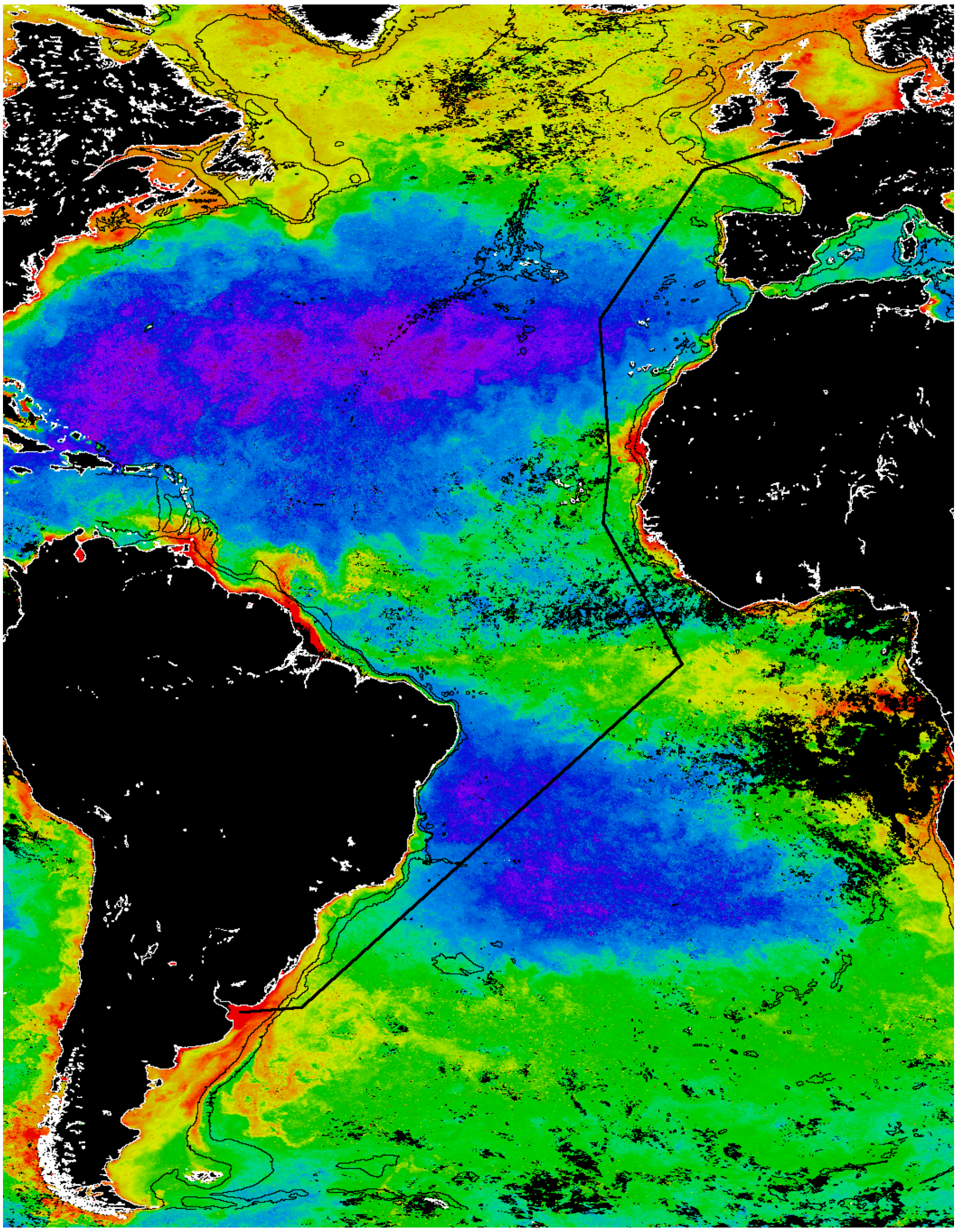
Atlantic Meridional Transect
AMT-11 Cruise Report



Grimsby (UK) to Montevideo (Uruguay)
12th September to 11th October 2000

Contents

Prepared and edited by:
Malcolm Woodward
Principal Scientist: AMT-11.

Plymouth Marine Laboratory
Prospect Place
Plymouth
Devon
PL1 3DH
England

m.woodward@pml.ac.uk
01752 633459 (office): 01752 633100 (switchboard)

Plymouth Marine Laboratory

Abstract

This report describes the scientific activities of the eleventh Atlantic Meridional Transect cruise (AMT-11) on board the British Antarctic Survey research vessel the RRS James Clark Ross.

The cruise sailed from Grimsby in the United Kingdom on 12th September 2000, and ended in Montevideo, Uruguay on October 11th.

The long-term objectives of the AMT programme are stated as follows:

- To better understand the links between biogeochemical processes, biogenic gas exchange, air-sea interactions and the effects on and the responses of oceanic ecosystems to climate change.
- To investigate the functional roles of biological particles, and the processes that influence ocean colour in ecosystem dynamics.
- To develop algorithms and the validation of remotely sensed observations of ocean colour.

As previously the cruise was centred close to 20 degrees West for the southern transect in the northern hemisphere, the track then deviated to the east to carry out the BAS swath bathymetry research survey, which was essentially a cruise within the AMT. Following this work in the Romanche Fracture Zone, part of the Mid-Atlantic ridge system, the cruise transect headed south-westerly past Ascension Island across the south Atlantic gyre, and on to Montevideo, Uruguay.

The scientific team were a truly international group who all contributed to produce an exceptional cruise from both the scientific and social aspects.

This cruise is sadly the last in the time series of cruises started in 1995 and supported almost entirely through Plymouth Marine Laboratory. This is a great loss of a resource to the UK and international scientific community with these cruises offering an almost unique opportunity for regular long transect scientific research. It is hoped that the UK community will in some way in the future find funding to re-instate the research programme.

AMT Aims

The long-term aims of the AMT programme are:

1. To understand the links between biogeochemical processes, biogenic gas exchange, air-sea interactions and the effects on, and the responses of the oceanic ecosystems to climate change.
2. To investigate the functional roles of biological particles and processes of ecosystem dynamics which influence ocean colour, and as such the programme aims towards the development of algorithms and the validation and interpretation of remotely sensed satellite observations of ocean colour.
3. To develop coupled physical-biological models of production and ecosystem dynamics, to improve our knowledge of processes, ecosystem dynamics, food-webs and fisheries, and to characterise biogeochemical oceanic provinces.

Acknowledgements

AMT-11 is the eleventh cruise in a series of transects of the Atlantic Ocean using the RRS James Clark Ross (JCR), one of the British Antarctic Surveys' Research ships.

The series of cruises have used this invaluable opportunity to carry out 'added value' science on top of the normal cruise transect legs of the JCR, between the UK and the south Atlantic. The ship goes south in September normally, with the passage leg terminating in The Falklands at Port Stanley, with a regular port-call in Montevideo for supplies. The ship then returns back to the UK after the summer fieldwork season in the Antarctic in May/June of the following year. On AMT-11, for financial reasons, we terminated the cruise in Montevideo.

The AMT science team are most grateful to Prof. Chris Rapley and all his teams in Cambridge, in logistics, personnel, planning, etc. etc. Without whose help and support this cruise and the AMT programme would not be possible.

Also thanks to all our international colleagues on the cruise for the financial support from their home Institutions and Universities.

