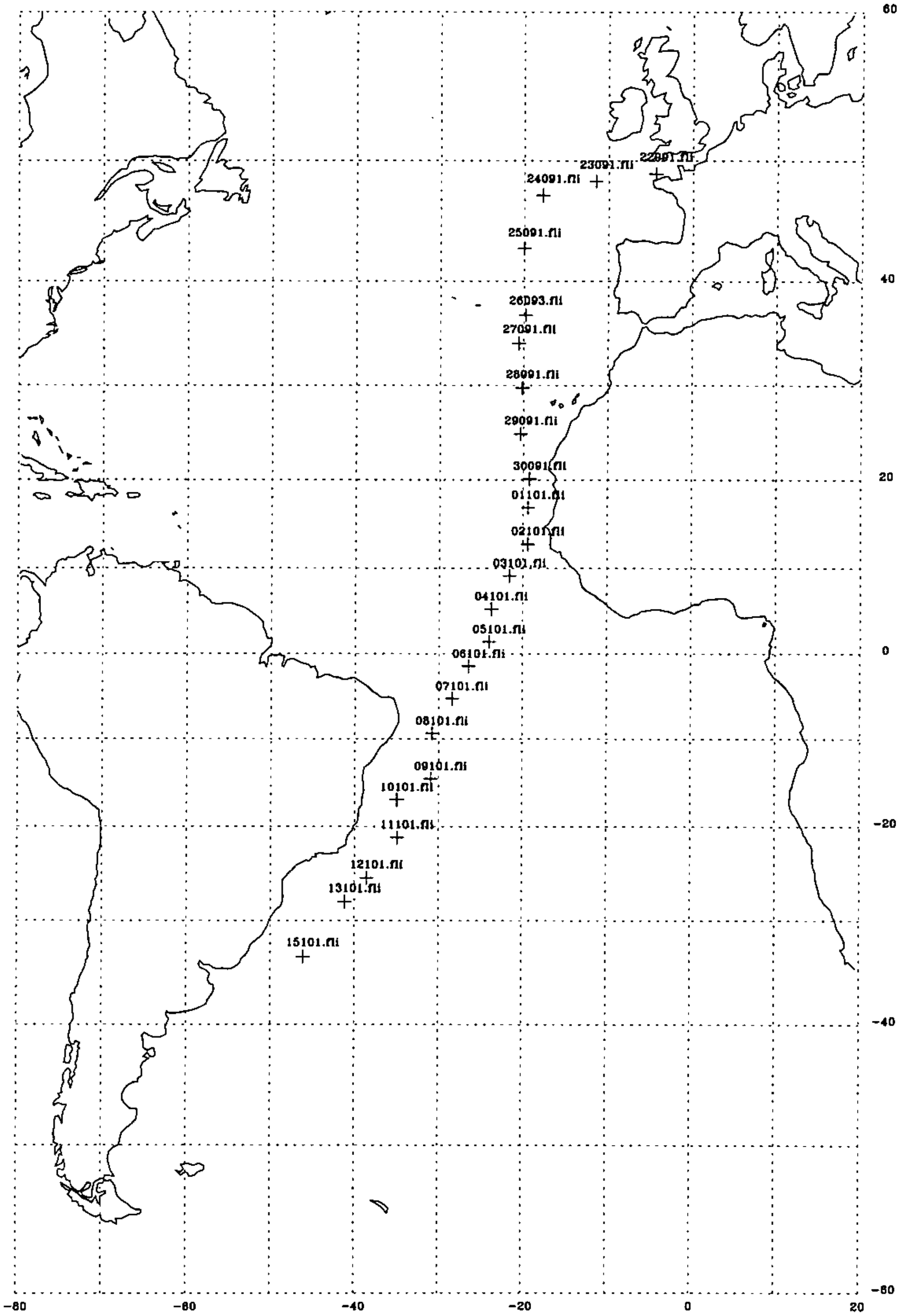
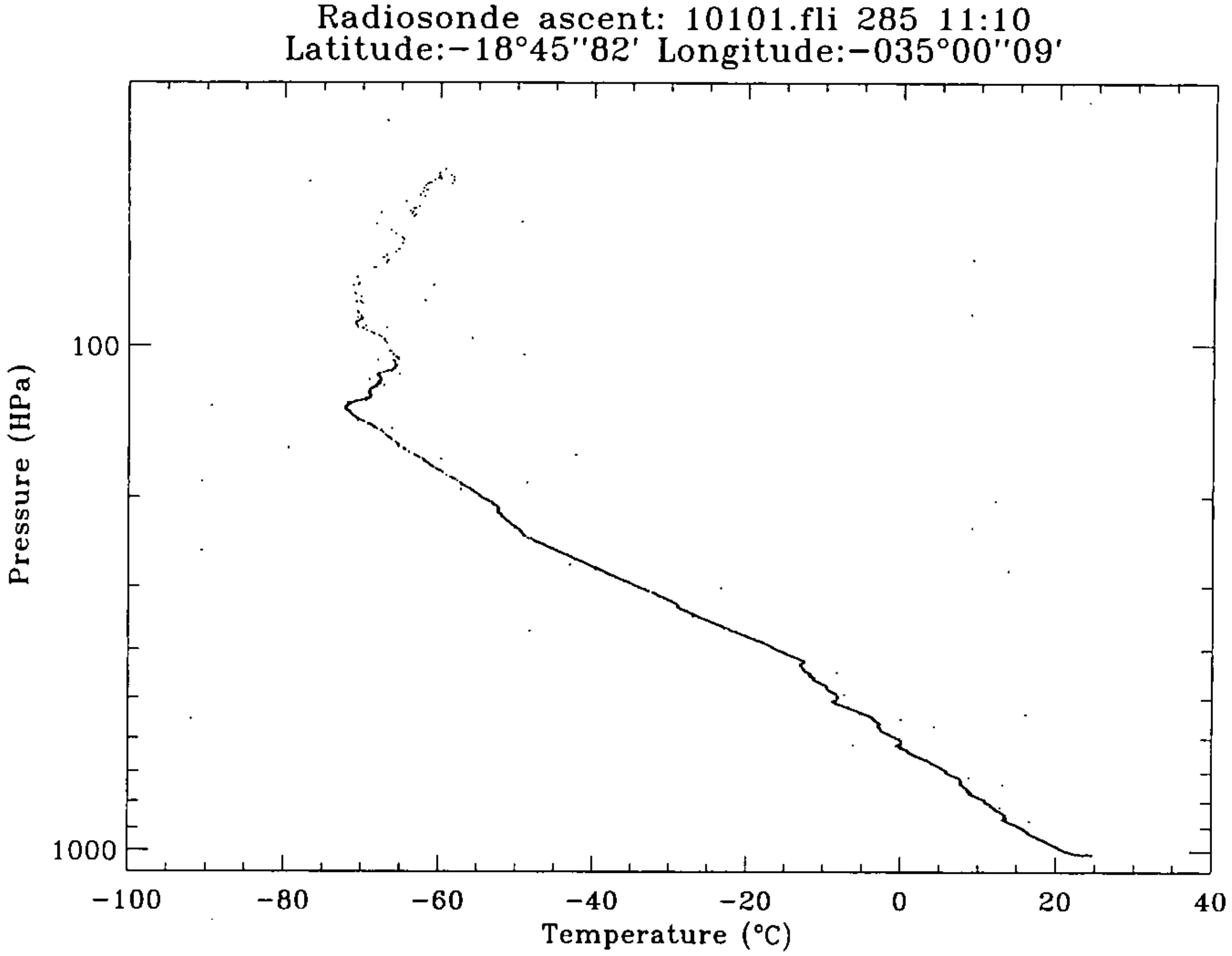


Fig 31


Radiosonde ascent: 10101.fli 285 11:10
Latitude:-18°45''82' Longitude:-035°00''09'
Pressure (HPa)
100
1000
-100
-80
-60
-40
-20
0
20
40
Temperature (°C)

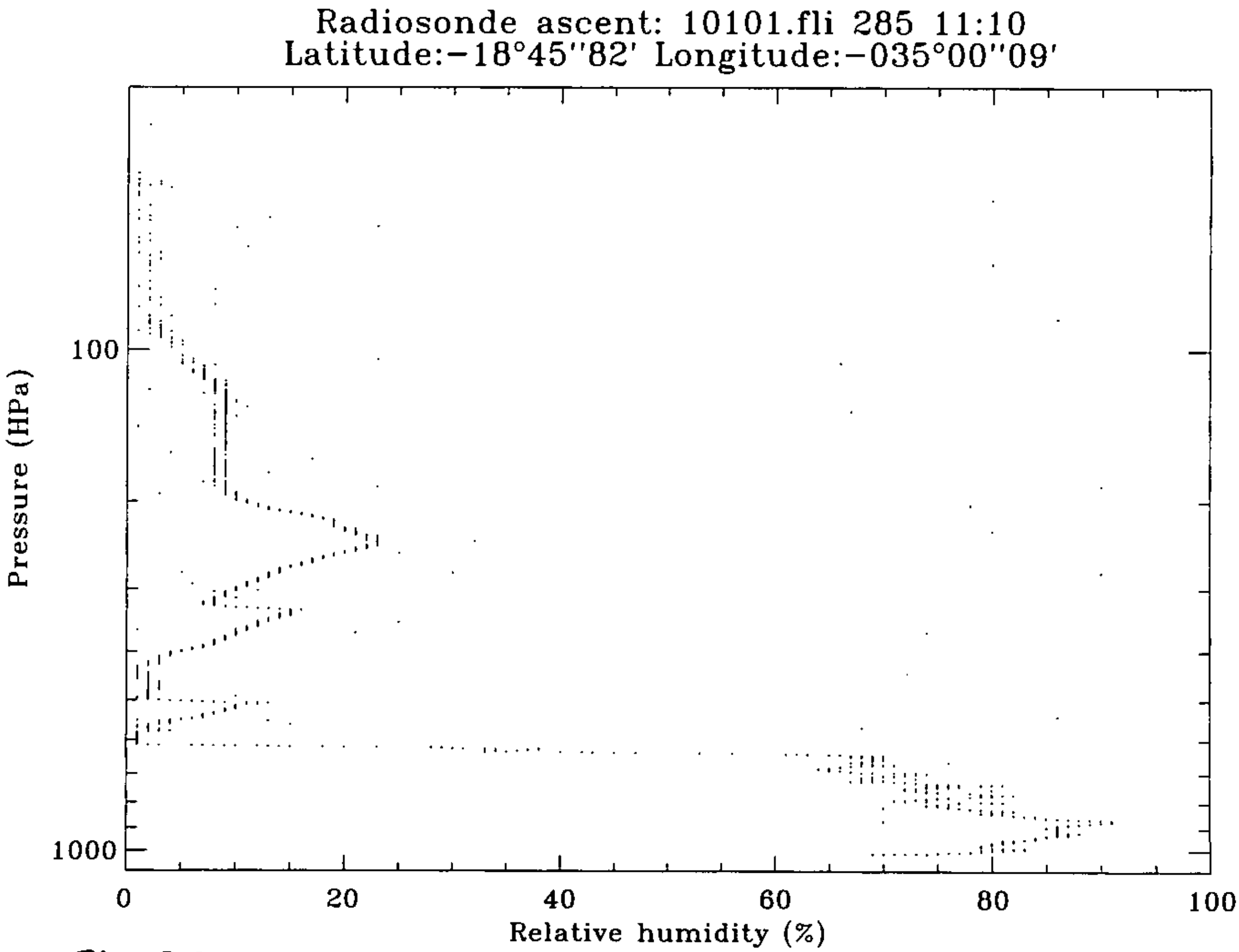

Radiosonde ascent: 10101.fli 285 11:10
Latitude:-18°45''82' Longitude:-035°00''09'
Pressure (HPa)
100
1000
0
20
40
60
80
100
Relative humidity (%)

Fig 32

Appendix A: Addresses and contact numbers for cruise participants

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Appendix B. Station times and positions

Station	Day	Start	End	Lat	Lon	notes
1	266	08:00	10:20	N 49° 40.49	W 05° 41.42	
2	267	09:30	12:00	N 48° 24.70	W 12° 30.00	1
3	268	10:30	12:26	N 47° 21.96	W 18° 12.70	
4	269	10:30	12:12	N 42° 54.04	W 19° 59.51	
5	270	11:25	12:07	N 38° 10.13	W 20° 00.78	
6	271	11:25	13:20	N 34° 01.98	W 21° 15.45	2
7	272	11:25	13:00	N 29° 29.58	W 21° 48.46	
8	273	11:25	13:10	N 24° 40.64	W 21° 24.09	
9	274	10:55	16:20	N 20° 05.14	W 20° 37.74	3
	275					4
10	276	10:55	12:30	N 12° 45.58	W 20° 32.68	
11	277	10:55	12:35	N 09° 03.14	W 22° 16.55	
12	278	10:55	12:30	N 05° 10.20	W 24° 00.98	
13	279	10:55	12:15	N 01° 17.37	W 25° 46.90	
14	280	10:55	12:20	S 02° 23.36	W 27° 27.25	
15	281	10:55	12:20	S 06° 29.02	W 29° 16.23	
16	282	11:55	13:15	S 10° 46.78	W 31° 14.46	
17	283	12:15	14:12	S 14° 53.44	W 33° 07.30	
18	284	11:55	13:21	S 18° 51.91	W 35° 02.76	
19	285	11:55	13:45	S 22° 55.87	W 36° 57.27	
20	285b	16:13	16:52	S 23° 20.90	W 37° 10.40	
21	286	11:55	13:20	S 26° 36.91	W 39° 36.00	
22	286b	16:00	17:00	S 27° 00.10	W 40° 00.80	
23	287	12:00	13:26	S 29° 51.04	W 42° 54.70	
24	288	12:00	13:20	S 32° 48.01	W 46° 06.98	
25	289	12:30	14:05	S 35° 42.73	W 49° 34.01	
26	289b	17:10	18:12	S 36° 05.40	W 50° 03.40	
27	290	11:50	13:30	S 37° 48.40	W 52° 11.63	
			291-296 Montevideo			
28	297	12:55	15:48	S 43° 34.71	W 55° 01.36	5
29	298	12:55	14:30	S 48° 00.12	W 55° 52.84	
30	299	11:00	11:45	S 51° 55.88	W 57° 53.64	

notes:

1. No CTDs -gantry failure
2. Limited cast due to bottle misfires
3. Gantry failure: extra 4hrs on station
4. No hydrographic station due to EEZ restrictions
5. CTD wire stranded & fouled on washer

PORTSMOUTH - MONTEVIDEO inc. AMT 3

Position	Lat	Long	Co.	Dist.	D.T.G.
No Man Land	50 44.65N	01 05.25W	121	5.0	6632.0
New Ground	50 42.00N	00 58.10W	178	2.0	6627.0
Nab	50 40.00N	00 58.00W	217	12.5	6625.5
St. Catherines	50 30.00N	01 10.00W	254	699.0	6612.5
Science Area	47 21.70N	18 11.70W	198	244.0	5913.5
20 W	43 30.00N	20 00.00W	180	320.0	5669.5
200' Madeira	38 10.00N	20 00.00W	194	258.0	5349.5
Outside 200'	34 00.00N	21 17.00W	185	372.0	5091.5
Off Canaries	27 50.00N	22 00.00W	170	517.5	4719.5
Off Cap Timrist Start no Science	19 20.00N	20 25.00W	180	375.0	4202.0
Off Dakar End no Science	13 05.00N	20 25.00W	204	2509.0	3827.0
Off Cabo Frio	25 00.00S	38 00.00W	222	812.0	1318.0
River Plate	35 00.00S	48 30.00W	227	245.0	506.0
Last Station	37 46.00S	52 12.00W	314	226.0	261.0
Banco Ingles	35 12.00S	55 35.00W	308	15.5	35.0
Is. de Flores	35 02.50S	55 50.00W	283	19.5	19.5
Pilots	34 58.00S	56 13.00W			0