And finally, the Principle Scientist and the scientific party acknowledge the invaluable assistance of the Officers and crew of the RRS James Clark Ross, led by Captain Jerry Burgan. Their professional skills have contributed hugely to the success of the scientific research of the AMT-11 cruise and the programme as a whole**.**

Cruise participants

This AMT was different to previous cruises in that it coupled a number of projects under the AMT banner. As well as the core scientists for the AMT there were two researchers from SOC carrying out meteorological investigations as part of the 'Autoflux' project, and also the newly fitted Swath Bathymetry system on board the JCR was being trialled on the long transect south and also to carry out a specific study of the eastern end of the Romanche fracture zone, just south of the equator.

These three disparate groups worked extremely well together, neither particularly interrupting each others science, and in fact the diversion of the ship to carry out the Swath studies actually gave an excellent scientific opportunity to the core biogeochemists to carry out a number of investigations in the equatorial upwelling area which is greatly under-researched.

Scientific personnel

AMT Group	**Institute**	**Role**
Malcolm Woodward	PML	Principal Scientist AMT, nanonutrients
Emilio Fernandez	UIV	Chlorophyll, primary production
Pablo Serrett	UIV	Oxygen production and Respiration.
Ramiro Varela	UIV	P-I curves, and absorption characteristics.
Vassilis Kitidis	PML, UIN	Nutrients and DOM breakdown.
Begona Castro	IEO	S Bacterial production and abundance.
Marta Varela	IEO	Nitrogen uptake.
Claudia Omachi	PML	Fast Repetition Rate Fluorometry, (FRRF)
Dave Suggett	PML/SOC	Chlorophyll, CHN sampling, Fluorometry
Sandy Thomala	SOC	Chlorophyll, CHN sampling.
Alejandro Isla	UIO	Zooplankton respiration, ammonia production
Marcos Lopes	UIO	Zooplankton biomass, and grazing.
Autoflux group		
Margaret Yelland	SOC	Surface fluxes system
Robin Pascal	SOC	Surface fluxes system
Swath bathymetry group		
Alex Cunningham	BAS	Swath bathymetry
Neil Mitchell	OX/CU	Swath bathymetry
BAS scientific support		
Andy Barker	BAS	IT Support
Vsevolod Afanasyev	BAS	ET Support
Supernumerary		
Don BONNER	Falkland Islands	

Key

BAS: British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK
OX: Oxford University, Wellington Square, Oxford, OX1 2JD, UK
CU: Cardiff University, Cardiff, Wales, CF10 3XQ, UK
PML: Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK
SOC: Southampton Oceanography Centre, European Way, Empress Dock, Southampton, SO14 3ZH, UK
IEO: Instituto Espanol de Oceanografia, Centro Costero de la Coruna, Muelle de Animas s/n, A Coruna, E-15001, Spain
UIN: University of Newcastle, Newcastle, NE1 7RU, UK
UIO: University of Oviedo, Oviedo, Spain
UIV: University of Vigo, Campus Lagoas-Marcosende, 36200 Vigo, Spain

Ship's personnel

Name:	**Rank / Rating:**
Jerry Burgan	Master
Graham Chapman	Chief Officer
Justin McCarthy	Second Officer
Neil Macleod	Third Officer
Steve Mee	Radio Officer
Duncan Anderson	Chief Engineer
Colin Smith	Second Engineer
Robert Macaskill	Third Engineer
Gerry Armour	Fourth Engineer
Doug Trevett	Deck Engineer
Anthony Rowe	Electrician
Hamish Gibson	Catering Officer
Pippa Bradbury	Doctor
Russell Brookes	Deck Cadet
Dean Burnett	Engineer Cadet
Colin Lang	Bosun
David Peck	Bosun's Mate
Martin Bowen	Seaman
Kelvin Chappell	Seaman
George Dale	Seaman
Keith Dickson	Seaman
Luke Trussler	Seaman
Erwin Allen	Motorman
Richard Parsley	Motorman
Danny Mcmanamy	Chief Cook
Tracey Macaskill	Second Cook
Lee Jones	Second Steward
Simon Hadgraft	Steward
Graham Raworth	Steward
Michael Weirs	Steward

AMT-11: Cruise Narrative:

The AMT-11 departed from Grimsby on Tuesday 12th September, leaving the lock gates at 0510, and sailed into the North Sea heading for Portsmouth for a port call to take on board aviation fuel.

During the first morning there was carried out a general test of the CTD equipment to ensure all sensors were responding and operational. This was only to a depth of 10 metres. Also the Sound Velocity Profiler (SVP) was tested to ensure all was operational also.

The AMT team had commenced mobilisation in Grimsby (UK) on the Sunday 10th, after arriving the day before. All was smoothly achieved with the help of the crew, in assisting the equipment siting and generally helping the scientists.

During the short passage leg to Portsmouth the various pieces of scientific lab equipment were checked out and there was noticed that due to a valve being left open that we had lost a large amount of the liquid nitrogen stored, so provision was made to replenish stocks at the dockyard, and this was successful. Also, it was found that the Beckman liquid scintillation counter was non functional. As this is imperative to count the radiological experimental samples, I investigated the possibilities of having a repair carried out in Portsmouth. This again was successful, although it was not particularly acceptable to have this instrument non-functional even before sailing. However, the repair was agreed to and completed. The machine ran well for 3 weeks of the cruise, but then had a week of intermittent functioning, but having watched the engineer we were able to carry out 'running' repairs. The machine has since recovered its functionality some what but still is prone to jamming. The machine was repaired with a 'used' part in order to get it working and a future full repair and service or purchase of a new machine needs to be investigated. However, we did achieve all the counting and analyses of the samples by the end of the cruise.

We sailed from Portsmouth on the evening of the 13th and headed west into the Channel.

One of the main activities that have underpinned all the AMT cruises is the regular sampling of the surface non-toxic seawater. The first sample was taken on the morning of the 14th and then continued at regular 4 hourly intervals, or with greater frequency at scientifically interesting areas, until the end of the cruise. These samples are taken for chlorophyll fluorescence, samples for later HPLC analyses at Plymouth, and for particulate carbon and nitrogen analyses.

Then at 1045 on the 14th we carried out the first of what were 46 CTD stations. The Seabird 911 plus CTD system with a sample bottle rosette of 12x 10 litre bottles was equipped also with the PAR light sensors and with transmission and fluorescence sensors. The system was kept supported by Sevvy and Andy the BAS technical support team. The functionality of the system was 100% with every CTD carried out without a lost bottle or malfunction. An excellent support provided from the two technicians to the cruise and something which is an absolutely vital element to the AMT, and indeed any biogeochemical type cruise, in having a reliable CTD system.

Following this first shallow CTD in the western end of the English Channel, by the next day we had crossed out from the channel to the western approaches, and then out over the shelf break to water depths in excess of 2000 metres. The CTD's were then standardised to a maximum depth of 250m, with the bottles being fired at targeted biological structures in the water column. The depth was chosen as a compromise between time on station, which is limited, but also to give a sufficient coverage of the water column to ensure that we always went below the mixed layer depth (normally a maximum of 180m in the south Atlantic gyre) and so allowing us to always study the important euphotic zone where the light influences the biological processes. By the cruise end we carried 46 successful CTD stations.

Because of the biological sampling requirements the programme for the daily CTD casts we carried out 2 CTD stations a day. There was first a pre-dawn cast normally timed around 0430, and this was to sample for the production studies, both primary production and for respiration and oxygen production experiments. Concurrently with the CTD were two triple-net casts to 200m with various net sizes attached so as to size fractionate the zooplankton size classes. The zooplankton samples from these net hauls were then used to study biomass, the taxonomic composition and the gut contents of the copepods. Feeding experiments were also carried out by incubating the samples and sub samples were also taken for respiration and excretion.

The CTD standard sampling and analysis was, apart from the water for the productivity samplings, for nutrient analysis. This was to study the distributions of nitrate, nitrite, silicate, phosphate and ammonia using conventional colorimetric techniques and also using new novel high sensitivity methods. Samples were also taken to study the distributions of chromophoric dissolved organic matter (CDOM) which is of great importance to the studies of ocean optics and hence to remote sensing by satellites.

The standard filtration samples were also taken for chlorophyll and particulate carbon and nitrogen, and investigations were also made with samples to study bacterial production and abundance.

The samples taken for the production studies were then incubated in the on-deck incubators for up to 24 hours using the ships non-toxic water supply as cooling. Various light fields were simulated using filters to mimic the light intensities experienced by the samples at the depth of water that they were taken from.

The second daily CTD was timed at around 1100, in order to give maximum sunlight irradiance. The standard sampling was carried out for the CTD, except this time the samples were more targeted at studies involving light and its effects on the biota. Standard samples were again taken for filtering and for the nutrients, but with this CTD samplings were carried out to study the photosynthesis/irradiance curves (P/I), which show the relationship between the light irradiance and the rate of carbon incorporated by photosynthetic processes. Samples were also taken for experiments to study the nitrogen uptake and regeneration of the phytoplankton with reference specifically to nitrate, ammonia and urea.

Whilst the CTD operations were taking place there were again net samples taken from the forward davit, one down to 100m for subsamples to later evaluate biomass by image analysis and to determine particulate carbon and nitrogen. A second net sampling for surface qualitative taxonomic phytoplankton samples was then obtained.

A third over the side operation was carried out at this late morning station with the deployment of the optics rig, with attached fast repetition rate fluorometer (FRRF). The optics rig consisted of the fluorometer, a CTD, and a pair of 7-channel irradiance and radiance sensors. The rig was lowered to 150m or 200m in the initial deployment and then to 60m at a second. On a couple of occasions when the sunlight was good with little cloud cover an extra optics cast was carried out during the afternoon.

This then concluded the overside operations for the day, but the underway sampling continued as did the regular deployment of the expendable bathythermographs (XBT), which were deployed to 1830m or 760m at different times of the day.

The station time was of course closely regulated as there was only a finite time for station work, which initially averaged to about 1 hour 45 minutes per day and this was closely regulated. The one problem that there was with this timing was the uncertainty of the actual amount of time allocated to the AMT and to the Swath study. In the ships programme there were 4 days added to passage for the AMT and 2 days for the Swath work. However, it then became apparent that the Swath required 2 days just for the scientific survey and that there was an extra almost 2 days to passage required for the deviation for the ‘normal’ track. This though did not materialise as a problem as the AMT in fact worked a more direct track to that initially considered and so one day was saved there. Then by judicious other means the almost extra day was saved in order that the ship was on time docking into Montevideo. Again, good discussions and communications between all concerned solved the problem before it really became one.

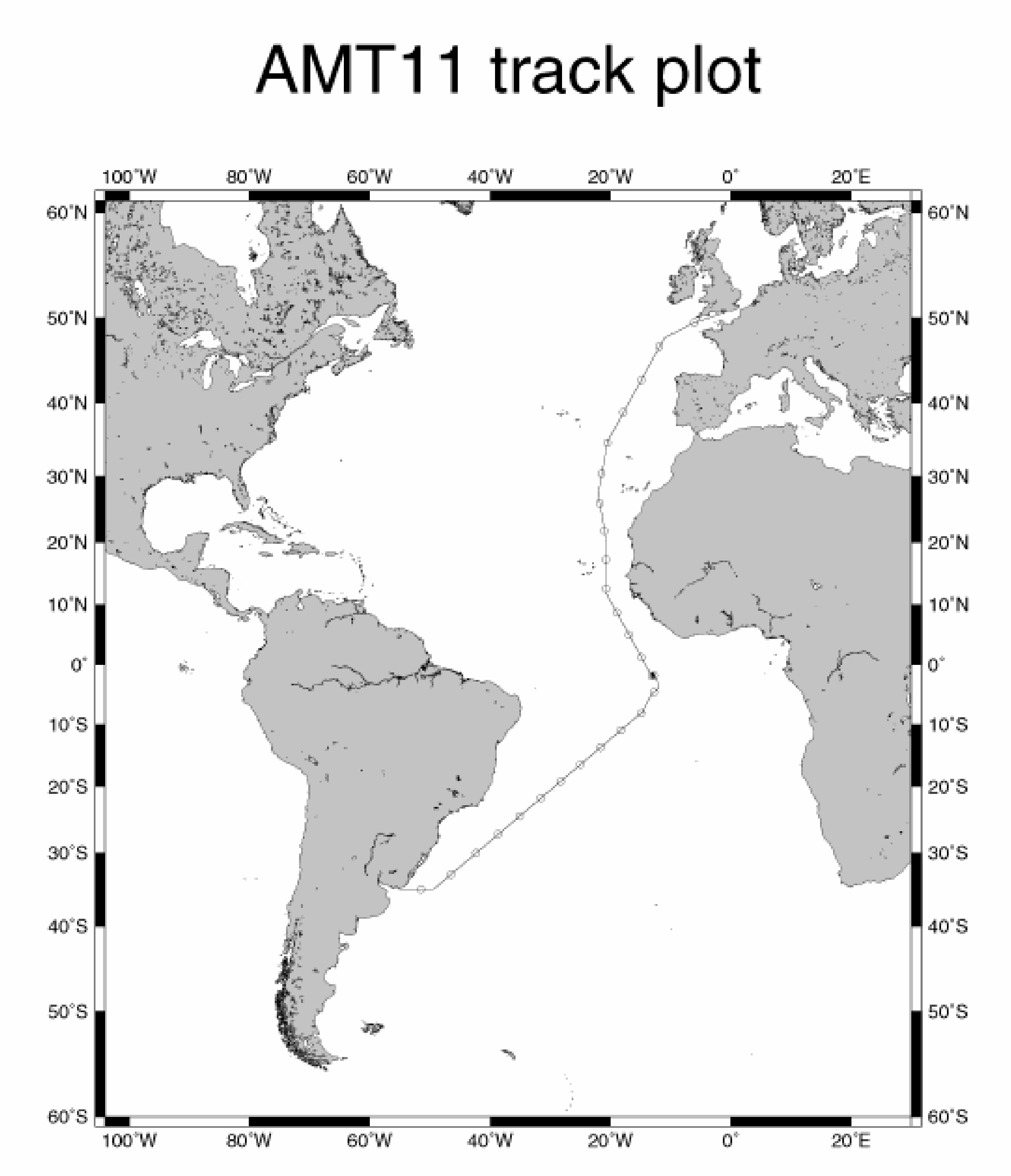
The swath bathymetry studies were ongoing for the cruise where possible as was the ‘autoflux’ studies, which were the continuous logging of the sea temperatures and the heat fluxes generated.

The cruise track took us south and avoided the 200 mile limits (EEZ) of the various Atlantic islands and coastal states. This track was plotted and allowed a maximum of science for a minimum deviation from the ‘standard’ passage. There were no diplomatic clearances for this cruise obtained due to the late decision taken to actually go ahead with the cruise itself. However, this did not seriously impact on the science due to the course taken. The only place where it was impossible to work was a period of about 36 hours between the Cape Verde Islands and Senegal where the overside science was stopped. Just north of the equator and south of these EEZ’s the ‘normal’ AMT track would turn to the south-west to head for south America, but with the requirements of the Swath work we deviated south east to occupy a station at approximately 1°S and 13°W. This was for a detailed survey of the eastern end of the Romanche fracture zone system, a part of the mid-Atlantic Ridge. This proved to be very successful, and indeed was a science of opportunity for the biogeochemists of the core AMT team as we were able to continue sampling an area where the equatorial upwelling was very strong. This is an area, mainly because of its remoteness, that is very understudied, and some excellent new investigations were carried out. The fact that the CTD casts and biogeochemistry could be continued shows an evolution in the possible way forward and future for the AMT programme. It is hoped that there will be future collaborations with the Swath science and the future AMT cruises, giving an extra dimension to the scientific findings.