Appendix C CTD-rosette water bottle log

station	266	267	268	269	270
CTD 1	none	none	7	7	7
production		due to	20	20	20
& chem		gantry	30	30	30
(m)		failure	40	40	40
			50	50	50
			60	60	60
			100	80	80
			150	100	100
			200	150	150
				200	200
CTD 2	2	none	2	7	2
pigments	6	due to	7	20	7
& zoop	10	gantry	20	30	20
(m)	20	failure	30	40	30
	30		40	50	40
	50		50	60	50
	70		60	80	60
			100	100	80
			150	150	100
				200	150

NB for 269, cast 1 was pigments and cast 2 productivity

station	271	272	273	274	276
CTD 1	80m	7	7	7	7
production	150m	20	20	20	20
& chem	200m	40	30	30	30
(m)		60	40	40	40
	7m	80	50	50	50
		100	60	60	60
		110	80 90m	80	80
		120	100	100	100
		150	150	150	150
		200	200	200	200
CTD 2	aborted:	2	2	2	2
pigments		7	7	7	7
& zoop		20	20	20	20
(m)		40	50	30	40
		60	80	40	45
		80	100	50	50
		100	102	60	60
		110	110	80	80
		120	120	100	100
		150	150	150	150

station	277	278	279	280	281
CTD 1	7	7	7	7	7
production	20	20	20	20	30
& chem	30	40	40	40	50
(m)	40	50	60	50	70
	50	60	70	65	90
	60	70	80	75	100
	80	80	90	85	110
	100	100	100	100	120
	150	150	120	120	140
	200	200	200	200	200
CTD 2	2	2	2	2	2
pigments	7	7	7	7	7
& zoop	20	20	40	20	50
(m)	30	30	60	40	80
	40	40	70	60	90
	45	60	78	80	100
	60	74	90	90	110
	80	90	100	100	120
	100	100	120	120	130
	150	150	150	150	150

station	282	283	284	285	286
CTD 1	7	7	7	7	7
production	25	30	25	20	40
& chem	50	60	50	40	70
(m)	75	80	75	60	80
	100	100	100	80	95
	120	120	110	90	110
	130	140	125	100	120
	140	160	140	120	140
	160	180	160	160	160
	200	200	200	200	200
CTD 2	2	2	2	2	2
pigments	7	7	7	7	7
& zoop	50	50	30	20	20
(m)	75	80	60	40	40
	100	100	90	60	60
	120	120	110	80	80
	130	140	125	100	95
	140	160	140	120	110
	160	180	160	130	120
	200	200	200	150	150

station	287	288	289	290	297
CTD 1	7	7	7	7	2
production	50	20	10	20	7
& chem	80	40	20	30	20
(m)	90	50	30	40	30
	100	60	40	50	40
	110	70	50	60	50
	120	80	60	80	60
	150	100	80	100	100
	200	150	150	150	150
		200	200	200	200
CTD 2	2	2	2	2	2
pigments	7	7	7	7	7
& zoop	30	20	10	20	20
(m)	60	40	20	30	30
	70	50	30	40	40
	80	60	40	50	50
	90	80	50	60	59
	100	100	60	80	80
	120	120	80	100	100
	150	150	150	150	150

station	298	299			
CTD 1	7	2			
production	20	7			
& chem	40	20			
(m)	60	30			
	70	40			
	80	50			
	100	60			
	120				
	150				
	200				
CTD 2	2	only one			
pigments	7	cast :-			
& zoop	20	shallow			
(m)	40	water.			
	50	All			
	70	material			
	80	from one			
	100	bottle			
	120				
	150				

Appendix D Scientific bridge log (all times are in GMT)

Date	SDY	Latitude	Longitude	Time	Activity
22/09/96	266	N 49° 40.1	W 5° 40.2	0800	Stopped on station #1 (trial)
				0822	CTD deployed (water depth 86m)
				0826	CTD at 70m
				0836	Optical rig deployed
				0852	CTD recovered
				0853	Optical rig recovered
				1000	Plankton net deployed
				1007	Plankton net recovered
				1020	Station complete
				1030	UOR deployed
				1035	UOR deployed to 400m
				1500	UOR recovered
23/09/96	267	N 48° 24.7	W 12° 30.0	0930	Stopped on station #2
				0945	Optical rig deployed
				0947	CTD deployed - oil leak from hydraulic hose on midship gantry
				0950	CTD recovered
				1020	Plankton net deployed 200m (1st cast)
				1037	Optical rig at surface
				1039	Optical rig recovered
				1043	Plankton net recovered
				1048	Plankton net redeployed 20m (2nd cast)
				1050	Plankton net recovered
				1053	Optical rig redeployed to 50m
				1055	Surface drift net deployed
				1101	Optical rig recovered
				1108	Floating buoy unit deployed
				1117	Plankton net recovered
				1130	Floating buoy unit recovered
				1200	Station complete
				1205	UOR deployed
				1226	UOR recovered on-board to change rig
				1235	UOR fully deployed to 430m
		N 48° 11.0	W 13° 46.6	1807	XBT launched
				1837	UOR recovered onto deck
24/09/96	268	N 47° 21.9	W 18° 12.7	1030	Stopped on station #3
				1039	Optical rig and CTD deployed
				1043	CTD at 200m
				1046	Plankton net deployed 200m (1st cast)
				1102	Optical rig recovered
				1104	Plankton net recovered
				1108	CTD recovered
				1109	Plankton net redeployed 100m (2nd cast)
				1112	Plankton net recovered
				1115	Drift net deployed
				1130	Drift net recovered
				1145	CTD redeployed to 200m
				1208	CTD recovered
				1226	Station complete
				1235	UOR deployed
				1238	XBT aborted - problems with software

				1436	UOR recovered
				2325	XBT launched
25/09/96	269	N 42° 54.0	W 19° 59.5	1030	Stopped on station #4
				1040	CTD, optical rig, plankton net deployed (1st cast)
				1045	CTD at 200m
				1053	Optical rig recovered
				1054	Plankton net recovered
				1058	Plankton net redeployed (2nd cast)
				1100	Plankton net recovered
				1106	Drift net deployed
				1110	CTD recovered
				1112	Optical rig deployed
				1125	Drift net recovered
				1135	CTD deployed; optical rid recovered
				1138	Drift buoy deployed
				1155	CTD recovered
				1159	Drift buoy recovered
				1212	Station complete
				1220	XBT launched
				1455	Thermometer in water from Port side
26/09/96	270			0005	XBT launched
		N 38° 10.3	W 20° 00.8	1125	Stopped on station #5
				1132	CTD deployed
				1133	Plankton net deployed (1st cast)
				1145	Drift buoy deployed
				1149	Plankton net recovered
				1154	Plankton net deployed (2nd cast)
				1106	CTD recovered
			?	1110	Plankton net recovered; drift buoy recovered
				1122	Drift net deployed
				1140	CTD deployed
				1145	Drift net recovered
				1146	Optical rig recovered
				1203	CTD recovered
				1207	Station complete
				1211	XBT launched
				1310	UOR deployed to 370m
				2026	UOR recovered and secured
				2300	XBT launched
27/09/96	271			0700	XBT launched
		N 34° 01.6	W 21° 15.3	1125	Stopped on station #6
				1127	Optical rig, plankton net deployed (1st cast)
				1130	CTD deployed to 200m
				1145	Plankton net recovered
				1150	Plankton net redeployed (2nd cast)
				1152	Plankton net recovered
				1154	Plankton net redeployed (3rd cast)
				1205	CTD recovered
				1210	Drifting buoy deployed; CTD redeployed; plankton net recovered
				1215	Drift net deployed

				1223	CTD recovered
				1224	Drifting buoy recovered
				1230	Optical rig redeployed - aborted
				1236	Drift net recovered
				1240	CTD redeployed; optical rig redeployed
				1250	Optical rig recovered
				1253	CTD recovered
				1303	CTD deployed to 80m
				1315	CTD recovered
				1320	Station complete
				1330	UOR deployed to 370m
				1330	XBT launched
				1837	UOR recovered
28/09/96	272			0115	XBT launched
				0726	XBT launched
		N 29°29.7	W 21°48.4	1125	Stopped on station #7
				1130	Plankton net (1st cast), optical rig deployed
				1134	CTD deployed to 200m
				1145	Plankton net recovered
				1150	Plankton net redeployed (2nd cast)
				1200	CTD recovered
				1212	Plankton net recovered
				1214	Optical rig recovered
				1216	Drift net deployed
				1223	Drifting buoy deployed
				1241	Drifting buoy recovered
				1245	Drift net recovered
				1252	CTD recovered
				1300	Station complete
				1304	UOR deployed to 375m
				1725	UOR recovered
				2130	XBT launched
29/09/96	273			0950	XBT launched
		N 24°40.6	W 21°24.0	1125	Stopped on station #8
				1127	Plankton net deployed (1st cast)
				1130	CTD (200m), optical rig deployed
				1145	Plankton net recovered
				1147	Plankton net redeployed (2nd cast)
				1150	Plankton net recovered
				1157	Plankton net redeployed (3rd cast)
				1209	Plankton net recovered
				1212	Drift net deployed
				1215	Optical rig recovered
				1220	Drifting buoy deployed
				1245	Drift net recovered; drifting buoy (NASA) deployed
				1255	Rocket buoy deployed
				1300	CTD recovered
				1305	NASA buoy recovered
				1310	Station complete
				1317	UOR deployed to 375m
				1605	XBT launched
				1753	UOR recovered
				2100	XBT launched

30/09/96	274			0100	XBT launched
				0500	XBT launched
				0900	XBT launched
		N 20° 04.1	W 20° 33.7	1055	Stopped on station #9
				1100	Plankton net (1st cast), optical rig deployed
				1105	Oil leak on midship gantry; CTD aborted
				1120	Plankton net recovered
				1121	Plankton net redeployed (2nd cast)
				1125	Plankton net recovered
				1126	Plankton net redeployed (3rd cast)
				1140	Optical rig recovered
				1142	Drifting buoy deployed
				1145	Drift net deployed
				1205	Drift net, drifting buoy recovered
				1215	Drift buoys (NASA) deployed
				1240	NASA buoys recovered
				1245	NASA buoys redeployed
				1320	NASA buoys recovered
				1345	Free Fall reference redeployed
				1405	Free Fall rocket redeployed
				1432	Free Fall reference recovered
				1435	Free Fall rocket recovered
				1440	Midship gantry deployment test - all OK
				1450	CTD deployed
				1521	CTD recovered
				1550	CTD redeployed
				1615	CTD recovered
				1620	Station complete
				1638	XBT launched
01/10/96	275			0120	XBT launched
				0450	XBT launched
				0930	XBT launched
				1540	XBT launched
02/10/96	276			0115	XBT launched
				0930	XBT launched
		N 12° 45.6	W 20° 32.7	1055	Stopped on station #10
				1100	Optical rig deployed
				1104	Plankton net deployed 200m (1st cast)
				1108	CTD deployed 200m
				1122	Plankton net recovered
				1125	Plankton net redeployed 20m (2nd cast)
				1128	Plankton net recovered
				1130	CTD recovered; plankton net redeployed 200m (3rd cast)
				1137	Optical rig recovered
				1145	Plankton net recovered; drifting buoy launched
				1152	Drift net deployed
				1200	Drifting buoy recovered
				1201	NASA buoy deployed; CTD redeployed
				1206	Rocket buoy deployed
				1215	Drift net recovered
				1224	CTD recovered

				1225	NASA buoys recovered
				1230	Station complete
				1240	UOR deployed to 380m
				2030	UOR recovered
03/10/96	277			0120	XBT launched
		N 9° 39.0	W 21° 59.0	0700	UOR deployed to 380m
				0920	UOR recovered
				0940	XBT launched
		N 9° 03.0	W 22° 16.5	1055	Stopped on station #11
				1100	Optical rig; plankton net (1st cast) deployed
				1102	CTD deployed
				1116	Plankton net recovered
				1122	Plankton net redeployed (20m, 2nd cast)
				1123	Plankton net recovered
				1125	Plankton net redeployed (200m, 3rd cast); CTD recovered
				1135	Optical rig recovered
				1138	Optical rig redeployed
				1145	Optical rig recovered
				1149	Plankton net recovered
				1151	Drifting buoy deployed; CTD deployed
				1153	Drift net deployed
				1210	Drifting buoy recovered
				1212	CTD recovered; NASA freefall buoy deployed
				1225	Drift net recovered
				1230	NASA buoy recovered
				1235	Station complete; UOR deployed
				1710	XBT launched
				2025	UOR recovered
				2130	XBT launched
04/10/96	278			0100	XBT launched
				0450	XBT launched
				0800	UOR deployed
				0835	XBT launched
				1050	UOR recovered
		N 5° 10.5	W 24° 00.6	1055	Stopped on station #12
				1100	Plankton net deployed (1st cast); optical rig deployed
				1105	CTD deployed
				1125	Plankton net recovered
				1128	Plankton net redeployed (20m, 2nd cast); CTD recovered
				1130	Plankton net recovered
				1131	Plankton net redeployed (200m, 3rd cast)
				1134	Light meter recovered
				1139	Light meter deployed
				1146	Plankton net recovered
				1150	Drift net deployed
				1152	CTD deployed; light meter recovered, buoy deployed
				1210	CTD recovered; Plankton net recovered
				1215	Drifting buoy recovered
				1216	Freefall buoys deployed
				1225	Freefall buoys recovered

				1230	Station complete; UOR deployed to 360m
				1455	UOR recovered
				2215	XBT launched
05/10/96	279			0515	XBT launched
				0925	XBT launched
		N 1° 17.3	W 25° 46.9	1055	Stopped on station #13
				1058	Optical rig deployed
				1105	Plankton net (1st cast) deployed; CTD deployed
				1114	Plankton net recovered
				1116	Plankton net redeployed (20m, 2nd cast)
				1118	Plankton net recovered
				1122	Plankton net redeployed (200m, 3rd cast)
				1125	CTD recovered
				1130	Optical rig recovered
				1132	Optical rig deployed
				1134	Optical rig recovered
				1136	Drifting buoy deployed; plankton net recovered
				1140	Drift net deployed
				1148	CTD deployed
				1155	Drifting buoy recovered
				1210	Drift net recovered; CTD recovered
				1215	Station complete
				1223	UOR deployed
				1225	XBT launched
				2013	XBT launched
		0° 00.0	W 26° 21.3	2016	Vessel crosses equator
				2230	XBT launched
06/10/96	280			0040	XBT launched
				0320	XBT launched
				0525	XBT launched
				0707	UOR recovered
				0726	XBT launched
		S 2° 23.4	W 27° 27.2	1055	Stopped on station #14
				1100	Plankton net deployed(1st cast); optical rig deployed
				1103	CTD deployed
				1113	Plankton net recovered
				1116	Plankton net redeployed (20m, 2nd cast)
				1120	Plankton net recovered
				1122	Plankton net redeployed (200m, 3rd cast); optical rig recovered; CTD recovered
				1128	Drifting buoy deployed
				1136	Plankton net recovered
				1140	Drift net deployed
				1145	Drifting buoy recovered
				1150	Freefall buoys deployed; CTD deployed
				1210	Freefall buoys recovered; CTD recovered
				1212	Drift net recovered
				1220	Station complete
				1223	UOR deployed to 360m
				1225	XBT launched
				1625	XBT launched
				1758	UOR recovered
				2130	XBT launched

07/10/96	281			0200	XBT launched
				0845	XBT launched
		S 6° 29.0	W 29° 16.0	1055	Stopped on station #15
				1100	Optical rig, plankton net (1st cast), CTD deployed
				1113	Plankton net recovered
				1116	Plankton net deployed (20m, 2nd cast)
				1120	Plankton net recovered
				1123	Drifting buoy deployed
				1126	Optical rig recovered; CTD recovered
				1134	Optical rig deployed; plankton net recovered
				1137	Drift net deployed
				1146	Optical meter recovered
				1150	Drifting buoy recovered
				1200	Freefall buoys deployed; CTD deployed
				1211	Drift net recovered
				1214	CTD recovered
				1216	Freefall buoys recovered
				1220	Station complete
				1225	UOR deployed; XBT launched
				1810	UOR recovered
08/10/96	282			0330	XBT launched
				0848	XBT launched
		S 10° 46.8	W 31° 14.4	1155	Stopped on station #16
				1200	Plankton net deployed (200m, 1st cast)
				1201	CTD, optical rig deployed
				1215	Plankton net recovered
				1216	Drifting buoy deployed; Plankton net redeployed (20m, 2nd cast)
				1220	Plankton net recovered; optical rig recovered
				1221	Plankton net redeployed (200m, 3rd cast)
				1240	Plankton net recovered; freefall buoys deployed
				1245	Drift net deployed
				1250	CTD deployed
				1305	Freefall buoys recovered
				1310	Drift net recovered; CTD recovered
				1315	Station complete
				1325	XBT launched
09/10/96	283			0205	XBT launched
				0800	XBT launched
		S 14° 53.0	W 33° 06.9	1215	Stopped on station #17
				1219	Plankton net deployed (200m, 1st cast)
				1228	CTD, optical rig deployed
				1230	Drifting buoy deployed
				1233	Plankton net recovered
				1235	Plankton net redeployed (20m, 2nd cast)
				1237	Plankton net recovered
				1240	Plankton net redeployed (3rd cast)
				1245	CTD recovered
				1249	Optical rig recovered
				1255	Plankton net recovered

				1256	Drift net deployed
				1300	Freefall buoys deployed
				1313	CTD deployed
				1327	Drift net recovered
				1330	Freefall buoys recovered
				1335	CTD recovered - bottles did not fire
				1340	CTD redeployed
				1404	CTD recovered
				1412	Station complete; UOR deployed to 360m
				1415	XBT launched
				1852	UOR recovered
				2040	XBT launched
10/10/96	284			0205	XBT launched
		S 18° 51.8	W 35° 02.7	1155	Stopped on station #18
				1200	Plankton net (1st cast); CTD deployed
				1201	Optical rig deployed
				1205	Drifting buoy deployed
				1218	Plankton net recovered
				1220	Plankton net redeployed (20m, 2nd cast)
				1222	Plankton net recovered
				1225	Plankton net redeployed (200m, 3rd cast)
				1230	Drifting buoy, CTD recovered
				1245	Freefall buoy deployed
				1246	Plankton net recovered
				1247	Drift net deployed
				1255	CTD deployed
				1310	Freefall buoys recovered
				1319	CTD, plankton nets recovered
				1321	Station complete
				2033	XBT launched
11/10/96	285			0210	XBT launched
				0945	XBT launched
		S 22° 55.9	W 36° 57.2	1155	Stopped on station #19
				1200	Plankton net deployed (1st cast)
				1202	CTD, drifting buoy deployed
				1205	CTD aborted; no fluorescence signal
				1212	Plankton net recovered
				1215	Plankton net redeployed (20m, 2nd cast)
				1216	Plankton net recovered
				1217	Plankton net redeployed (200m, 3rd cast)
				1222	CTD deployed; drifting buoy recovered
				1228	Freefall buoys deployed
				1233	Plankton net recovered
				1235	Drift net deployed
				1245	CTD recovered
				1307	Plankton net recovered
				1310	Freefall buoys recovered
				1315	CTD redeployed
				1340	CTD recovered
				1345	Station complete
				1347	UOR deployed
				1610	UOR recovered
		S 23° 20.9	W 37° 10.4	1613	Stopped on station #20 (optics only)
				1615	Reference deployed
				1618	Rocket deployed
				1647	Reference recovered

				1652	Rocket recovered; station complete
				1700	UOR deployed
				1914	UOR recovered
12/10/96	286	S 26° 36.9	W 39° 36.0	1155	Stopped on station #21
				1200	Optical rig, CTD, plankton net (1st cast) deployed
				1209	Drifting buoy deployed
				1213	Plankton net recovered
				1215	Plankton net redeployed (2nd cast)
				1217	Plankton net recovered
				1220	Plankton net redeployed (3rd cast)
				1225	Optical rig, CTD recovered
				1235	Plankton net recovered; freefall buoys deployed
				1236	Drift net deployed
				1255	CTD deployed
				1305	Drift net recovered
				1315	CTD, freefall buoys recovered
				1320	Station complete
				1335	XBT launched
		S 27° 00.1	W 40° 00.8	1600	Stopped on station #22 (optics only)
				1611	Optical rig deployed
				1632	Optical rig recovered
				1642	Reference deployed
				1645	Rocket deployed
				1656	Reference, rocket recovered
				1700	Station complete
				1722	XBT launched
13/10/96	287			0135	XBT launched
		S 29° 51.0	W 42° 54.0	1200	Stopped on station #23
				1201	Plankton net deployed (1st cast)
				1202	CTD deployed
				1212	Plankton net recovered
				1215	Plankton net redeployed (2nd cast)
				1217	Plankton net recovered
				1218	Plankton net redeployed (3rd cast)
				1227	CTD recovered
				1232	Plankton net recovered
				1235	Drift net deployed
				1255	CTD redeployed
				1302	Drift net recovered
				1315	CTD recovered
				1326	Station complete
				1328	UOR deployed
				1910	UOR recovered
				2020	XBT launched
14/10/96	288			0055	XBT launched
				0840	XBT launched
		S 32° 48.0	W 46° 07.0	1200	Stopped on station #24
				1202	Plankton net (1st cast), CTD, optical rig deployed
				1215	Plankton net recovered
				1220	Plankton net redeployed (2nd cast)
				1222	Plankton net recovered

				1224	Plankton net redeployed (3rd cast)
				1228	CTD recovered
				1238	Optical rig recovered
				1240	Plankton net recovered
				1243	Drift net deployed
				1258	CTD redeployed
				1315	Drift net recovered
				1318	CTD recovered
				1320	Station complete
				1326	UOR deployed
				1335	XBT launched
				1900	UOR recovered
				1905	XBT launched
15/10/96	289			0305	XBT launched
		S 35° 42.7	W 49° 24.2	1230	Stopped on station #25
				1234	Plankton net (1st cast), optical rig deployed
				1242	Drifting buoy deployed
				1245	CTD deployed
				1250	Plankton net recovered
				1251	Plankton net redeployed (2nd cast)
				1254	Plankton net recovered
				1255	Plankton net redeployed (3rd cast)
				1310	Drifting buoy, CTD, optical rig, plankton net recovered
				1315	Drift net deployed
				1326	Freefall buoys deployed
				1338	CTD redeployed
				1345	Drift net recovered
				1350	Freefall buoys recovered
				1400	CTD recovered
				1405	Station complete
				1410	XBT launched; UOR deployed
				1705	UOR recovered
		S 36° 05.4	W 50° 03.4	1710	Stopped on station #26 (optics only)
				1712	Reference and rocket deployed
				1732	Reference and rocket recovered
				1743	Optical rig redeployed
				1812	Optical rig recovered
				1815	UOR deployed to 360m
				2010	UOR recovered
				2011	XBT launched
				2105	UOR redeployed
16/10/96	290			0300	XBT launched
				1145	UOR recovered
		S 37° 48.0	W 52° 11.6	1150	Stopped on station #27
				1155	Plankton net deployed (1st cast)
				1157	CTD deployed to 200m
				1200	Optical rig deployed
				1205	Drifting buoy deployed
				1208	Plankton net recovered
				1211	Plankton net redeployed (2nd cast)
				1213	Plankton net recovered
				1215	Plankton net deployed
				1225	CTD recovered
				1227	Optical rig recovered

				1230	Plankton net recovered
				1232	Drift net deployed; drifting buoy recovered
				1240	Freefall buoys deployed
				1254	CTD redeployed
				1306	Plankton net, freefall buoys recovered
				1319	CTD recovered
				1330	Station complete
22/10/96	296	S 38° 41.2	W 55° 00.3	1640	XBT launched
		S 40° 20.6	W 54° 59.4	2340	XBT launched
23/10/96	297	S 42° 46.0	W 54° 59.0	0930	XBT launched
		S 43° 34.0	W 55° 01.5	1255	Stopped on station #28
				1300	Plankton net deployed (200m, 1st cast)
				1305	Light meter deployed
				1310	CTD deployed
				1312	Drifting buoy deployed
				1320	Plankton net recovered
				1323	Plankton net redeployed (20m, 2nd cast)
				1325	Plankton net recovered
				1326	Plankton net redeployed (200m, 3rd cast)
				1330	Light meter recovered
				1335	Drifting buoy recovered
				1342	CTD recovered
				1343	Plankton net recovered
				1346	Drift net deployed
				1350	Freefall buoys deployed
				1408	CTD redeployed
				1415	Freefall buoys recovered
				1417	Plankton net recovered
				1420	CTD cable jammed and jumped out of traction winch - unable to recover
				1520	CTD wire repair complete; continue deployment
				1526	Resume hauling CTD slowly and firing bottles
				1530	CTD wire strand caught
				1535	Resume hauling
				1546	CTD recovered
				1548	Station complete
		S 43° 33.8	W 55° 00.3	1554	UOR deployed
		S 43° 33.8	W 55° 00.3	1555	XBT launched
		S 43° 49.3	W 55° 04.4	1720	XBT launched
		S 44° 00.8	W 55° 02.0	1815	XBT launched
		S 44° 05.8	W 55° 00.6	1845	XBT launched
		S 44° 15.0	W 55° 00.0	1930	XBT launched
		S 44° 24.0	W 55° 00.0	2015	XBT launched
		S 44° 36.3	W 54° 59.3	2115	XBT launched
		S 44° 36.0	W 54° 59.0	2120	UOR recovered
		S 44° 59.9	W 54° 58.1	2305	XBT launched
24/10/96	298	S 45° 13.1	W 54° 58.3	0005	XBT launched
		S 45° 26.4	W 55° 00.2	0105	XBT launched
		S 45° 50.3	W 55° 04.9	0305	XBT launched
		S 46° 17.7	W 55° 07.8	0450	XBT launched
		S 46° 47.4	W 55° 20.3	0705	XBT launched

		S 47° 46.8	W 55° 47.0	1145	XBT launched
		S 48° 00.7	W 55° 52.8	1255	Stopped on station #29
				1258	Plankton net deployed (200m, 1st cast)
				1301	Optical rig deployed
				1302	CTD deployed
				1310	Drifting buoy deployed
				1315	Plankton net recovered
				1317	Plankton net deployed (2nd cast)
				1320	Plankton net recovered
				1330	Optical rig recovered
				1332	CTD recovered
				1337	Drifting buoy recovered
				1340	Drift net deployed
				1342	Freefall buoys deployed
				1400	CTD redeployed
				1415	Freefall buoys, drift net recovered
				1425	CTD recovered
				1430	Station complete
		S 48° 00.8	W 54° 52.3	1435	UOR deployed, XBT launched
		S 48° 50.8	W 56° 16.5	1915	UOR recovered
25/10/96	299	S 50° 27.7	W 57° 02.9	0320	XBT launched
		S 51° 55.8	W 57° 53.6	1100	Stopped on station #30
				1105	Plankton net deployed (1st cast)
				1106	CTD deployed
				1107	Plankton net recovered
				1110	Plankton net redeployed (2nd cast)
				1115	Plankton net recovered
				1118	Optical rig, drift net deployed
				1135	Optical rig recovered
				1136	Drift net recovered
				1145	CTD recovered; station complete

Appendix E. Meteorological record for AMT3 ,

Day	Time	Vis	Wind Dir	Force	Pressure	Temp Air	Sea	Sea State	Swell	Sky	Notes
266	0000				1011.2	13.0	15.8				
Su22	0400				1012.5	12.7	15.0				
	0800				1014.1	12.9	14.0				
	1200	Good	N	3	1014.6	13.1	15.2	Slight	Mod	Ci	
	1600	Good	SW	3	1013.4	14.1	16.7	Slight	Low	5/8 High	
	2000	Good			1011.9	14.8	16.5				
267	0000	Good	SxSW	5	1008.7	14.9	16.4		Low	4/8 St	
Mo23	0400	Good	SxSE		1006.2	14.4	16.5			8/8 Medium	Light Rain
	0800	Good	NNW		1009.0	15.8	16.6		Low	4/8 Cu,Ac	Showers
	1200	Good	NNW	3	1011.3	16.0	16.8	Slight	Low	5/8 Sc,Ac	Showers
	1600	Good	NW	6	1012.9	16.2	17.1	Mod	Low	5/8 Sc,Ac	
	2000	Good	NNW	5	1015.7	16.0	16.4	Mod	Mod	3/8 Sc	
268	0000	Good	W	4	1015.7	15.9	16.6	Slight	Mod	8/8 St,Cs	
Tu24	0400	Good	WSW	6	1012.6	16.3	16.9	Mod	Mod	7/8 St,Ci	
	0800	Good	SW	7	1009.5	14.8	16.6	Rough	Mod	7/8 Sc	
	1200	Good	SSW	6	1008.9	15.9	16.4	Rough	Mod	7/8 Sc	Passage of cold front 1200
	1600	Good	WxSW	5	1010.7	16.8	17.3	Mod	Mod	6/8 Cu,As	
	2000	Good	WxNW	5	1014.2	16.5	17.0	Mod	Mod	5/8 Cu	
269	0000	Good	WxNW	3	1015.9	16.9	17.6	Slight	Mod	6/8 Cu,Ac,Cs	
We25	0400	Good	WxSW	2	1015.8	17.5	18.4	Slight	Low	7/8 Sc	Patches of Fog
	0800	Good	W	4	1017.4	19.0	19.0	Slight	Low	7/8 Sc	
	1200	Good	W	4	1018.9	19.5	19.3	Slight	Low	4/8 Sc	
	1600	Good	WxS	5	1019.8	20.4	20.3	Slight	Low	8/8 Sc	
	2000	Good	W	4	1022.1	20.7	20.9	Slight	Low	6/8 Sc	
270	0000	Good	W	2	2.1	20.9	21.5	Slight	Low	1/8 Cu,Ci	
Th26	0400	Good	WxN	1	1023.8	21.3	21.7	Slight	Low	7/8 Cu	
	0800	Good	NWxW	3	1024.9	21.0	21.5	Slight	VLow	3/8 Cu,Sc	
	1200	Good	NWxW	3	1025.6	21.5	22.0	Slight	VLow	3/8 Cu	
	1600	Good	NxE	2	1024.8	22.5	23.2	Slight	VLow	2/8 Cu,Ci	
	2000	Good	NE	3	1024.7	21.9	23.1	Slight	VLow	2/8 Cu	
271	0000	Good	NE	3	1024.6	22.0	23.2	Slight	Low	3/8 Cu,Ac	
Fr27	0400	Good	ENE	1	1022.8	22.1	23.1	Slight	Low	5/8 Cu	0300 Total eclipse of moon
	0800	Good	NExE	4	1023.1	22.6	23.6	Slight	Low	5/8 Cu,Sc	Sea starting to liven up
	1200	Good	NExE	5	1022.9	22.7	23.8	Slight	Low	6/8 Cu,Sc	
	1600	Good	ExN	5	1020.9	23.2	24.0	Slight	Low	4/8 Sc,Cu	Light shwrs Ra
	2000	Good	ExN	5	1020.0	22.7	24.3	Slight	Low	5/8 Sc,Cu	Light shwrs Ra
272	0000	Good	ExN	4	1019.8	22.8	23.9	Slight	Low	3/8 Cu	
Sa28	0400	Good	ExN	3	1018.6	22.5	24.1	Slight	Low	Nil	
	0800	Good	E	4	1018.8	22.8	24.1	Slight	Low	3/8 Cu,Sc	
	1200	Good	E	4	1019.1	23.2	24.4	Slight	Low	2/8 Cu	
	1600	Good	E	4	1017.8	23.2	24.8	Slight	Low	2/8 Cu	
	2000	Good	E	3	1019.3	23.0	24.7	Slight	Low	1/8 Cu	
273	0000	Good	VRB	1	1020.3	22.7	24.7	Slight	Low	4/8 Sc	
Su29	0400	Good	NExN	3	1019.0	22.8	24.7	Slight	Low	5/8 Sc	
	0800	Good	NE	4	1019.0	23.2	24.7	Slight	Low	5/8 Cu,Sc,Ac	
	1200	Mod	NE	6	1018.9	23.8	24.8	Slight	Low	7/8 Cu,Sc	
	1600	Mod	NExN	5	1016.9	24.3	24.8	Slight	Low	7/8 Sc, Ac	
	2000	Mod	NExE	6	1016.7	24.7	24.8	Mod	Low	8/8 Sc,Ac	
274	0000	Mod	NExE	5	1015.8	25.5	24.6	Mod	Low	8/8 Sc	
Mo30	0400	Mod	NE	4	1013.7	26.0	24.2	Mod	Low	8/8 Sc	
	0800	Mod	NE	5	1013.9	25.5	24.3	Mod	Low	8/8 Sc	
	1200	Mod	NExN	5	1013.9	25.1	24.7	Mod	Low	8/8 Ci	Very Hazy
	1600	Mod	NE	5	1012.0	25.1	24.9	Mod	Low	8/8 Ac,Ci	Very Hazy
	2000	Mod	NNE	6	1011.9	24.7	25.8	Mod	Low	SKC	Very Hazy
275	0000	Mod	NExN	5	1011.7	25.5	26.5	Mod	Low	8/8 As	Very Hazy
Tu01	0400	Mod	NxE	5	1009.9	25.6	26.9	Mod	Low	8/8 As	Very Hazy