After leaving the Swath study area there was then almost a straight track to Montevideo, except for a small deviation to carry out an opportunistic survey of an undersea volcano site close to Ascension Island. The last 11 days were across the oligotrophic, or 'marine desert' of the south Atlantic Gyre, again giving a huge contrast to the productive area of the equatorial upwelling south of the equator.

The final CTD was on Monday 9th October, and the underway ceased also at 1400 the same day.

A very successful cruise, aided in great part by a good sound working relationship and excellent communications between the science team and the captain and officers. Any problems there were, were dealt with simply and quickly.



Daily Science log

12/9/00

Sailed from Grimsby at 0505, Tuesday 12th September.

On station at 1030, test Station, 53⁰06'1N 01⁰19.5'E

Depth 17m, heading 255.

1044: CTD in the water to 10m, Optics deployed to 15m, then recovered at 1101.

1104: SVP (Sound Velocity profiler) deployed

1116: SVP recovered

1125: off station

Followed by test XBT deployment.

Science get together of all the science people with AMT, SOC and Swath people + BAS support guys.

13/9/00

0312: Commenced magnetic calibration turns for the SOC Autoflux lab equipment, consisting of 2 360' turns to starboard, then resume course for Pompey.

0750: Docked at Portsmouth. Commenced the aviation fuel replenishment.

Some of the Team ashore. Visit from Patrick Holligan and Mike Lucas in am.

1130: Delivery of liquid nitrogen from Cryospeed, very efficient and cheap !

1400; John Butler the Beckman engineer arrived to repair the Liquid Scintillation counter. Good guy, gave an air of confidence. Fixed the machine by 1800 and serviced it. All calibrated and up to spec, excellent! Emilio is very happy, and BAS are picking up the tab. Main problem was that it was not serviced this year as it is on a 2 year cycle of servicing. A short sighted idea, they (David Blake) have since commented as that AMT is only user and with the uncertainty of its future basically why bother to spend any money on it if they (BAS) have to. Oh dear !

Sailed Portsmouth at about 1900, nice evening, good sunset, team in good spirits, morale high and prospect of good science is high.

Science meeting of the AMT core scientists to discuss the first CTD and the underway sampling protocols. Water volumes etc discussed and detailed below:

SCIENTIST	0430 CTD	1100 CTD	WHAT FOR	VOLUME
Marta	NO	YES	-	6 litres (3depths)
Alejandro, Marcos	YES	YES	Zooplankton net samples + Chloro a at mid am CTD	30 litres from the chlorophyll max
Begonia	YES	NO	Bacterial Production	100 ml, 5 depths
Malc and Vas	YES	YES	Nutrients, micro and nano	500mls
Sandy/Claudia/Dave	NO	YES	HPLC	4 litres all depths
S/C/D	NO	YES	Chlorophyll a	250mls, all depths
S/C/D	NO	YES	Coccolithophores	200mls all depths
S/C/D	YES	YES	CHN	2 litres all depths
S/C/D	NO	YES	FRRF/PI	350mls
S/C/D	YES	NO	FRRF	250mls
S/C/D	NO	YES	Absorption	250mls
Pablo	YES	NO	Oxygen product and Respiration	4 litres, 5 depths
Ramiro	NO	YES	PI curves	1.5 litres, 3 depths
Ramiro	NO	YES	Absorption	3 litres, 3 depths
Emilio	YES	NO	Primary product.	1.5 litres, 5 depths
Emilio	NO	YES	Size fractionated PP	250mls, all depths

Also: Dave Suggett to carry out a surface net haul during the mid am CTD station at the same time as the optics rig deployment and CTD.

Emilio will add a net deployment to 100 metres prior to this.

250 metres will be the bottom bottle.

On station, ship with sun on starboard, and the request of Autoflux that the ships head is to windward or as near as possible during the CTD.

14/9/00

1053: Commenced first station (AMT 11/01), approx directly south of Plymouth, CTD deployed to 60m, Optics deployed to 80m. Plus nets.

1119: Finish and proceed.

1132 XBT launch

1702 XBT launch

2250 XBT launch

15/9/00

0417: CTD deployed to 250m, nets deployed forward, two deployments to 200m

0447: CTD recovered

0456 Nets recovered

0500: Depart station and on course

0530: XBT launch, failed (a bad box of probes, change box)

0552: XBT launch (OK, successful).

0946: On station: AMT 11/03

0952: Optics deployed (150m), CTD deployed (250m), and surface nets forward deployed

1006: Sound velocity Profiler (SVP) deployed from the port gantry, to 500m. (Involved with the Swath work).

1009: Second Optics cast (100m). Nets recovered, CTD onboard.

1018: SVP recovered

1022: Proceeding

1122: XBT launch

1637: XBT launch

2303 XBT launch

16/9/00

0420: Commence slowing for station

0434: CTD deployed (AMT 11/04) (250m)

0438: Forward nets deployed,

0451: CTD on deck

0453: Nets recovered

0500: On course and departed.

1049: On station, CTD deployed (AMT 11/05) (250m). Nets to 100m deployed. Optics deployed to 150m.

1101: Nets recovered, and surface nets redeployed.

1111: Optics rig redeployed to 60m

1113: CTD on deck

1114: optics recovered and nets.

1128: XBT deployed, and underway on track and speed.

1212: XBT launched

1912: XBT launched

2342: XBT launched

17/9/00

0425: On station, CTD (AMT 11-06) (250m)
0434: Nets deployed to 200m.
0447: Nets recovered and redeployed to 200m
0452: CTD recovered
0506: Nets recovered
0512: On course and speed
0533: XBT launch
1044: On station, CTD (AMT 11-07) (250m)
1047: Nets to 100m and Optics deployed to 150m
1055: Nets recovered and redeployed to surface. Optics recovered
1109: CTD on deck and nets recovered
1120: XBT deployed
1125: On track and proceeding
2346: XBT launch

18/9/00

0443: On station, CTD (AMT 11-08) (250m)
0448: Forward nets deployed to 200m
0451: CTD deployed to 250m
0502: nets recovered and redeployed to 200m
0511: CTD on deck
0521: Nets recovered
0527: On course and proceeding
0643: XBT launched
1044: On station CTD (AMT 11-09)
1046 Nets to 100m deployed and Optics to 150m, and CTD deployed
1053 Nets recovered, and redeployed for surface netting
1101: Optics recovered and then redeployed to 60m
1106: nets recover, CTD on deck and optics recovered
1119: XBT launch at 6 knots, deep XBT (1830m, T5)
1123: Underway and departed.
1754: XBT launched, T7
2340: XBT launched, T7

19/9/00

0444: On station, CTD (AMT 11-10) (250)
0448: Forward nets deployed (200m)
0449: CTD deployed.
0502: Nets recovered
0505:Nets redeployed to 200m
0510: CTD on deck
0520: Nets recovered.
0526: On course and speed.
0601; XBT launch
1045: On station
1046: Nets deployed forward to 100m
1048: CTD deployed to 250m (AMT 11-11)
1050: Optics deployed to 150m
1053: Nets recovered

1056: Nets launched to surface water

1105: Redeploy optics to 60m

1106: Nets recovered and CTD on deck

1110: Optics recovered

1122: XBT launched, T5 to 1830m

1723: XBT launched, T7

2346: XBT launched, T7

20/9/00

0444: JCR on station.