Day	Time	Vis	Wind Dir	Force	Pressure	Temp Air	Sea	Sea State	Swell	Sky	Notes
	0800	Mod	N	3	1010.0	25.6	27.7	Slight	Low	6/8 Sc	Very Hazy
	1200	Mod	NxW	3	1010.6	26.6	27.3	Slight	V.Low	4/8 Cu	Very Hazy
	1600	Mod	WNW	3	1008.4	27.1	29.4	Smooth	V.Low	5/8 Cu	Very Hazy
	2000	Mod	SWxW	3	1009.0	27.3	28.3	Smooth	V.Low	2/8 Sc	Very Hazy
276	0000	Good	WxS	4	1011.1	27.1	28.5	Slight	V.Low	4/8 Cu	Very Hazy
We02	0400	Good	SWxN	2	1009.7	27.1	28.5	Slight	V.Low	2/8 Cu	Very Hazy
	0800	Mod	WxS	3	1010.9	27.1	28.6	Slight	V.Low	2/8 Cu,Ac	Very Hazy
	1200	Mod	W	2	1012.3	28.4	28.5	Smooth	V.Low	4/8 Cu	Hazy
	1600	Mod	Calm	0	1010.5	28.2	29.4	Calm	V.Low	2/8 Cu	Hazy
	2000	Mod	SE	3	1011.4	26.6	28.9	Smooth	V.Low	8/8 Cu,Sc	Sh Rain, Cb seen earlier
277	0000	Good	SExS	5	1012.6	26.3	28.2	Slight	Low	2/8 Cu,Ac	
Th03	0400	Good	ESE	2	1011.1	26.9	28.4	Smooth	Low	3/8 Cu	
	0800	Good	SExE	2	1012.4	26.7	28.4	Smooth	Low	7/8 Cu,Sc,Ac,Ci	Haze Gone, Very Clear
	1200	Good	SExE	2	1013.5	27.1	28.4	Smooth	V.Low	3/8 Cu,Ci	
	1600	Good	S	1	1010.5	27.4	28.8	Smooth	V.Low	2/8 Cu,Ci	
	2000	Good	SExS	3	1012.2	27.2	29.1	Smooth	V.Low	6/8 TCu	RaShowers
278	0000	Good	SE	1	1013.2	27.0	28.7	Smooth	V.Low	3/8 Cu,Ci	
Fr04	0400	Good	SE	1	1011.6	26.8	28.7	Smooth	V.Low	SKC	
	0800	Good	E	1	1012.7	26.8	28.4	Smooth	V.Low	3/8 Cu,Ci	
	1200	Good	VRB	1	1013.9	27.5	28.6	Smooth	V.Low	3/8 TCu,Ac,Ci	RaShowers
	1600	Mod	SWxS	2	1011.7	25.5	28.4	Slight	Low	8/8 Cb,TCu,Sc	RaShowers
	2000	Poor	SE	4	1013.2	23.5	27.9	Mod	Low	8/8 Cb,TCu,Sc	Heavy RaShowers
279	0000	Mod	SWxW	4	1012.6	24.6	27.6	Slight	Low	6/8 St,Cu	
Sa05	0400	Mod	SSE	4	1010.9	25.6	27.7	Slight	Low	8/8 Sc	
	0800	Good	SSE	4	1011.5	25.1	27.1	Slight	Low	7/8 Cu,Sc,Ac	
	1200	Good	SExS	4	1012.8	25.8	26.9	Slight	Low	5/8 Cu,Ac	
	1600	Good	SE	5	1010.1	26.0	27.5	Slight	Low	4/8 TCu,Ac	
	2000	Good	SE	3	1011.1	25.8	26.8	Slight	Low	5/8 TCu	
280	0000	Good	SE	4	1012.4	25.5	26.3	Slight	Low	4/8 TCu,Ac,Ci	RaSh during last hour
Su06	0400	Good	SE	4	1010.2	25.2	26.3	Slight	Low	2/8 Cu	
	0800	Good	SExE	5	1011.1	25.1	26.4	Slight	Low	3/8 Cu	
	1200	Good	SE	4	1012.9	25.4	26.3	Slight	Low	2/8 TCu,Ac	
	1600	Good	SE	5	1009.8	25.7	26.6	Slight	Low	2/8 TCu,Cu,Ci	
	2000	Good	ESE	5	1010.5	25.7	26.6	Slight	Low	3/8 Cu	
281	0000	Good	SExE	4	1012.6	25.7	26.3	Mod	Low	2/8 Cu,Ac	RaSh during last 4 hours
Mo07	0400	Good	SE	4	1010.8	25.2	26.3	Mod	Low	2/8 Cu	
	0800	Good	SExE	5	1011.5	25.1	26.5	Mod	Low	1/8 TCu, Sc	
	1200	Good	SE	4	1013.6	25.9	26.7	Mod	Low	2/8 Cu	
	1600	Good	ESE	5	1011.1	25.3	26.8	Mod	Low	2/8 Cu,Sc	
	2000	Good	ExS	4	1012.8	25.3	26.8	Mod	Low	7/8 TCu,Sc	RaSh during last 4 hours
282	0000	Good	SExE	6	1014.6	25.4	26.7	Rough	Mod	2/8 Cu	
Tu08	0400	Good	ESE	6	1013.2	25.1	26.4	Rough	Mod	3/8 Cu,Sc	
	0800	Good	ESE	5	1014.4	25.1	26.6	Mod	Mod	2/8 Cu	
	1200	Good	E	4	1016.4	25.4	26.2	Mod	Mod	2/8 Cu,Ac	
	1600	Good	ESE	5	1014.2	25.3	26.3	Mod	Mod	3/8 Cu	
	2000	Good	ESE	5	1014.9	25.1	26.2	Slight	Mod	4/8 Cu	
283	0000	Good	ESE	4	1017.3	24.7	25.8	Slight	Mod	3/8 Cu	
We09	0400	Good	ESE	4	1015.5	24.4	25.5	Slight	Low	3/8 TCu,Cu	
	0800	Good	SExE	4	1015.6	24.1	25.9	Slight	Low	3/8 Cu	
	1200	Good	ExS	4	1017.6	24.4	26.0	Slight	Low	4/8 TCu	
	1600	Good	ExS	3	1015.7	24.4	26.1	Slight	Low	3/8 TCu,Cu	
	2000	Good	ESE	3	1015.2	24.2	26.2	Slight	Low	2/8 Cu	
284	0000	Good	ESE	3	1017.6	24.0	25.7	Slight	Low	2/8 Cu	
Th10	0400	Good	ExS	2	1015.5	23.6	25.8	Slight	Low	1/8 Cu	
	0800	Good	E	2	1015.0	23.3	24.8	Slight	Low	6/8 Sc,Cu	RaSh
	1200	Good	SE	4	1017.2	21.9	24.6	Slight	Low	7/8 Sc,Cu	RaSh during past 4 hrs
	1600	Good	SE	4	1015.2	21.9	24.3	Slight	Low	4/8 Sc,Cu	
	2000	Good	SSE	4	1015.0	21.6	24.1	Smooth	Low	1/8 Cu,Ci	

Day	Time	Vis	Wind Dir	Force	Pressure	Temp Air	Sea	Sea State	Swell	Sky	Notes
285	0000	Good	SE	4	1016.7	21.6	24.0	Smooth	Low	2/8 Cu	
Fr11	0400	Good	ESE	3	1015.0	21.1	23.6	Smooth	Low	2/8 Cu	
	0800	Good	NE	2	1015.1	20.7	23.1	Smooth	Low	1/8 Cu,Ac	
	1200	Good	E	2	1016.6	20.7	22.4	Smooth	Low	3/8 Cu,Sc,Ci	
	1600	Good	ExS	3	1014.1	20.7	23.3	Smooth	Low	3/8 Cu,Ci	
	2000	Good	ExS	3	1013.4	20.6	22.5	Smooth	Low	4/8 Cu,Ac,Ci	
286	0000	Good	ExN	3	1016.0	20.4	22.3	Smooth	Low	4/8 Cu,Ac	
Sa12	0400	Good	ENE	3	1015.1	20.1	21.2	Smooth	Low	2/8 Cu	
	0800	Good	NE	3	1013.7	19.8	21.5	Smooth	Low	2/8 Cu,Cs	
	1200	Good	NE	4	1014.7	20.4	20.9	Smooth	Low	3/8 Cu,Cs	
	1600	Good	NE	5	1013.2	20.5	21.1	Smooth	Low	5/8 Cu,Sc,Ci	
	2000	Good	NE	3	1013.0	20.8	20.4	Smooth	Low	4/8 Cu,Cs	
287	0000	Good	ENE	3	1013.4	19.7	19.5	Smooth	Low	7/8 Sc	
Su13	0400	Mod	NE	3	1012.0	19.9	21.0	Smooth	Low	8/8 Sc	Rain
	0800	Mod	NExN	3	1010.6	19.9	20.0	Smooth	Low	8/8 Sc	Rain
	1200	Mod/Poor	NExN	3	1010.4	19.5	19.8	Smooth	Low	8/8 St	Rain
	1600	Mod/Poor	NNE	3	1008.4	19.3	19.5	Smooth	Low	8/8 St,Sc	Rain
	2000	Mod	NNW	3	1006.6	19.3	19.3	Smooth	Low	8/8 St	Rain
288	0000	Poor	ESE	2	1007.2	18.4	18.9	Smooth	Low	8/8 Sc	Rain
Mo14	0400	Poor	ESE	5	1005.5	17.8	19.1	Mod	Low	8/8 St,Sc	Rain
	0800	Poor	SE	6	1004.5	17.2	19.1	Rough	Mod	8/8 St,Sc	
	1200	Good	SE	7	1007.0	17.2	18.9	Rough	Mod	8/8 St,Sc,As	
	1600	Good	SE	6	1008.8	15.5	18.3	Rough	Mod	8/8 St,Sc	
	2000	Good	SE	6	1010.5	16.1	18.3	Rough	Low	8/8 Sc	
289	0000	Good	S	5	1014.2	16.3	18.3	Mod	Low	4/8 Cu,Sc	
Tu15	0400	Good	SSE	5	1014.8	15.5	18.4	Mod	Low	8/8 Sc,Ac	
	0800	Good	SSE	4	1016.8	14.1	15.7	Slight	Low	5/8 Sc	
	1200	Good	SxE	1	1019.9	13.9	16.8	Smooth	Low	4/8 Sc	
	1600	Good	NNE	2	1019.2	15.1	17.7	Smooth	Low	2/8 Cu,Ci	
	2000	Good	N	3	1017.4	15.8	17.3	Slight	Low	3/8 Cu	
290	0000	Good	N	5	1017.0	15.7	18.3	Mod	Low	3/8 Cu,Sc	
We16	0400	Good	NxE	6	1013.9	16.8	18.1	Mod	Low	SKC	
	0800	Good	NxW	7	1013.3	17.1	18.2	Rough	Low	7/8 Sc	
	1200	Good	NNW	6	1013.2	17.4	17.1	Rough	Mod	7/8 Sc,Ac,Cs	
	1600	Good	NxW	7	1012.1	16.1	18.5	Rough	Mod	6/8 Cs	
	2000	Good	NNE	5	1010.2	16.4	16.9	Mod	Mod	3/8 Ci	
291	0000	Good	NE	4	1010.2	14.8	17.8	Mod	Low	3/8 Cb,Cu,Ci	Lightning in Distance
Th17	0400	Good	NE	5	1008.6	16.9	18.8	Mod	Low	8/8 St,Cb,Ac	Lightning in Distance
296											
Tu22	0500	Good	SE	5	1028.5	11.2	19.9	Slight	Low	4/8 Ac	
	0800	Good	SE	4	1027.7	10.3	19.8	Slight	Low	4/8 Sc,Ac	
	1200	Good	SE	4	1029.0	9.3	10.3	Slight	Mod	3/8 Cu,Ac	
	1600	Good	ESE	2	1027.7	7.8	8.6	Smooth	Mod	SKC	
	2000	Good	ENE	2	1026.4	8.8	9.1	Smooth	Mod	1/8 Ci	
297	0000	Good	NNE	2	1026.6	8.6	8.8	Smooth	Mod	SKC	
We23	0400	Good	NxW	3	1025.4	8.9	9.2	Slight	Low	SKC	
	0800	Good	NNW	4	1024.0	9.0	8.9	Slight	Low	3/8 Cs	
	1200	Good	NW	6	1023.8	10.4	9.9	Mod	Low	7/8 Cs,Ac	
	1600	Good	NW	6	1023.3	10.8	11.0	Mod	Mod	7/8 Cs	
	2000	Good	NW	5	1021.8	11.0	12.7	Slight	Mod	7/8 Cs	
298	0000	Good	NW	4	1021.4	10.0	9.7	Slight	Low	7/8 St	
Th24	0400	Good	NNW	4	1019.1	8.3	8.2	Slight	Low	6/8 St	

Day	Time	Vis	Wind Dir	Force	Pressure	Temp Air	Sea	Sea State	Swell	Sky	Notes
	0800	Good	NNW	6	1015.4	9.1	8.4	Mod	Low	1/8 Ci	
	1200	Good	NxW	6	1011.2	8.5	5.6	Mod	Low	6/8 Cs	
	1600	Good	NNW	7	1007.4	7.7	5.5	Rough	Low	4/8 Cs	
	2000	Good	NNW	7	1004.1	7.4	6.1	Rough	Low	7/8 Ac,Cs	
299	0000	Good	NW	6	1002.7	6.7	6.1	Mod	Low	7/8 Ac,Cs	
Fr25	0400	Good	NW	4	1000.5	6.3	5.9	Mod	Low	8/8 As	

Appendix F. Underway sample and chlorophyll log.