0445: Nets deployed to 200m

0447: CTD deployed to 250m (AMT 11-12)

0500: Nets recovered

0509: CTD recovered

0519: On course and speed

0609: XBT launched

1045: On station

1046: Nets deployed to 100m. Optics deployed to 150m

1048: CTD deployed to 250m (AMT 11-13)

1053: Nets recovered

1056: Nets redeployed to the surface

1102: Optics recovered and redeployed to 60m

1105: Nets recovered

1107: CTD on deck

1109: Optics recovered

1121: XBT launch, T5 to 1830m

1300: AMT team science meeting to confirm plans for the following couple days, check sampling strategy etc with everyone.

1745: XBT launch, T7

2343: XBT launch, T7

21/9/00

0444: On station

0446: Nets deployed forward, to 200m

0448 CTD deployed (AMT 11-14) to 250m

0501: Nets recovered

0503: Nets redeployed to 200m

0509: CTD on deck

0519: Nets recovered forward

0606: XBT launch, T5.

1043: On station,

1046: Nets to 100m deployed

1047: Optics rig deployed to 150m

1049: CTD deployed to 250m (AMT 11-15)

1053: Nets on-board, Redeploy to surface water

1102: Optics recovered and redeployed to 60m

1107: Optics and nets recovered.

1109: CTD recovered.

1121: Three XBT launches with T5's. Terminations and errors for first two, ship slowed to 6 knots to deploy them.

1612: Slow to 6 knots and launch T5 XBT, still problems, needed two attempts

1947: Slow to 6 knots for deep T5 XBT

2337: Slow to 6 knots for deep T5 XBT

2359: Cease science overside operations during passage through Cape Verde and Senegal EEZ's.

22/9/00

Container cleaning/rubbing down and painting, followed by fire drill and practice of fire extinguishers and hoses on deck. Data work-up and general lab preparation.

23/9/00

1045: On station,

1046: Nets to 100m deployed

1047: Optics to 150m deployed

1049: CTD deployed to 250m (AMT11-17)

1053: Nets recovered

1056: Surface nets deployed

1102: Optics recovered

1103: Optics redeployed to 60m

1106: Nets recovered

1108: CTD on deck and Optics recovered

1123: Deep XBT, to 1830m, T5 probe.

1717: XBT (T7) deployed

2347: XBT deployed, T7

24/9/00

0445: On station

0446: Forward nets deployed to 200m

0449: CTD deployed to 250m, (AMT11-18)

0502: Nets recovered

0503: Nets redeployed to 200m

0511: CTD on deck,

0519:Nets recovered

0811: XBT launch, T5 to 760m

1046: On station

1048: Optics deployed to 150m

1050: CTD deployed to 250m, (AMT 11-19

1054: Nets deployed forward to 100m

1101: Nets recovered

1103: Nets redeployed forward to surface water

1104: Optics rig redeployed

1107: CTD on deck

1108: Nets recovered

1110: Optics recovered

1121: XBT launch to 1830 metres, T5.

1500: On station 18a

1501: Deploy CTD to 15m (AMT11-18a). Four drops to 15m for calibrations of temperature sensors.

1502: Optics deployed to 150m

1517: Optics recovered

1518: CTD recovered

1734: XBT launch, T7 to 760m.

2345: XBT launch, T7 to 760m

25/9/00
0445: On station
0447: Forward nets deployed to 200m
0449: CTD deployed to 250m (AMT11-19)
0503: Nets recovered
0505: Nets redeployed to 200m
0511: CTD recovered on deck.
0522: Nets recovered forward
0526: On course
1045: On station
1046: Nets to 100m deployed forward
1047: Optics deployed to 150m
1050: CTD deployed to 250m (AMT 11-20)
1054: Nets recovered
1057: Redeploy surface nets.
1102: Optics recovered
1103: Optics redeployed to 60m
1107: Nets recovered
1108: Optics recovered
1109: CTD recovered
1123: XBT, T5 launch to 1830m
1744: XBT launch
2356: XBT launch, T7 to 760m

26/9/00
0458: On station
0501: Forward nets deployed to 200m, and CTD deployed to 250m (AMT 11-21)
0515: Nets recovered
0517: Nets redeployed to 200m
0523: CTD recovered
0533: Nets recovered
0539: On course
0604: XBT launched
1043: On station
1045: Optics deployed to 150m
1046: Nets deployed to 100m,
1051: CTD deployed to 250m (AMT 11-22)
1052: Nets recovered
1057: Surface nets deployed
1100: Optics recovered
1101: Optics redeployed to 60m
1105: Optics recovered
1109: CTD recovered, and nets.
1123: XBT deployed, T5 to 1830m
1758: XBT launched

27/9/00
0120: Commence the Swath survey, JR53, at SW1
0256: Through SW2.
0349: Through SW3.

0437: On station
0438: Nets deployed to 200m
0440: CTD deployed, (AMT 11-23)
0452: Nets recovered forward
0454: Nets redeployed.
0459: CTD recovered
0511: Nets recovered forward
0520: Through SW4
0533: XBT launch. T5 to 1830
0900: Through SW 5.
0938: On station
0942: SVP deployed
1000: CTD deployed to 250m (AMT 11-24), Nets deployed to 150m, Optics deployed
1011: SVP recovered
1015: Nets recovered
1018: Redeploy forward nets to surface
1024: Optics recovered
1025: Optics redeployed to 60m
1026: CTD on deck.
1027: Nets recovered
1030: Optics recovered
1036: XBT launch: T5 to 1830m.
1048: Through SW6
1434: Through SW7
1503: Through SW8
1742: XBT launched
1902: Through SW9
1942: Through SW10
2330: Through SW11
2353: XBT deployed

28/9/00

0007: Through SW12
0405: Through SW13
0412: On Station 25
0414: Forward nets deployed to 200m
0415: CTD deployed, (AMT 11-25), to 250m
0428: Nets recovered
0430: Nets redeployed to 200m
0435: CTD recovered
0447: Nets recovered
0509: XBT, T7 to 760m
0515: Through SW14
0912: Through SW15
0937: On Station 26
0938: Nets deployed forward to 150m
0940: Optics deployed to 150m
0941: CTD deployed to 250m (AMT 11-26)
0944: Nets recovered
0946: Deploy surface net

0954: Optics recovered
0955: Optics redeployed to 60m
1000: CTD on deck, nets recovered
1001: Optics recovered
1010: XBT launched, T5 to 1830m
1013: Through SW16
1404: Through SW17
1523: Through SW18
1633: Through SW19
1655: Through SW20
1740: XBT launched, T5 to 1830m
1754: Through SW21
1940: Through SW22
2202: Through SW23
2355: XBT deployed, T7 to 760m

29/9/00

0619: Through SW24, and the completion of the Swath survey grid. Course now set for the track to Montevideo.
1045: On station
1047: Nets deployed to 100m
1048: Optics deployed to 150m
1049: CTD deployed to 250m, (AMT 11-27)
1054: Nets recovered
1056: Deploy surface nets
1106: Optics recovered
1107: Redeploy optics to 60m
1110: CTD on deck
1112: Nets recovered
1113: Optics recovered
1124: XBT launch, T5 to 1830m
1740: XBT launch, T5 to 1830m
2346: XBT launch, T7 to 760m

30/9/00

0445: On Station
0447:Nets deployed forward to 200m
0450: CTD deployed to 250m (AMT 11-28)
0502: Nets recovered forward
0504: Nets deployed forward to 200m
0511: CTD on deck
0520: XBT deployed, T7 to 760m
0830: Slow to 10 knots for Swath study of Ascension undersea volcano
0912: XBT deployed, T5 to 1830m
0945: Resume normal speed
1048: On station: nets deployed forward to 100m
1050: Optics deployed to 150m
1052: CTD deployed to 250m (AMT 11-29)
1056: Nets recovered
1057: Surface nets deployed