Date	Time GMT	Lat dec deg	Long dec deg	temp (O. Log)	Fluor (O. Log)	Salinity (O. Log)	HPLC Vol.	Chl a & HPLC No.	Corrected Chl a ug/l	Nutrient samples	Iodine samples	Bacterial samples
22-Sep	O700	49.73N	5.37W	14.4	5.1	35.06	0.42 litre	1	7.34	M		
(266)	O930	49.69	5.7	14.1	5.4	35.34	0.5	2	2.153			
	1115	49.65	5.93	14.1	4.7	35.4	1	3	2.773	N		
	1310	49.53	6.47	15.9	4.2	35.52	1	4	1.514	O		
	1500	49.43	6.99	16.5	2.5	35.52	1	5	0.623	P		
	1700	49.31	7.57	16.6	2.1	35.58	1	6	0.352	Q		
	1910	49.18	8.32	16.5	1.7	35.6	2 litre	7	0.243	R		
	2100	49.1	8.87	16.5	1.7	35.59	2	8	0.238	S		
	2300	48.98	9.46	16.1	3.4	35.58	2	9	0.606	T		
23-Sep	O100	48.86	10.03	16.2	3.6	35.59	2	10	0.88	U		
(267)	O300	48.75	10.6	16.2	3.9	35.59	2	11	0.668	V		
	O500	48.65	11.2	16.4	2.8	35.57	2	12	0.633	W		
	O700	48.54	11.8	16.4	3.4	35.58	2	13	0.674	X		
	O900	48.43	12.37	16.8	2.2	35.64	2	14	0.455	M		
	1100	48.42	12.51	16.8	2.4	35.65	2	15	0.391	N		
	1300	48.38	12.68	17	2.1	35.64	2	16	0.378	O		
	1505	48.28	13.23	16.9	2	35.62	2	17	0.363	P		
	1700	48.19	13.72	17.1	2.3	35.62	2	18	0.415	Q		
	1900	48.1	14.12	16.3	3.3	35.55	2	19	0.677	R		
	2100	48	14.72	16.5	3.5	35.58	2	20	0.696			
	2300	47.91N	15.18W	16.3	4.3	35.63	2	21	0.92	A		
24-Sep	O100	47.8	15.71	16.3	3.8	35.59	2	22	0.636			
(268)	O300	47.69	16.28	16.4	4.3	35.67	2	23	0.732	B		
	O500	47.61	16.86	17	3.6	35.67	2	24	0.514			
	O800	47.48	17.65	16.6	4.2	35.62	2	25	0.606	C		
	1000	47.38	18.14	16.7	4.6	35.62	2	26	0.751			
	1400	47.09	18.39	16.7	3.3	35.62	2	27	0.755	D		
	1600	46.72	18.59	17.3	3	35.68	2	28	0.487			
	1745	46.29	18.76	17.2	5	35.68	1	29	0.61	E		
	2000	45.82	19.01	17.1	4.5	35.66	1.5	30	0.607			
	2200	45.42	19.19	17.5	2.6	35.65	2	31	0.449	F		
	2400	44.99	19.36	17.6	2.7	35.64	2	32	0.402			
25-Sep	O200	44.55	19.49	18	2.5	35.67	2	33	0.257	A		

Date	Time GMT	Lat dec deg	Long dec deg	temp (O. Log)	Fluor (O. Log)	Salinity (O. Log)	HPLC Vol.	Chl a & HPLC No.	Corrected Chl a ug/l	Nutrient samples	Iodine samples	Bacterial samples
(269)	O400	44.1	19.62	18.4	1.8	35.67	2	34	0.217			
	O600	43.67	19.75	18.4	1.8	35.7	2	35	0.189	B		
	O800	43.22	19.84	19	1.3	35.79	2	36	0.149			
25-Sep	1000	42.8	19.81	19.3	1.3	35.77	2	37	0.14	C		
(269)	1400	42.3	19.78	19.5	1.3	35.72	2	38	0.178	D		
	1600	41.89	19.77	20.2	1.2	36.01	2	39	0.127			
	1800	41.73	20.01	21	1.2	36.03	2	40	0.114	E		
	2000	41.35N	20.03W	20.9	1.1	35.86	2	41	0.12			
	2200	40.92	19.99	22	1.1	36.17	2	42	0.138	G		
	2400	40.49	19.96	21.5	1.1	36.18	2	43	0.142			
26-Sep	O200	40.09	19.93	21.6	1.1	36.18	2	44	0.116	H		
(270)	O400	39.64	19.9	21.7	1.1	36.16	2	45	0.122			
	O600	39.21	19.85	21.6	1.1	36.16	2	46	0.114	I		
	O900	38.55	19.77	21.6	1.1	36.15	2	47	0.096			
	1100	38.11	19.73	22	1	36.33	2	48	0.085	J		
	1500	37.84	20.12	23.3	0.9	36.54	2	49	0.087	K		
	1700	37.47	20.22	23.3	0.9	36.51	2	50	0.074			
	1900	37.12	20.33	23.1	0.9	36.62	2	51	0.071	L		
	2100	36.68	20.46	23.1	0.9	36.55	2	52	0.075			
	2300	36.36	20.56	23.2	0.9	36.32	2	53	0.089	A		
27-Sep	O100	36.01	20.66	23.3	0.9	36.49	2	54	0.095			
(271)	O300	35.56	20.81	23.2	0.9	36.34	2	55	0.092	B		
	O500	35.23	20.92	23	1	36.27	2	56	0.104			
	O700	34.84	21.03	23.5	0.9	36.57	2	57	0.079	C		
	O900	34.46	21.14	23.6	0.9	36.55	2	58	0.071			
	1100	34.07	21.25	23.8	0.9	36.55	2	59	0.077	D		
	1500	33.74	21.31	24.1	1	36.62	2	60	0.087	E		
	1700	33.37N	21.36W	24.4	1	36.75	2	61	0.069			
	1855	33.02	21.41	24.4	0.9	36.75	2	62	0.07	F		
	2100	32.6	21.46	24.3	1	36.86	2	63	0.075			
	2303	32.13	21.51	23.9	0.9	37.02	2	64	0.064	G		
28-Sep	O100	31.7	21.55	23.8	1	36.96	2	65	0.056			
(272)	O300	31.24	21.59	24	1	36.94	2	66	0.052	H		
	O500	30.81	21.64	24.2	1	36.97	2	67	0.056			
	O700	30.38	21.7	24.2	0.9	36.97	2	68	0.052	I		

Date	Time GMT	Lat dec deg	Long dec deg	temp (O. Log)	Fluor (O. Log)	Salinity (O. Log)	HPLC Vol.	Chl a & HPLC No.	Corrected Chl a ug/l	Nutrient samples	Iodine samples	Bacterial samples
	0900	29.95	21.75	24.3	0.9	37.22	2	69	0.058			
	1103	29.52	21.81	24.5	0.9	37.22	2	70	0.055	J		
	1500	29.12	21.85	24.8	0.9	37.22	2	71	0.047			
	1705	28.73	21.89	24.8	0.9	37.28	2	72	0.038	K		
	1902	28.35	21.93	24.8	0.9	37.2	2	73	0.053			
	2104	27.9	21.98	24.5	0.9	37.19	2	74	0.047	L		
	2305	27.46	21.93	24.7	0.9	37.17	2	75	0.085			
29-Sep	0106	26.99	21.84	24.6	0.9	37.35	2	76	0.051	M		
(273)	0300	26.57	21.75	24.6	0.9	37.33	2	77	0.057			
	0508	26.11	21.66	24.7	0.9	37.31	2	78	0.064	N		
	0700	25.65	21.58	24.7	0.9	37.35	2	79	0.065			
	0901	25.18	21.49	24.7	1	37.09	2	80	0.085	O		
	1100	24.73N	21.41W	24.8	1	37.1	2	81	0.132			
	1503	24.34	21.33	24.9	1	37.05	2	82	0.115	P		
	1700	23.97	21.26	24.8	1	36.9	2	83	0.111			
	1900	23.57	21.2	24.8	1	36.8	2	84	0.096	Q,R		
	2100	23.12	21.11	24.8	1.1	36.56	2	85	0.143			
	2303	22.66	21.02	24.6	1.1	36.77	2	86	0.146	G		
30-Sep	0100	22.23	20.96	24.2	1.2	36.74	2	87	0.164	H		
(274)	0300	21.78	20.86	24.1	1.7	36.28	2	88	0.329	I		
	0500	21.32	20.77	24.2	1.1	36.42	2	89	0.171	J		
	0700	20.83	20.68	24	1.6	36.25	2	90	0.222	K		
	0900	20.37	20.6	24.3	1.3	36.3	2	91	0.238	L		
	1700	19.97	20.62	24.5	2.5	36.23	2	92	0.524	M		1
	1835	19.71	20.54	25.4	1.4	36.36	2	93	0.288	N		2
	2105	19.32	20.42	25.5	1.3	36.38	2	94	0.265	O		3
	2305	18.97	20.46	26.3	1.2	36.29	2	95	0.198	P		4
01-Oct	0111	18.57	20.42	26.7	1.1	36.17	2	96	0.174	Q		5
(275)	0259	18.25	20.42	26.9	1.1	36.16	2	97	0.217	R		6
	0500	17.87	20.42	27.1	1.1	36.19	2	98	0.171	G		7
	0700	17.52	20.41	27.6	1.1	36.16	2	99	0.208	H		8
	0903	17.13	20.41	27.2	1.2	36.09	2	100	0.218	I		9
	1100	16.79N	20.41W	27.1	1.1	36.07	2	101	0.222	J		10
	1300	16.43	20.41	27.7	1.1	36.08	2	102	0.244	K		11
	1500	16.07	20.42	28.9	1	35.65	2	103	0.172	L		12

Date	Time GMT	Lat dec deg	Long dec deg	temp (O. Log)	Fluor (O. Log)	Salinity (O. Log)	HPLC Vol.	Chl a & HPLC No.	Corrected Chl a ug/l	Nutrient samples	Iodine samples	Bacterial samples
	1700	15.71	20.48	29.4	1	35.65	2	104	0.151	M		13
	1900	15.36	20.43	28.7	1	35.77	2	105	0.183	N		14
	2100	15.02	20.42	28.3	1	35.84	2	106	0.174	O		15
	2300	14.68	20.39	28.3	1.1	36.03	2	107	0.268	P		16
	2400	14.5	20.38	28.4	1.8	36.2	2	108	0.768			17
02-Oct	O100	14.34	20.37	28.4	1.5	36.17	2	109	0.58	S		18
(276)	O300	14	20.36	28.5	1.9	36.12	2	110	0.821	T		19
	O500	13.66	20.37	28.6	1	35.43	2	111	0.17	U		20
	O700	13.34	20.39	28.7	1	35.44	2	112	0.169	V		21
	O900	13.01	20.45	28.6	1	35.7	2	113	0.158	W		22
	1300	12.69	20.57	28.7	1	35.16	2	114	0.157			23
02-Oct	1500	12.38	20.72	29	1	35.45	2	115	0.138			24
(276)	1700	12.07	20.88	29.1	1	35087	2	116	0.204			25
	1900	11.75	21.02	29.3	1	35.57	2	117	0.129			26
	2100	11.43	21.17	29.1	1	35.28	2	118	0.132			27
	2300	11.06	21.47	28.5	1	35.25	2	119	0.181	H		28
03-Oct	O100	10.68	21.52	28.3	1	35.04	2	120	0.167	M		29
(277)	O300	10.34N	21.69W	28.3	1	35.33	2	121	0.161	M?		30
	O500	9.97	21.85	28.4	1	35.47	2	122	0.174	N		31
	O700	9.65	21.99	28.4	1	35.45	2	123	0.182	O		32
	O900	9.34	22.14	28.4	1.1	35.4	2	124	0.207	P		33
	1300	8.99	22.31	28.6	0.9	35.59	2	125	0.161	Q		34
	1500	8.65	22.46	28.8	0.9	35.65	2	126	0.119	R		35
	1700	8.31	22.6	29	1	35.48	2	127	0.125	S		36
	1900	7.97	22.74	29	1	35.34	2	128	0.129	M		37
	2109	7.61	22.88	29.1	1	35.54	2	129	0.114	T		38
	2302	7.24	23.03	28.5	1	35.1	2	130	0.113	U		39
04-Oct	O101	6.87	23.2	28.8	1	34.83	2	131	0.115	V		40
(278)	O259	6.5	23.38	28.9	1	34.99	2	132	0.125			41
	O458	6.14	23.54	28.6	1	34.96	2	133	0.118	W		42
	O700	5.78	23.71	28.5	1	34.77	2	134	0.135		S1	43
	O900	5.44	23.86	28.5	1	34.7	2	135	0.113	X		44
	1300	5.09	24.05	28.8	0.9	34.64	2	136	0.127	N	S2	45
	1500	4.77	24.21	28.8	1	34.75	2	137	0.141			
	1700	4.4	24.37	27.7	1.1	34.15	2	138	0.191	O	S3	46

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	1900	4.05	24.53	27.7	1.1	34.11	2	139	0.18			
	2100	3.7	24.69	27.8	1	34.99	2	140	0.202	P	S4	47
	2300	3.35N	24.85W	27.7	1.1	35.2	2	141	0.178			
05-Oct	O100	2.99	25.02	26.9	1	35.55	2	142	0.111	Q	S5	48
(279)	O303	2.64	25.18	27.7	1	35.71	2	143	0.148			
	O502	2.29	25.33	27.6	1	35.74	2	144	0.147	R	S6	49
	O700	1.95	25.49	27.3	1.1	35.68	2	145	0.134			
	O902	1.58	25.66	26.8	1.1	35.58	2	146	0.141	S	S7	50
	1300	1.2	25.82	27	1	35.6	2	147	0.136	T	S8	51
	1503	0.88	25.97	27.3	1	35.7	2	148	0.141			
	1643	0.43N	26.17W	27.4	1	35.72	2	149	0.096	U	S9	52
	2100	0.13S	26.41W	26.3	1.4	35.95	2	150	0.13	V	S10	53
	2300	0.45	26.53	26.3	1.7	35.99	2	151	0.182			
06-Oct	O100	0.77	26.68	26.3	1.1	36.04	2	152	0.097	W	S11	54
(280)	O300	1.12	26.85	26.3	1	36.06	2	153	0.084			
06-Oct	O500	1.44	27.01	26.4	1.1	36.13	2	154	0.102	X	S12	55
(280)	O703	1.77	27.16	26.3	1.2	36.12	2	155	0.125			
	O900	2.09	27.31	26.3	1.1	36.11	2	156	0.121	M	S13	56
	1300	2.49	27.51	26.5	1	36.11	2	157	0.109	N	S14	57
	1700	3.18	27.8	26.6	1	36.07	2	158	0.101	O	S15	58
	1902	3.51	27.96	26.6	1.1	36.04	2	159	0.071			
	2100	3.88	28.11	26.4	1	36.06	2	160	0.068	P	S16	59
	2302	4.26S	28.28W	26.4	1	36.03	2	161	0.095			
07-Oct	O100	4.65	29.45	26.3	1.1	36.01	2	162	0.091	Q	S17	60
(281)	O304	5.05	28.63	26.3	1	36	2	163	0.087			
	O500	5.43	28.8	26.3	1.1	36.01	2	164	0.085	R	S18	61
	O703	5.8	28.93	26.4	1	36.03	2	165	0.084			
	O900	6.14	29.12	26.5	1	36	2	166	0.09	S	S19	62
	1300	6.59	29.32	26.7	1	36.02	2	167	0.098	T	S20	63
	1500	6.93	29.5	26.8	1	36.05	2	168	0.085			
	1704	7.33	29.67	26.8	1	36.05	2	169	0.084	U	S21	64
	1900	7.66	29.82	26.8	1	36.05	2	170	0.076			
	2100	8.02	30	26.8	0.9	36.05	2	171	0.063	V	S22	65
	2300	8.38	30.15	26.7	1	36.09	2	172	0.058			
08-Oct	O100	8.75	30.32	26.6	0.09	36.7	2	173	0.057	W	S23	66

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(282)	O300	9.09	30.42	26.5	1	36.24	2	174	0.049	X		
	O500	9.46	30.64	26.4	1	36.29	2	175	0.055	O	S24	67
	O700	9.84	30.8	26.6	0.9	36.25	2	176	0.056			
	O900	10.24	30.98	26.5	1	36.25	2	177	0.055	N	S25	68
	1000	10.46	31.08	26.4	0.9	36.31	2	178	0.051			
	1400	10.91	31.31	26.2	0.9	36.41	2	179	0.047	M	S26	69
	1600	11.28	31.47	26.3	0.9	36.45	2	180	0.052			
	1800	11.66	31.64	26.2	0.9	36.44	2	181	0.044	P	S27	70
	2000	12.03	31.8	26.2	0.9	36.67	2	182	0.04			
	2200	12.43	31.98	26	0.9	36.79	2	183	0.047	Q	S28	71
	2400	12.81	32.14	25.8	0.9	36.89	2	184	0.045			
	O200	13.23	32.28	25.8	0.9	36.86	2	185	0.043	R	S29	72
	O400	13.63	32.41	25.5	0.9	37.06	2	186	0.038			
	O600	14.05	32.54	25.8	0.9	36.78	2	187	0.045	S	S30	73
	O800	14.47	32.67	25	0.9	36.75	2	188	0.045			
	1000	14.88	32.79	26.1	1	36.8	2	189	0.05	T	S31	74
	1600	15.21	33.29	26.2	0.9	36.96	2	190	0.045	U	S32	75
	1805	15.57	33.46	26.3	0.9	36.78	2	191	0.035			
	2011	15.96	33.64	26.1	0.9	36.94	2	192	0.047	W	S33	76
09-Oct	2203	16.31	33.79	26	0.9	37.08	2	193	0.05			
(283)	2400	16.7	33.96	25.8	0.9	37.19	2	194	0.061	X	S34	77
10-Oct	O153	17.03	34.13	25.7	0.9	37.2	2	195	0.057			
(284)	O400	17.43	34.34	25.8	0.9	37.18	2	196	0.04	M	S35	78
	O600	17.8	34.5	25.1	0.9	37.27	2	197	0.053			
	O800	18.15	34.69	24.8	1	37.16	2	198	0.08	N	S36	79
	1001	18.54	34.89	24.6	1	37.1	2	199	0.08			
	1400	18.97	35.09	24.6	0.9	37.1	2	200	0.066	O	S37	80
	1600	19.35	35.25	24.3	0.9	37.04	2	201	0.064			
	1804	19.72	35.42	24.2	1	37	2	202	0.069	P	S38	81
	2000	20.08	35.58	24.1	1	37.04	2	203	0.067			
	2200	20.44	35.76	24.1	1	37.18	2	204	0.09	Q	S39	82
11-Oct	OO15	20.83	35.96	23.9	1	37.19	2	205	0.086			
(285)	O200	21.16	36.12	23.4	1	37.09	2	206	0.094	R	S40	83
	O400	21.52	36.29	23.6	1	37.15	2	207	0.098			
	O600	21.87	36.48	23	1	36.94	2	208	0.082	S	S41	84

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	O800	22.23	36.64	23.1	1	37.01	2	209	0.087			
	1003	22.62	36.81	22.5	1.1	36.8	2	210	0.099	T	S42	85
	1405	22.97	36.99	23	1	36.94	2	211	0.106	U		86
	1601	23.33	37.17	23.3	1	37.03	2	212	0.091			
	2000	23.93	37.46	22.6	1.1	36.85	2	213	0.085	V	S43	87
	2204	24.32	37.66	22.4	1	36.8	2	214	0.083			
	2400	24.69	37.85	22.2	1	36.62	2	215	0.089	W	S44	88
12-Oct	O200	25.05	38.05	21.8	1	36.63	2	216	0.073			
(286)	O400	25.39	38.37	21.1	1	36.64	2	217	0.086	X	S45	89
	O600	25.68	38.67	21.5	1.1	36.76	2	218	0.081			
	O800	25.99	38.99	21.4	1.1	36.75	2	219	0.109	M	S46	90
	1000	26.33	39.33	21	1	36.62	2	220	0.098			
	1400	26.73	39.71	21.1	1	36.66	2	221	0.115	N	S47	91
	1600	27	40.01	21.1	1	36.64	2	222	0.125			
	1802	27.15	40.16	21.6	1	36.78	2	223	0.114	O	S48	92
	2004	27.45	40.45	20.2	1	36.39	2	224	0.088			
	2204	27.74	40.75	20.1	1	36.21	2	225	0.093	P	S49	93
	2400	28.03	41.06	19.5	1	36.11	2	226	0.094			
13-Oct	O205	28.32	41.38	19.5	1.1	36.11	2	227	0.102	Q	S50	94
(287)	O402	28.62	41.67	21	1.1	36.62	2	228	0.085			
	O603	28.93	41.98	21.1	1.2	36.66	2	229	0.129	R	S51	95
	O801	29.24	42.3	20.1	1.1	36.37	2	230	0.098			
	1000	29.57	42.63	20.1	1.1	36.38	2	231	0.098	S	S52	96
13-Oct	1400	29.95	43.02	19.7	1.1	36.21	2	232	0.142	T	S53	97
(287)	1604	30.23	43.35	19.5	1.1	36.05	2	233	0.129			
	1800	30.5	43.65	19.3	1.3	35.86	2	234	0.198	U	S54	98
	2005	30.79	43.94	19.3	1.2	36.13	2	235	0.178			
	2215	31.08	44.25	19.3	1.2	36.22	2	236	0.117	V	S55	99
	2400	31.3	44.49	18.9	1.2	36.11	2	237	0.125			
14-Oct	O200	31.56	44.78	19	1.2	36.17	2	238	0.122	W	S56	100
(288)	O400	31.83	45.07	19.1	1.2	36.23	2	239	0.158			
	O600	32.11	45.34	18.5	1.4	36.12	2	240	0.173	X	S57	101
	O800	32.36	45.6	19	1.5	36.22	2	241	0.278			
	1000	32.61	45.88	18.1	1.4	36.09	2	242	0.136	M	S58	102
	1403	32.87	46.2	18.9	2	36.2	2	243	0.45	N	S59	103

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	1604	33.15	46.45	17.6	2	35.93	2	244	0.295			
	1802	33.4	46.76	18	1.8	35.88	2	245	0.404	O?	S60	104
	2003	33.63	47.02	18.3	1.8	36.05	1.5	246	0.334			
	2203	33.89	47.3	18.4	1.4	35.98	1.5	247	0.18	M	S61	105
	2400	34.14	47.57	18.3	1.5	36.05	2	248	0.2			
15-Oct	O200	34.49	47.83	18.4	1.5	36.06	2	249	0.241	N	S62	106
(289)	O409	34.71	48.15	18.6	1.3	35.97	2	250	0.154			
	O621	34.97	48.48	18.2	1.4	34.68	2	251	0.176	O	S63	107
	O804	35.18	48.76	15.5	4.8	35.19	2	252	0.571			
	O854	35.26	48.88	15.1	5.5	34.72	1	252A	0.439			
	1107	35.53	49.3	15.7	2.3	35.11	1.5	253	0.456	P	S64	108
	1502	35.8	49.8	17.3	1.6	35.78	1.5	254	0.397			
	1715	36.09	50.06	17.4	1.4	35.85	2	255	0.275	Q	S65	109
	1908	36.22	50.17	17.5	1.5	35.8	2	256	0.305			
	2100	36.42	50.4	17.1	2	35.82	1.5	257	0.391	R	S66	110
	2300	36.65	50.67	18.4	1.2	35.96	2	258	0.099			
16-Oct	O100	36.9	50.98	18.3	1.4	35.98	2	259	0.117	M	S67	111
(290)	O310	37.13	51.3	18.2	1.3	35.92	2	260	0.116			
	O457	37.34	51.57	18	1.4	35.9	2	261	0.198	N	S68	112
	O701	37.6	51.83	18.2	1.4	36.06	2	262	0.204			
	O900	37.91	51.93	16.8	1.7	35.64	2	263	0.358	O	S69	113
	1100	37.86	52.14	17.4	1.7	35.73	2	264	0.392			
22-Oct	1345	38.02	55	11.1	3.5	33.78	1	265	1.616	S	S70	114
(296)	1500	38.31	54.99	9	2.3	33.84	1.5	266	1.136			
	1700	38.79	55	8.9	1.7	33.91	1.5	267	0.846	T	S71	115
	1905	39.28	54.97	8.4	1.7	33.94	1.5	268	0.696			
	2105	39.74	54.96	9.1	4	34.23	1	269	0.816	U	S72	116
22-Oct	2301	40.2	54.98	8.8	5	34.17	1	270	0.646			
23-Oct	O100	40.67	55.01	9.2	3.1	34.09	1	271	0.436	V	S73	117
(297)	O300	41.17	55	9.3	3.2	34.06	1	272	0.506			
	O500	41.69	54.99	9.4	3.9	34.08	1	273	0.696	W	S74	118
	O700	42.18	54.99	9	2.4	34.1	1	274	0.286			
	O900	42.66	54.99	9.8	4.8	34.39	1	275	0.836	X	S75	119
	1105	43.17	54.99	10.1	3.5	34.52	1	276	0.896			
	1700	43.78	55.06	11	3	34.71	1	277	1.126	M	S76	120

Date	Time GMT	Lat dec deg	Long dec deg	temp (O. Log)	Fluor (O. Log)	Salinity (O. Log)	HPLC Vol.	Chl a & HPLC No.	Corrected Chl a ug/l	Nutrient samples	Iodine samples	Bacterial samples
	1900	44.01	55	11.5	3.1	34.83	1	278	1.106			
	2100	44.57	54.99	11.5	4	34.88	1	279	1.046	N	S77	121
	2300	45.01	54.97	10.4	4	34.51	1	280	0.815			
24-Oct	O100	45.46	54.98	8.7	3.3	34.14	1.5	281	0.507	O	S78	122
(298)	O300	45.9	55	7.7	3.2	34.1	1	282	0.454			
	O500	46.35	55.15	8.6	3.3	34.35	1	283	0.683	P	S79	123
	O656	46.77	55.33	9.8	2.8	34.53	1	284	0.904			
	O858	47.21	55.52	8.4	3.3	34.16	1	285	0.817	Q	S80	124
	1105	47.65	55.73	8.1	2.3	34.11	1.5	286	0.672			
	1503	47.11	55.92	5.4	1.5	33.77	1.5	287	0.947	R	S81	125
	1656	48.45	56.1	5.5	1.5	33.81	1.5	288	0.344			
	1901	48.82	56.26	5.5	1.3	33.82	1.5	289	0.178	S	S82	126
	1955	48.97	56.34	5.9	7	33.75	1	290	1.726			
	2024	49.05	56.39	6.3	13.2	33.741	0.5	291	3.896			
	2306	49.56	56.63	6.2	14.6	33.67	0.5	292	7.181	A	S83	127
25-Oct	O100	49.97	56.82	6.2	10.6	33.6	0.5	293	5.391			
(299)	O300	50.58	57.02	5.8	2.4	33.6	1.5	294	1.081	B	S84	128
	O500	50.84	57.23	6	2.8	33.51	2	295	0.81			
	O700	51.26	57.42	6.3	2.1	33.47	2	296	0.566	G	S85	129
	O900	51.72	57.6	6.2	2.9	33.46	1.5	297	0.813			
	1100	51.93	57.89	6.2	2.8	33.41	1.5	298	0.78	T	S86	130

Appendix G. Station HPLC and chlorophyll log. HPLC to be analysed at PML.
(chlorophyll analysed on board by the Welshmeyer fluorescence method)

DATE	CRUISE STATION	LAT	LONG		HPLC DEPTH(m) (2.1 litres)		CHL A DEPTH(m) (0.25 lit)	*FLUOR*	*Correct* Chl a µg/l
22-Sep	1	49.68N	5.69W		2		2	61.2	1.753
(266)					6		6	67	1.919
					10		10	63.8	1.828
					20		30	52.4	1.501
					30		70	4.41	0.125
					50				
					70				
24-Sep	3	47.37N	18.21W		2		7	22.6	0.648
(268)					7		20	25.2	0.722
					20		30	25.2	0.722
					30		40	10.8	0.309
					40		60	3.66	0.104
					50				
					60		P7	26.2	0.751
					100		P40	17.3	0.496
					150				
25-Sep	4	42.72N	19.82W		7		7	6.5	0.186
(269)					20		20	8.82	0.252
					30		30	12.7	0.364
					40		40	17.7	0.507
					50		60	7.55	0.216
					60				
					80		P7	6.08	0.174
					100		P40	12.8	0.367
					150				
26-Sep	5	38.17N	20.01W		7		7	6.84 (?)	
(270)					20		20	2.37	0.068
					30		30	2.5	0.071
					40		40	3.56	0.102
					50		60	7	0.2
					60				
					80		P7	2.9	0.083
					100		P40	4.56	0.13
					150				
27-Sep	6	34.03N	21.26W		7		7	2.66	0.075
(271)					80			2.89	0.082
							80	17	0.487
								14.5	0.415
							P7	2.85	0.081
							P80	15.5	0.444
28-Sep	7	29.49N	21.81W		7		7	2.02	0.057
(272)					20		60	4.45	0.127
					40		100	9.25	0.265
					60		110	8.91	0.255
					80		120	5.86	0.168

DATE	CRUISE	LAT	LONG		HPLC		CHL A	*FLUOR*	*Correct*
	STATION				DEPTH(m)		DEPTH(m)		Chl a µg/l
					(2.1 litres)		(0.25 lit)		
.					100				
.					110		P7	1.92	0.055
.					120		P110	8.89	0.254
.					150				
29-Sep	**8**	24.68N	21.40W		7		7	5.02	0.143
(273)					20		80	8.08	0.231
					50		100	16.9	0.484
					80		102	14.4	0.412
					100		110	12	0.344
					102				
					110		P7	4.95	0.141
					120		P90	9.82	0.281
					150				
30-Sep	**9**	20.08N	20.63W		7		7	11.3	0.323
(274)					20		20	13	0.372
					30		30	17	0.487
					40		40	37.1	1.063
					50		60	5.22	0.149
					60				
					80		P7	11.1	0.318
					100		P40	28.2	0.808
					150				
02-Oct	**10**	12.76N	20.54W		7		7	6.06	0.173
(276)					20		40	31.3	0.897
					40		45	25.4	0.728
					45		50	23.9	0.685
					50		60	19.4	0.556
					60				
					80		P7	6.73	0.192
					100		P40	20.8	0.596
					150				
03-Oct	**11**	9.05N	22.27W		7		7	6.28	0.18
(277)					20		20	8.08	0.231
					30		30	10.6	0.303
					40		45	23.1	0.662
					45		60	16.8	0.481
					60				
					80		P7	5.83	0.167
					100		P50	21.2	0.607
					150				
04-Oct	**12**	5.17N	24.02W		7		7	4.34	0.124
(278)					20		30	7.98	0.228
					30		60	16.4	0.47
					40		74	21.6	0.619
					60		90	16.5	0.473
					74				
					90		P7	5.73	0.164
					100		P70	20.4	0.585
					150				