1104: Optics recovered
1106: Optics redeployed to 60m
1110: Optics recovered, Nets recovered
1112: CTD on deck
1126: XBT launch @6 knots, T5 to 1830m
1752: XBT launch @6 knots, T5 to 1830m
2346: XBT launch, T7 to 760m
2400: Clocks retarded 1 hour. Ships time now 1 hour behind GMT and 2 hours behind UK time

01/10/00

0529: On Station
0532: Nets deployed to 200m
0533: CTD deployed to 250m (AMT 11-30)
0546: Nets recovered
0549: Nets redeployed to 200m
0555: CTD recovered on deck
0607: Nets recovered
0633: XBT launched, T7 to 760m
1145: On station: $10^0$54'.1S $018^0$14'.9W
1146: Nets to 100m
1149: CTD to 250m, (AMT 11-31)
1150: Optics deployed to 150m
1156: Nets recovered.
1157: Surface net deployed.
1206: Optics recovered
1208: Optics redeployed to 60m.
1209: CTD on deck
1213: Nets recovered
1215: Optics recovered
1226: XBT launch, T5 to 1830m.
1821: XBT launch, T5 to 1830m

2/10/00

0047: XBT launch, T7 to 760m.
0544: On station, $13^0$01.5'S 020^0 46.3W
0546: Nets launched to 200m
0549:CTD deployed to 250m, (AMT 11-32)
0600: Nets recovered
0602: Nets redeployed to 200m
0611: CTD recovered
0617: Nets recovered forward.
0730: XBT launch: T7 on leaving, to 760m.
1142: On station,$13^0$39.9'S 021^0 33.9'W
1143: Nets deployed forward to 100m
1145: CTD deployed to 250m, (AMT 11-33)
1146: Optics deployed to 150m
1150: Nets recovered
1153: Nets redeployed to surface
1202: Optics recovered
1203: Optics redeployed to 60m

1205: CTD on deck
1207: Nets recovered
1209: Optics recovered
1226: XBT launch: T5 to 1830m, failed
1203: XBT launch: T5 to 1830m.
1830: XBT launch: T5 to 1830m.

3/10/00

0055: XBT launch: T7 to 760m.
0529: On station: $15^0$45.0’S 024^0 04.7’W
0530: Nets deployed forward to 200m
0534: CTD deployed to 270m, (AMT 11-34)
0543: Nets recovered
0545: Nets redeployed to 200m
0556: CTD recovered on deck
0600: Nets recovered forward
0614: XBT launch: T7 to 760m
1142: On Station: $16^0$25.6’S 024^0 54.5’W
1143: Nets deployed to 100m
1147: Optics deployed to 150m and CTD to 280m (AMT 11-35)
1150: Nets recovered
1152: Nets redeployed forward to surface
1203: Optics recovered
1204: Optics redeployed to 60m
1208: Nets recovered
1210: Optics recovered; CTD on deck
1246: XBT launch: T5 to 1830m
1827: XBT launch: T5 to 1830m

4/10/00

0047: XBT launch: T7 to 760m
0530: On station: $18^0$27.4’S 027^0 24.7’W
0531: Nets deployed forward to 200m
0533: CTD deployed to 280m, (AMT 11-36)
0544: Nets recovered forward
0546: Nets redeployed forward to 200m
0557: CTD on deck
0602: Nets recovered
0616: XBT launched: T7 to 760m
1143: On station: $19^0$07.7’S 028^0 14.6’W
1144: Nets deployed to 100m
1146: Optics deployed to 200m
1147: CTD deployed to 280m: (AMT 11-37)
1151: Nets recovered
1154: Nets redeployed to surface
1207: CTD on deck
1209: Optics recovered
1210: Optics redeployed to 60m
1213: Nets recovered
1218: Optics recovered

1230: XBT launch: T5 to 1830m

1456: On station, Optics station 37A, $19^0$24.9'S 028^0 35.8'W

1500: Deploy Optics to 200m

1528: Optics recovered

1529: Redeploy Optics to 60m

1533: Recover Optics, but stay on station for Autoflux data gathering

1556: Depart station

1827: XBT launch: T5 to 1830m

5/10/00

0045: XBT launch: T7 to 760m

0530: On station: $21^0$03.5'S 30^0 39.6'W. Nets deployed to 200m

0535: CTD deployed to 280m: (AMT 11-38)

0544: Nets recovered forward

0546: Nets redeployed forward to 200m

0557: CTD recovered

0600: Nets recovered

0616: XBT launch: T7 to 760m

1030: Ships safety meeting, PSO represents scientific party

1144: On station: $21^0$04.7'S 30^0 41.2'W. Deploy nets to 100m

1147: CTD deployed to 280m: (AMT 11-39)

1148: Optics deployed to 200m

1051: Nets recovered

1052: Nets redeployed to surface

1205: CTD on deck

1209: Optics recovered

1210: Nets recovered

1235: XBT launch: T5 to 1860m

1832: XBT launch: T5 to 1860m

6/10/00

0049: Launch XBT: T7 to 760m

0600: On station: $23^0$48.3'S 34^0 07.9'W

0601: Forward nets deployed to 200m

0604: CTD deployed to 280m: (AMT 11-40)

0614: Nets recovered

0617: Nets redeployed to 200m

0626: CTD on deck

0632: Nets recovered

0649: XBT launched: T7 to 760m

1243: On station: $24^0$35.7'S 35^0 08.9'W

1244: Nets deployed forward to 100m

1247: CTD deployed to 280m (AMT 11-41)

1249: Optics deployed to 200m

1250: Nets recovered

1252: Surface nets deployed

1307: Nets recovered, and CTD on deck

1311: Optics recovered

1312: Optics redeployed to 60m

1318: Optics recovered

1324: XBT launch: T5 to 1830m, abort
1328: XBT launch: T5 to 1830m
1335: STCM (Ships Three Component Magnetometer) figure of eight manoeuvre
1400: Back on course
1936: XBT launch: T5 to 1830m

7/10/00

Clocks retarded by one hour
0048: XBT launched: T7 to 760m
0600: On station: $26^0$36.7'S 37^0 45.6'W
0603: Forward nets deployed to 200m
0606: CTD deployed to 280m: (AMT 11-42)
0617: Nets recovered
0620: Nets redeployed to 200m
0629: CTD recovered
0634: Nets recovered
0646: XBT launched: T7 to 760m
1243: On station: $27^0$19.3'S 38^0 42.0'W
1244: Nets deployed forward to 100m
1245: Optics deployed to 200m
1247: CTD deployed to 280m; (AMT 11-43)
1250: Nets recovered
1252: Nets redeployed to surface
1305: CTD on deck
1310: Nets recovered
1312: Optics recovered
1314: Optics redeployed to 60m
1318: Optics recovered
1335: XBT launch: T5 to 1830m
1518: Water inlet probe to mid position, due to rough weather
1925: Deep XBT launched T5 to 1830m

8/10/00

0148: XBT launched, T7 to 760m
0616: On station: $29^0$18.7'S 41^0 20.7'W,
0617: Nets deployed forward to 200m
0620: CTD deployed to 280m: (AMT 11-44)
0630: Nets recovered
0632: Nets redeployed to 200m
0642: CTD recovered
0648: Nets recovered forward
0727: XBT launch, T7 to 760m
0812: Slow vessel to recover 'Soap', damaged by the bad weather.
1255: On station: $30^0$05.2'S 42^0 22.3'W
1256: Nets deployed forward to 100m
1259: Optics deployed to 200m
1301: CTD deployed to 280m (AMT 11-45)
1303: Nets recovered
1305: Surface nets deployed
1319: Nets recovered