DATE	CRUISE STATION	LAT	LONG		HPLC DEPTH(m) (2.1 litres)		CHL A DEPTH(m) (0.25 lit)	*FLUOR*	*Correct* Chl a µg/l
05-Oct	**13**	1.29N	25.78W		7		7	6.32	0.181
(279)					40		60	12.6	0.361
					60		70	17.9	0.513
					70		78	29.9	0.857
					78		100	12	0.344
					90				
					100		P7	5.63	0.161
					120		P80	25.9	0.742
					150				
06-Oct	**14**	2.39S	27.45W		7		7	4.22	0.12
(280)					20		40	4.69	0.134
					40		80	8.07	0.231
					60		90	15.1	0.432
					80		120	5.57	0.159
					90				
					100		P7	4.6	0.131
					120		P85	13.7	0.392
					150				
07-Oct	**15**	6.48S	29.27W		7		7	2.82	0.08
(281)					50		80	4.09	0.117
					80		90	10.3	0.295
					90		110	14.3	0.409
					100		130	5.13	0.147
					110				
					120		P7	3.67	0.105
					130		P110	14.6	0.418
					150				
08-Oct	**16**	10.78S	31.25W		7		7	1.52	0.043
(282)					50		50	2.17	0.062
					75		100	5.17	0.148
					100		130	11	0.315
					120		160	4.32	0.123
					130				
					140		P7	1.76	0.05
					160		P130	10.2	0.292
					200				
09-Oct	**17**	14.89S	33.12W		7		7	2.07	0.059
(283)					50		50	1.73	0.049
					80		100	3.31	0.094
					100		140	11.8	0.338
					120		180	5.56	0.159
					140				
					160		P7	2.19	0.062
					180		P140	9.79	0.28
					200				
10-Oct	**18**	18.87S	35.05W		7		7	2.42	0.069
(284)					30		60	2.54	0.072
					60		110	7.63	0.218

DATE	CRUISE	LAT	LONG		HPLC		CHL A	*FLUOR*	*Correct*
	STATION				**DEPTH(m)**		**DEPTH(m)**		**Chl a µg/l**
					(2.1 litres)		**(0.25 lit)**		
					90		125	13.9	0.398
					110		160	5.75	0.164
					125				
					140		P7	2.96	0.084
					160		P125	12.4	0.355
					200				
11-Oct	**19**	22.93S	36.95W		7		7	3.51	0.1
(285)					20		40	3.74	0.107
					40		80	9.96	0.285
					60		100	13	0.372
					80		130	4.9	0.14
					100				
					120		P7	3.86	0.11
					130		P100	8.6	0.246
					150				
12-Oct	**21**	26.62S	39.60W		7		7	3.94	0.112
(286)					20		40	4.35	0.124
					40		80	11.5	0.329
					60		95	15.3	0.438
					80		120	7.79	0.223
					95				
					110		P7	4.32	0.123
					120		P95	15.5	0.444
					150				
13-Oct	**23**	29.85S	42.91W		7		7	4.2	0.12
(287)					30		60	7.5	0.215
					60		80	21.4	0.613
					70		90	20.4	0.584
					80		120	6.58	0.188
					90				
					100		P7	4.89	0.14
					120		P90	20.6	0.59
					150				
14-Oct	**24**	32.80S	46.12W		7		7	13	0.372
(288)					20		40	12.2	0.349
					40		50	15	0.429
					50		60	10.8	0.309
					60		80	4.64	0.133
					80				
					100		P7	13.5	0.387
					120		P60	16	0.458
					150				
15-Oct	**25**	35.71S	49.57W		7		7	19.7	0.564
(289)					10		20	19.1	0.547
					20		30	23.2	0.665
					30		50	10.5	0.301
					40		80	1.79	0.051
					50				
					60		P7	23.1	0.662

DATE	CRUISE STATION	LAT	LONG		HPLC DEPTH(m) (2.1 litres)		CHL A DEPTH(m) (0.25 lit)	*FLUOR*	*Correct* Chl a µg/l
					80		P30	22	0.63
					150				
16-Oct	**27**	37.81S	52.19W		7		7	12.1	0.347
(290)					20		30	18.3	0.524
					30		50	17.4	0.498
					40		60	14.1	0.404
					50		80	6.06	0.173
					60				
					80		P7	15.6	0.447
					100		P40	14	0.401
					150				
23-Oct	**28**	43.58S	55.01W		7		7	37.2	1.066
(297)					20		20	35.5	1.016
					30		30	31.7	0.909
					40		50	6.07	0.174
					50		80	1.61	0.045
					60				
					80		P7	38.3	1.098
					100		P30	36.7	1.052
					150				
24-Oct	**29**	48.00S	55.88W		7		7	12.6	0.361
(298)					20		40	12	0.344
					40		70	16.8	0.481
					50		80	16.9	0.484
					70		120	10.2	0.292
					80				
					100		P7	12	0.344
					120		P80	17	0.487
					150				
25-Oct	**30**	51.93S	57.89W		7		7	26.6	0.762
(299)					20		20	26.8	0.768
					30		30	21.9	0.628
					40		40	15.3	0.438
					50		50	12.2	0.349
					60				

Appendix H. UOR Tow log

Tow No	Day	Date	Time;GMT	Ops/Wire	Lat	Long	Tow time	No Unds	Depth Ra	Sensors	Sensors	Comment	Comment
A301	266	22/09/96	10.28	L /400m	49 40.0 N	05 40. W				Chs JA5	Log JA10	Servo 05	
			15.08	R	49 25.2 N	07 00.3 W	4h40	19	7-68m	I001/R001		93.34	
A302	267	23/09/96	12:20	L /432	48 24.7 N	12 30.4 W				same	same		
			18:35	R	48 07.3 N	14 06.3 W	6h09	25	11-71m			123 (216.3)	
A303	268	24/09/96	12:27	L /350	47 21.2 N	18 11.7 W				same	same	Wing jam	
			14:35	R	47 02. N	18 26.5 W	2h08	1+FD	5-82m			Port wing bolt out	
A304	270	26/09/96	13:10	L /370	38 10.1 N	20 01.1 W				same	same		
			20:25	R	36 53. N	20 24. W	7h15	31	5-66m				
A305	271	27/09/96	13:27	L /370	34 02.3 N	21 15.6 W				same	same		
			18:38	R	32 36. N	21 25.5 W	5h12	21	8-68m				
A306	272	28/09/96	13:02	L /375	29 29.4 N	21 48.8 W				same	same		
			17:30	R	28 38.2 N	21 54.3 W	4h28	17	5-65m				
A307	273	29/09/96	13:13	L /375	24 41.2 N	21 24.7 W				same	same		
			17:53	R	23 48. N	21 14. W	4h40	17	6-67m				
A308	276	02/10/96	12:33	L /380	12 46.1 N	20 32.2 W				same	same		
			20:23	R	11 33.2 N	21 06.8 W	7h50	28	10-69m		&Tr/006		
A309	277	03/10/96	07:01	L /375	09 38.8 N	21 59.8 W				same	same	Wing Jam as above	
			09:15	R	09 22. N	22 08. W	2h14	1+FD			&Tr/006	No data Pl	ug dam
A310	277	03/10/96	12:31	L /380	09 04.1 N	22 16.8 W				same	Log JA08		
			20:28	R	07 45. N	22 49.5 W	7h57	28	10-69m		&Tr/006		
A311	278	04/10/96	08:01	L /360	05 36.0 N	23 47.2 W				same	same		
			10:50	R	05 10.5 N	24 00.6 W	2h 49	11	7-67m		&Tr/006		
A312	278	04/10/96	12:32	L /365	05 10.4 N	24 08.0 W				same	same		
			14:52	R	04 47.2 N	24 12. W	2h 20	3 + FD	10-68m		&Tr/006	Wing jam ?	
A313	279	05/10/96	12:20	L /365	01 18.2 N	25 46.6 W				Chs JA3	Log JA8	Fit Servo 02	
	280	06/10/96	07:04	R	01 45. S	27 09. W	18h 44	120	10-68m	I001/R001	no Tr		
A314	280	06/10/96	12:20	L /365	02 24.5 S	27 27.4 W				same	same		
			17:58	R	03 19.3 S	27 51.6 W	5h 38	36	7-67m				
A315	281	07/10/96	12:26	L/365	06 28.8 S	29 16.2 W				same	same		
			18:05	R	07 29.5 S	29 45.6 W	5h 39	36	5-65m				
A316	283	09/10/96	14:13	L /360	14 54.3 S	33 07.8 W				same	same		
			18:46	R	15 52.5 S	33 36. W	4h 33	30	5-65m	New cable termination			

Tow No	Day	Date	Time;GMT	Ops/Wire	Lat	Long	Tow time	No Unds	Depth Ra	Sensors	Sensors	Comment	Comment
A317	285	11/10/96	13:46	L 360	22 54.8 S	36 58.0 W				same	same		
			16:10	R	23 20.9 S	37 10.6 W	2h 24	15	3-64m				
						total	94h 40						
A318	285	11/10/96	16:59	L /360	23 21.5 S	37 11.1 W				same	same		
			19:14	R	23 45.0 S	37 22.4 W	2h 15	14	3-64m				
A319	287	13/10/96	13:29	L /371	29 53.2 S	42 55.7 W				same	same		
			19.05	R	30 38. S	43 47. W	5h 30	36	5-65m				
A320	288	14/10/96	13:27	L /370	32 47.9 S	46 07.6 W				same	same		
			18:55	R	33 30.4 S	46 52.4 W	5h 28	34	10-68m				
A321	289	15/10/96	14:07	L /370	35 43.6 S	45 38.9 W				same	same		
			17:05	R	36 05.4 S	50 03.4 W	2h 58	18	16-73m				
A322	289	15/10/96	18:17	L /370	36 06.5 S	50 04.1 W				same	same		
			20:10	R	36 19. S	50 17. W	1h 55	12	18-73m				
A323	289	15/10/96	21:05	L /370	36 25.4 S	50 24.0 W				same	same		
	290	16/10/96	09:39	A/C	38 00.0 S	51 58.6 W							
	290	16/10/96	11:46	R	37 48.8 S	52 11.5 W	14h 41	90	13-68m				
						total	127h 57						
A324	297	23/10/96	15.55	L /360	43 34.8 S	55 00.5 W						CHS flash fails	
			21:17	R	44 36.0 S	54 59.4 W	5h 23	44	May-63	same	same		
A325	298	24/10/96	14:34	L /360	48 01.0 S	55 52.4 W							
			19:14	R	48 52.6 S	56 17.6 W	4h 40	28	7-64m	same	same		
25						total	138h						

Appendix I. Optical data logs:- a) 'Seafalls'

Cast No.	SDY	Longitud	Latitude	Dark	Cast Start	End	CCD Pic.	Good data Lu	Ed	Es	Depth	Comments
1	273	-21.4052	24.678		1234	1238		X	X	X	102	First SeaFALLS station; fall rate a little high.
2	274	-20.6372	20.087	1200	1250	1252		X	X		82	Es tilts too large due to a fouled weight cable.
3	274	-20.6372	20.087		1255	1258		X	X		102	Es tilts too large due to a fouled weight cable.
4	274	-20.6372	20.087		1302	1305		X	X		76	Es tilts too large due to a fouled weight cable.
5	274	-20.6372	20.087		1308	1312		X	X		102	Es tilts too large due to a fouled weight cable.
6	274	-20.6372	20.087		1414	1418		X	X	X	108	
7	274	-20.6372	20.087		1422	1427	1435	X	X	X	100	
8	276	-20.5383	12.764	1145	1208	1211		X	X	X	103	
9	276	-20.5383	12.764		1217	1221		X	X	X	104	
10	277	-22.2788	9.0667	1227	1217	1220		X	X	X	104	Better sky conditions than for SeaOPS cast.
11	278	-24.0118	5.1762	1210	1219	1222		X	X	X	106	
12	280	-27.4523	-2.3683	1143	1153	1157		X	X	X	105	Better sky conditions than for SeaOPS cast.
13	280	-27.4523	-2.3683		1159	1202		X	X		113	Clear sky; bad reference tilts (no MVDS data).
14	281	-29.2693	-6.4763	1156	1209	1213		X	X		110	Clear sky; bad reference tilts (MVDS data).
15	282	-31.2473	-10.769	1231	1243	1248		X	X	X	151	Small floats added to reference cable; clear sky.
16	282	-31.2473	-10.769		1252	1259		X	X	X	200	Small amount of clouds at very end of cast.
17	283	-33.1217	-14.888	1257	1309	1314		X	X	X	151	Clouds moved in after cast started.
18	283	-33.1217	-14.888		1317	1323		X	X	X	202	Small cloud in middle of cast, otherwise clear.
19	284	-35.0488	-18.855	1234	1248	1253		X	X	X	154	Overcast with minor sun breaks.
20	284	-35.0488	-18.855		1256	1303		X	X	X	176	Better of the two casts.
21	285	-36.9588	-22.918	1314	1243	1249	1257	X	X	X	202	No SeaOPS data during this time period.
22	285	-36.9588	-22.918		1255	1301		X	X	X	202	Better sky conditions than cast 21.
23	285	-37.1805	-23.348	1611	1624	1631	1634	X	X	X	203	Better sky conditions than cast 24.
24	285	-37.1805	-23.348		1638	1645		X	X	X	202	
25	286	-39.5993	-26.616	1224	1247	1252	1302	X	X	X	153	
26	286	-39.5993	-26.616		1255	1259		X	X	X	152	
27	286	-39.5993	-26.616		1305	1310		X	X	X	153	Best sky conditions for casts 25-27.
28	286	-40.0143	-27.001	1636	1646	1651		X	X	X	125	
29	289	-49.6207	-35.716	1318	1337	1340		X	X	X	102	Almost completely clear sky.