1320: CTD recovered
1326: Optics recovered
1327: Optics redeployed to 60m
1334: Optics recovered
1342: XBT launched: T5 to 1830m
1520: On station for optics cast: 30^{0}16.7’S 42^{0} 38.1’W
1523: Optics deployed to 150m
1539: Recover optics
1938: XBT launch: T7 to 760m

9/10/00

0155: XBT launch: T7 to 760m
1243: On station for the last time: 33^{0}08.7’S 46^{0} 35.8’W
1244: Nets deployed to 100m
1246: Optics deployed to 200m
1247: CTD deployed to 280m
1251: Nets recovered
1252: Surface nets deployed
1306: CTD on deck and nets recovered
1309: Optics recovered
1310: Optics redeployed to 60m
1315: Optics recovered
1330: XBT launch T5 to 1830m – aborted
1335: XBT launch T5 to 1830m
1928: XBT launch T7 to 760m, 33^{0}57.8’S 47^{0} 44.0’W

Individual Research Reports

Mesozooplankton respiration, excretion, and feeding.

Alejandro Isla & Marcos López

Universidad de Oviedo

During the AMT-11, two different incubations were done each day to estimate mesozooplankton metabolic rates and feeding. Oxygen consumption by mesozooplankton provide us information about their minimum requirements and an index of metabolism, whereas the determination of ammonia (which is the major form of dissolved nitrogen excreted by marine zooplankton) and phosphate excretion is of special interest because of their importance as immediately available nutrients for phytoplankton. Feeding experiments were carried out to determine the amount and type of food ingested by copepods, one of the main groups of mesozooplankton.

In addition, at the mostly of the stations from which we collected the animals for the incubations, samples for determination of mesozooplankton biomass, taxonomic composition, and copepods gut contents, were taken.

All the hauls were done at early morning stations (see Table 1) using a WP2 triple net of 60 cm diameter each ring, equipped with 200 µm mesh. The nets were deployed to 200 m and towed vertically at low speed (approx. 0.5 m/s). The contents of the cod ends were always passed through three sieves of 1000, 500 and 200 µm mesh to separate the mesozooplankton by size class on small, medium, and large.

Biomass

The samples were filtered onto pre-weighed GF/A filters, which were stored in Petri dishes and then transferred to the –20 ºC freezer. After the dry mass determination, CHN analysis will be done.

Taxonomic composition

The samples for the determination of taxonomic composition and abundance were preserved on 4% formaldehyde solution.

Copepods gut contents

Herbivory activity of copepods is estimated by measuring chlorophyll a and derived pigments on their guts, according to the gut fluorescence method (Mackas & Bohrer, 1976): the samples are filtered through a paper filter, which is frozen as soon as possible at –20 ºC. Some of the samples will be measured by HPLC to evaluate selectivity between phytoplankton groups.

Incubations

The animals collected for both types of incubation were acclimated for about 1 hour in seawater filtered by 0.2 µm, and then were passed to 1 l bottles filled wit filtered seawater in the case of the respiration and excretion experiment, whereas the feeding incubation was done using seawater caught from the maximum of chlorophyll and filtered by 100 µm. The incubations were performed at the temperature of the maximum of chlorophyll and under dim light. For the feeding experiments, an incubator with rotating wheels was used to gently agitate the samples, maintaining the food in suspension.

Three controls (with no animals), and three replicates by each size fraction were set. In the feeding incubation, two extra replicates by size class were set to estimate chlorophyll degradation to non fluorescent compounds during copepod ingestion in order to correct the results obtained by the gut fluorescence method.

The incubations were removed after 16-18 hours. At the end of the incubations, and after all the sub-samples were taken, the content of each bottle was filtered through GF/A filters to collect the animals incubated. Then, the filters were frozen at –20 ºC and stored for their subsequent CHN analysis.

Sub-sampling

Respiration and excretion

From each bottle, we took two samples for oxygen determination and two samples for ammonia and phosphate. The oxygen was measured on board according to the Winkler titration method using a 721 NET Titrino, whereas the samples for determination of ammonia and phosphate were frozen at –20 ºC for their subsequent analysis at the laboratory. From the difference between controls and treatments bottles in oxygen and ammonia and phosphate, we can estimate respiration and excretion rates by mesozooplankton.

Feeding

The following subsamples were took from control (without copepods), treatment (each size class incubated is considered a treatment), and initial (at the starting of the incubation) bottles

- Subsamples for flow-cytometry analysis were fixed on 1 % glutaraldehyde and frozen at –70 ºC.
- To determine whether the cells are autotrophic or heterotrophic, subsamples were collected for epifluorescence microscopy.
- In addition, some 100 ml subsamples were preserved on 5 % Lugol solution to count microplankton, in order to estimate omnivory by copepods.
- To estimate chlorophyll a degradation, subsamples of 300 ml were filtered through GF/F filters, and the remainder (including copepods and fecal pellets), was filtered also onto GF/F filters to compare with the amount of chlorophyll in the control bottles.

All the samples (except oxygen) will be analyzed at the laboratory.

References

Mackas, D.L. and Bohrer, R.N. (1976). Fluorescence analysis of zooplankton gut contents and an investigation of diel feeding patterns. *J. Exp. Mar. Biol. Ecol*., **25**: 77-85.

Table 1. List of activities carried out during the AMT-11

Station	*Biomass*	*Gut contents*	*Taxonomic composition*	*Resp. & Excr. incubations*	*Feeding incubations*
2	**X**			**X**	**X**
4	**X**			**X**	**X**
6	**X**	**X**	**X**	**X**	**X**
8	**X**	**X**	**X**	**X**	**X**
10	**X**	**X**	**X**	**X**	**X**
12	**X**			**X**	**X**
14	**X**	**X**	**X**	**X**	**X**
17	**X**	**X**	**X**	**X**	**X**
19	**X**	**X**	**X**	**X**	**X**
21	**X**	**X**	**X**	**X**	**X**
23	**X**	**X**	**X**	**X**	**X**
25	**X**	**X**	**X**	**X**	**X**
28	**X**	**X**	**X**	**X**	**X**
30	**X**	**X**	**X**	**X**	**X**
32	**X**	**X**	**X**	**X**	**X**
34	**X**	**X**	**X**	**X**	**X**
36	**X**	**X**	**X**	**X**	
38	**X**	**X**	**X**	**X**	
40	**X**	**X**	**X**	**X**	**X**
42	**X**	**X**	**X**	**X**	**X**
44	**X**	**X**	**X**	**X**	**X**

Optics

Claudia Yuki Omachi

Deployment of optical rig

For previous Atlantic Meridional Transect (AMT) Cruises, the Fast Repetition Rate Fluorometer (FRRF) has been deployed by attachment to the CTD integrated bottle-sampling rosette. However, throughout AMT 11, it was integrated into the profiling optical rig to avoid shadow from the rosette and also from the ship (Fig. 1).