Cast No.	SDY	Longitud	Latitude	Dark	Cast Start	End	CCD Pic.	Good data Lu	Ed	Es	Depth	Comments
30	289	-49.6207	-35.716		1342	1345		X	X	X	102	Pretty clear sky.
31	289	-50.058	-36.093	1657	1721	1725		X	X	X	106	Good data to compare with last UOR undulation.
32	289	-50.058	-36.093		1726	1729		X	X	X	103	Clear sky with a little high cirrus.
33	290	-52.19	-37.812	1234	1249	1252		X	X	X	102	
34	290	-52.19	-37.812		1258	1302		X	X	X	103	Best sky conditions for casts 33 and 34.
35	297	-55.0067	-43.574	1338	1405	1408		X	X	X	76	High cirrus.
36	297	-55.0067	-43.574		1410	1413		X	X	X	79	High cirrus; better conditions than for cast 35.
37	298	-55.8718	-48.003	1337	1348	1351		X	X	X	101	High thin cirrus.
38	298	-55.8718	-48.003		1353	1356		X	X	X	103	Probably the best in terms of sky conditions.
39	298	-55.8718	-48.003		1358	1402		X	X	X	102	Strange fall rates at times.
40	298	-55.8718	-48.003		1404	1408		X	X	X	102	

Appendix I. b):- 'Seaops log'

Cast No.	SDY	Longitude	Latitude	Es	Darks Lu/Ed	Logger Assignment Port 1	Port 2	Down Beg.	Cast End	CCD Pic.	Up Beg.	cast End
0	266	-5.6903	49.6748		832	OCR-021	OCI-029	841	845		846	851
1	267	-12.5	48.4128	900	929	OCR-021	OCI-029	951	1010	1015	1018	1037
2	268	-18.2052	47.3653	1015	1023	OCR-021	OCI-029	1043	1047	1048	1051	1056
3	269	-19.8075	42.7047	1011	1018	OCR-021	OCI-029	1112	1121		1121	1132
4	270	-20.0167	38.1703	1103	1109	OCR-021	OCI-029	1218	1227	1229	1231	1244
5	271	-21.2575	34.0293	1012	1119	OCR-021	OCI-029	1133	1142	1145	1147	1157
6	272	-21.8078	29.4968	1009	1119	OCR-021	OCI-029	1133	1146	1153	1155	1208
7	273	-21.4052	24.6778	1108	1114	OCR-021	OCI-029	1143	1154	1156	1159	1210
8	274	-20.5663	20.0685	954	1001	OCR-021	OCI-029	1104	1114	1117	1120	1130
9	276	-20.5407	12.7622	936	943	OCR-021	OCI-029	1106	1115	1118	1121	1131
10	277	-22.2762	9.053	910	942	OCR-021	OCI-029	1103	1112	1115	1116	1125
11	277	-22.2762	9.059		1147	OCR-021	OCR-035	1138	1140		1141	1144
12	278	-24.016	5.1727	851	851	OCR-021	OCI-029	1106	1115	1119	1121	1130
13	278	-24.0143	5.175		1155	OCR-021	OCR-002	1142	1146		1147	1152
14	279	-25.7813	1.2932	1036	1036	OCR-021	OCI-029	1102	1109	1113	1115	1124
15	280	-27.4557	-2.3855	1005	1005	OCR-021	OCI-029	1102	1108	1111	1113	1120
16	280	-27.4542	-2.3805		853	OCI-002	OCI-029	1126	1129		1131	1133
17	281	-29.2707	-6.4827	958	958	OCR-021	OCI-029	1104	1110	1115	1117	1124
18	281	-29.2712	-6.4758		1149	OCR-021	OCR-001	1134	1138		1141	1145
19	282	-31.2433	-10.7767	1437	1037	OCR-021	OCI-029	1204	1210	1224	1212	1218
20	283	-32.8047	-15.2098	1125	1125	OCR-021	OCI-029	1231	1237	1240	1242	1248
21	284	-35.0467	-18.8627	1121	1154	OCI-040	OCI-029	1204	1210	1215	1217	1223
22	286	-40.015	-27.0027	1207	1606	OCR-021	OCI-029	1614	1620	1621	1624	1630
23	288	-46.118	-32.7967	1125	1125	OCI-001	OCI-029	1207	1218	1221	1223	1235
24	289	-49.5863	-35.7125	1152	1152	OCR-021	OCI-029	1243	1251	1253	1256	1304
25	289	-50.0605	-36.0985		1738	OCR-021	OCI-029	1745	1756	1736	1757	1808
26	290	-52.1932	-37.8083	1109	1129	OCR-021	OCI-029	1202	1210	1213	1215	1224
27	297	-55.005	-43.5775	1233	1233	OCR-021	OCI-029	1309	1315	1317	1320	1327
28	298	-55.8772	-48.003	1228	1234	OCR-021	OCI-029	1306	1314	1317	1319	1327
29	299	-57.8962	-51.9325	1142	1142	OCR-021	OCI-029	1118	1123	1126	1128	1133

Appendix I. b):- 'Sea

Cast No.	SDY	Longitude	Latitude	Lu	Ed	Es	CF	Depth	Comments
0	266	-5.6903	49.6748	DU	DU	DU	DU	52	Test station; no significant problems.
1	267	-12.5	48.4128		DU	DU	DU	201	Lu data not available due to cabling failure.
2	268	-18.2052	47.3653	DU	DU	U	DU	54	Es failure during downcast and part of upcast.
3	269	-19.8075	42.7047				DU	110	No Lu, Ed, and Es data due to deck box "open" circuits.
4	270	-20.0167	38.1703	DU	DU	DU	DU	110	PRR battery disconnected from ground.
5	271	-21.2575	34.0293	DU	DU	DU	DU	115	PRR data stream kept failing.
6	272	-21.8078	29.4968	DU	DU	DU	DU	150	PRR works grounded to Satlantic power common.
7	273	-21.4052	24.6778	DU	DU	DU	DU	120	MVDS must be on PRO-DCU and SeaOPS on DECK-100.
8	274	-20.5663	20.0685	DU	DU	DU	DU	117	DECK-100 went "open" when the CTD hydraulics started.
9	276	-20.5407	12.7622	DU	DU	DU	DU	111	DECK-100 went "open" before station started.
10	277	-22.2762	9.053	DU	DU	DU	DU	106	Upcast is less cloudy than downcast.
11	277	-22.2762	9.059	DU	DU	DU	DU	29	Intercomparison of OCR-021 and OCR-035 radiometers.
12	278	-24.016	5.1727	DU	DU	DU	DU	104	Downcast is less cloudy than upcast; PRR not working.
13	278	-24.0143	5.175	DU	DU	DU	DU	52	Intercomparison of OCR-021 and OCR-002.
14	279	-25.7813	1.2932	DU	DU	DU	DU	93	Downcast is less cloudy than upcast.
15	280	-27.4557	-2.3855	DU	DU	DU	DU	76	Upcast is less cloudy than downcast.
16	280	-27.4542	-2.3805	DU	DU	DU	DU	33	Intercomparison of OCI-029 and OCI-002.
17	281	-29.2707	-6.4827	DU	DU	DU	DU	78	DECK-100 went "open" just as downcast started.
18	281	-29.2712	-6.4758	DU	DU	DU	DU	50	Intercomparison of OCR-021 and OCR-002.
19	282	-31.2433	-10.7767	DU	DU	DU		76	Clear skies for both casts; CTDFTR not operational.
20	283	-32.8047	-15.2098	DU	DU	DU		77	Upcast less cloudy than downcast; CTDFTR still not operational.
21	284	-35.0467	-18.8627	DU	DU	DU	DU	77	Intercomparison of OCI-029 and OCI-040.
22	286	-40.015	-27.0027	DU	DU	DU		65	SeaFALLS cable used for SeaOPS; bad ship shadow; no CDTFTR.
23	288	-46.118	-32.7967	DU	DU	DU		125	Intercomparison of OCI-029 and OCI-001; heavy overcast.
24	289	-49.5863	-35.7125	DU	DU	DU		101	Clear sky for both casts.
25	289	-50.0605	-36.0985	DU	DU	DU		126	Clear sky for both casts with just a little high cirrus.
26	290	-52.1932	-37.8083	DU	DU	DU		100	Upcast is sunnier than downcast.
27	297	-55.005	-43.5775	DU	DU	DU		76	High cirrus clouds; upcast a little brighter than downcast.
28	298	-55.8772	-48.003	DU	DU	DU		100	High thin cirrus.
29	299	-57.8962	-51.9325	DU	DU	DU		61	Heavy overcast; shelf station; water depth 75-80m.

Appendix J. Phytoplankton Log Sheet

Stn	JD	Depth	Size-Chl	Size-photo	Total Chl	Total Photo	P-I exp	POC/N	Lugol's	Formaline
1	268	7	x	x	x	x	x	1,2,3,4	9643	9642
		20	x	x	x	x		5,6		
		30	x	x	x	x		7,8		
		40	x	x	x	x	x	9,10,11, 12	9645	9644
		60	x	x	x	x	x	13,14		
2	269	7	x	x	x	x	x	15,16,17,18	9647	9646
		20	x	x	x	x		19,20		
		30	x	x	x	x		21,22		
		40	x	x	x	x	x	23,24,25,26	9649	9648
		50	x	x	x	x				
		60	x	x	x	x	x	27,28		
		80		x		x				
3	270	7	x	x	x	x	x	29,30,31,32	9651	9650
		20	x	x	x	x		33,34		
		30	x	x	x	x		35,36		
		40	x	x	x	x	x	37,38	9653	9652
		50	x	x	x	x				
		60	x	x	x	x		39,40		
		80	x	x	x	x	x		9655	9654
4	271	7	x	x	x	x	x	41,42,43,44	9657	9656
		80	x	x	x	x	x	45,46,47,48	9659	9658
5	272	7	x	x	x	x	x	49,50,51,52	9661	9660
		40	x	x	x	x		53,54,		
		60	x	x	x	x	x			
		80	x	x	x	x		55,56		
		100	x	x	x	x		57,58		
		110	x	x	x	x	x	59,60,61,62	9663	9662
		120	x	x	x	x				
6	273	7	x	x	x	x	x	63,64,65,66	9665	9664
		40	x	x	x	x	x	67,68	9667	9666
		60	x		x			69,70		
		80	x		x					
		90	x	x	x	x	x	71,72,73,74	9669	9668
		100	x	x	x	x				
		120	x	x	x	x		75,76		
7	274	7	x	x	x	x	x	77,78,79,80	9671	9670
		20	x	x	x	x			9673	9672
		30	x	x	x	x	x	81,82		
		40	x	x	x	x	x	83,84,85	9675	9674
		50	x	x	x	x		87,88		
		60	x	x	x	x		89,90		
		80	x	x	x	x				
8	276	7	x	x	x	x	x	91,92,93,94	9677	9676
		20	x	x	x	x	x	95,96	9679	9678
		30	x	x	x	x		97,98		
		40	x	x	x	x	x	99,100,101,102	9681	9680
		50	x	x	x	x				
		60	x	x	x	x		103,104		
		80	x	x	x	x				
9	277	7	x	x	x	x	x	105,106,107,108	9683	9682
		20	x	x	x	x				
		30	x	x	x	x	x	109,110	9685	9684
		40	x	x	x	x		111,112		
		50	x	x	x	x	x	113,114,115,116	9687	9686
		60	x	x	x	x		117,118		
		80	x	x	x	x				

Stn	JD	Depth	Size-Chl	Size-photo	Total Chl	Total Photo	P-I exp	POC/N	Lugol´s	Formaline
10	278	7	x	x	x	x	x	119,120,121,122	9689	9688
		20	x	x	x	x				
		40	x	x	x	x	x	123,124	9691	9690
		60	x	x	x	x		125,126		
		70	x	x	x	x	x	127,128,129,130	9693	9692
		80	x	x	x	x		131,132		
		100	x	x	x	x				
11	279	7	x	x	x	x	x	133,134,135,136	9695	9694
		40	x	x	x	x	x		9697	9696
		60	x	x	x	x		137,138	9701	9700
		70	x	x	x	x			9703	9702
		80	x	x	x	x	x	139,140,141,142	9699	9698
		100	x	x	x	x		143,144	9705	9704
		120	x	x	x	x				
12	280	7	x	x	x	x	x	145,146,147,148	9707	9706
		40	x	x	x	x	x	149,150	9709	9708
		65	x	x	x	x				
		75	x	x	x	x		151,152		
		85	x	x	x	x	x	153,154,155,156	9711	9710
		100	x	x	x	x				
		120	x	x	x	x		157,158		
13	281	7	x	x	x	x	x	159,160,161,162	9713	9712
		50	x	x	x	x	x	163,164	9715	9714
		70	x	x	x	x				
		90	x	x	x	x		165,166		
		110	x	x	x	x	x	167,168,169,170	9717	9716
		120	x	x	x	x				
		140	x	x	x	x		171,172		
14	282	7	x	x	x	x	x	173,174,175,176	9719	9718
		50	x	x	x	x				
		75	x	x	x	x	x	177,178	9721	9720
		100	x	x	x	x		179,180		
		120	x	x	x	x				
		130	x	x	x	x	x	181,182,183,184	9723	9722
		140	x	x	x	x		185,186		
15	283	7	x	x	x	x	x	187,188,189,190	9725	9724
		60	x	x	x	x	x		9727	9726
		80	x	x	x	x		191,192		
		100	x	x	x	x		193,194		
		120	x	x	x	x				
		140	x	x	x	x	x	195,196,197,198	9729	9728
		160	x	x	x	x		199,200		
16	284	7	x	x	x	x	x	201,202,203,204	9731	9730
		50	x	x	x	x			9737	9736
		75	x	x	x	x	x	205,206	9733	9732
		100	x	x	x	x		207,208	9739	9738
		110	x	x	x	x				
		125	x	x	x	x	x	209,210,211,212	9735	9734
		140	x	x	x	x		213,214	9741	9740
17	285	7	x	x	x	x	x	215,216,217,218	9743	9742
		40			x	x				
		60	x	x	x	x		219,220	9745	9744
		80			x	x		221,222		
		90			x	x				
		100	x	x	x	x	x	223,224,225,226	9747	9746
		120			x	x		227,228		

Stn	JD	Depth	Size-Chl	Size-photo	Total Chl	Total Photo	P-I exp	POC/N	Lugol's	Formaline
18	286	7	x	x	x	x	x	229,230,231,232	9749	9748
		40			x	x		233,234		
		70	x	x	x	x		235,236		
		80			x	x				
		95	x	x	x	x	x	237,238,239,240	9751	9750
		110			x	x		241,242		
		120			x	x				
19	287	7	x	x	x	x	x	243,244,245,246	9753	9752
		50	x	x	x	x	x	247,248	9755	9754
		80			x	x		249,250		
		90	x	x	x	x	x	251,252,253,254	9757	9756
		100			x	x		255,256		
		110			x	x				
		120			x	x				
20	288	7	x	x	x	x	x	257,258,259,260	9759	9758
		20	x	x	x	x		261,262		
		40	x	x	x	x	x	263,264	9761	9760
		50			x	x				
		60	x	x	x	x	x	265,266,267,268	9763	9762
		80	x	x	x	x		269,270		
		100			x	x				
21	289	7	x	x	x	x	x	271,272,273,274	9765	9764
		20	x	x	x	x		275,276		
		30	x	x	x	x	x	277,278,279,280	9767	9766
		40	x	x	x	x		281,282		
		50	x	x	x	x	x	283,284	9769	9768
		60			x	x				
		80			x	x				
22	290	7	x	x	x	x	x	285,286,287,288	9771	9770
		20	x	x	x	x		289,290		
		30	x	x	x	x		291,292		
		40	x	x	x	x	x	293,294,295,296	9773	9772
		50			x	x				
		60	x	x	x	x	x	297,298	9775	9774
		80			x	x				
23	297	2		x	x	x				
		7	x	x	x	x	x	299,300,301,302	9776	9777
		20	x	x	x	x		303,304		
		30	x	x	x	x	x	305,306,307,308	9778	9779
		40			x	x		309,310		
		50	x	x	x	x	x	311,312	9780	9781
		60	x	x	x	x				
24	298	7	x	x	x	x	x	313,314,315,316	9782	9783
		20	x	x	x	x		317,318		
		40	x	x	x	x	x	319,320	9784	9785
		60	x	x	x	x		321,322		
		70			x	x				
		80	x	x	x	x	x	323,324,325,326	9786	9787
		100			x	x				
25	299	7	x		x		x	327,328,329,330	9788	9789
		20	x		x		x	331,332,333,334	9792	9793
		30	x		x			335,336		
		40	x		x		x	337,338	9790	9791
		50	x		x			339,340		
		60	x		x					