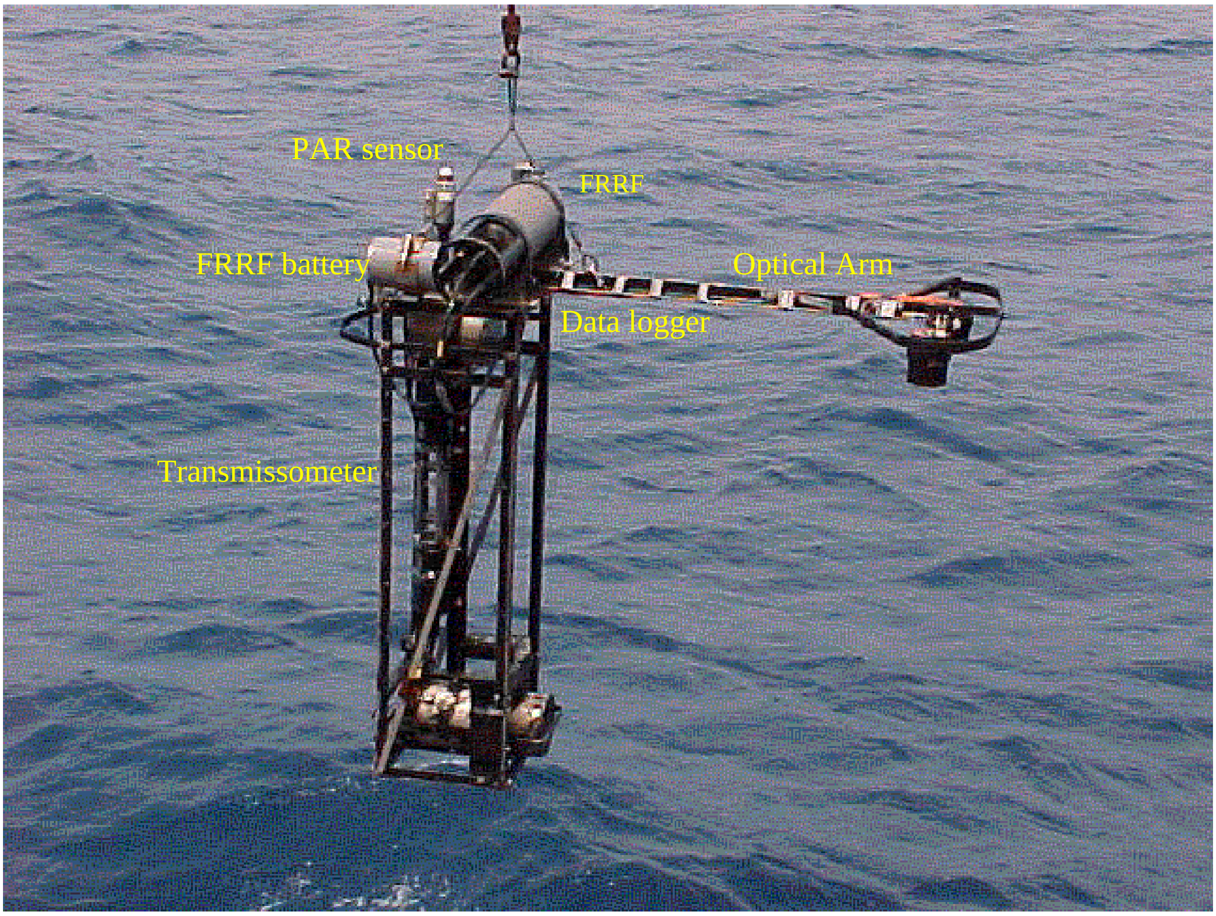
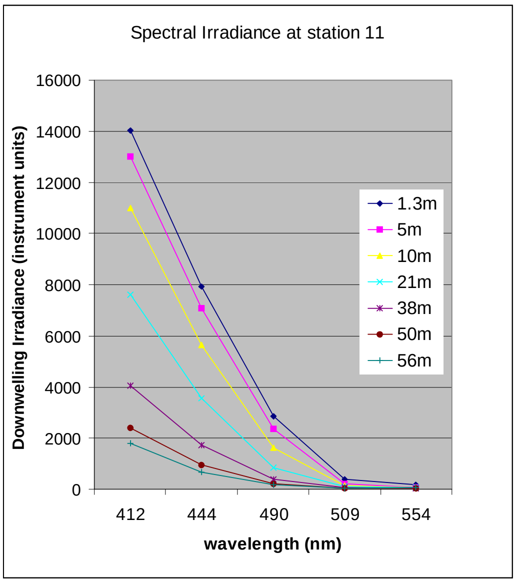


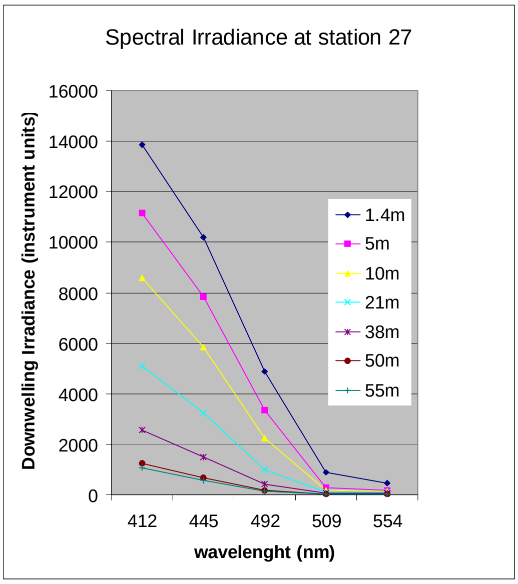
Figure 1. Arrangement of the optical rig employed for AMT 11

The FRRF and PAR sensor are attached in the upper most part of the rig to avoid shadow from any part of the rig. The optical arm has irradiance and radiance sensors at 7 wavelengths, of which 5 correspond with SeaWiFS bands: 412, 443, 490, 510, 555 and also at 620 and 670 nm. The option to turn the irradiance sensor up side down allows Q-factor measurements which are used for remote sensing purposes. The rig also carries a transmissometer and CTDF attached to a self-powered logger where these and the optical data are stored. The rig was deployed from the starboard quarter into the sun to avoid ship shadow. Two casts were carried out during each CTD station. The first deployment was to 150-200m, with a fast down cast (50m/min) for the optical measurements and slower up cast (15m/min) for the FRRF measurements. The second deployment was to 60m at 50m/min for the Q-factor measurement. The optical and CTDF data will be processed after the cruise in the PML.

The spectral shape of light in the water column measured by the optical rig is illustrated in Figure 2. The spectral composition of light throughout the water column varies according to substances in seawater, for example, the pigment distribution. Relatively more light of 445 nm was observed at mesotrophic stations (CTD station 27) than at oligotrophic stations (CTD station 11) and is the result of greater absorption of blue (412 nm) light.

Figure 2. Spectral downwelling irradiance, instrument units, at 2 contrasting stations: CTD 11 (oligotrophic) and 27 (mesotrophic).





Fast Repetition Rate Fluorometry

Claudia Omachi & Dave Suggett

Two Fast Repetition Rate Fluorometers (FRRFs) were programmed to generate singular electron transfer throughout phytoplankton photosystem-II (following Kolber *et al.* 1998) to enable the quantitative estimation of phytoplankton physiology and, ultimately, gross oxygenic production (Kolber and Falkowski 1993). Each FRRF has two optical chambers. One measures the physiological responses under relative dark conditions (a fixed housing) whilst the other is exposed to ambient light. A titanium FRRF was attached to the optical rig and profiled to 150-200m during each late morning CTD cast. Data were collected per 10ms (the highest current resolution of the instrument) but logged internally as 1 averaged data point per 2 seconds per channel to increase the signal to noise ratio. The data were downloaded to a P.C. following each cast and processed through a program developed by Chelsea Instruments. This program outputs the fluorescence yields (F_o, F_m and F_v), quantum efficiency of photochemistry (F_v/F_m), effective absorption cross section (σ_{PSII}), the probability of energy transfer between reaction centres (ρ) and the time of electron transfer (τ) for photosystem-II.

The basin scale distribution of the variable fluorescence yield (F_v = maximum fluorescence yield, F_m – background fluorescence yield, F_o) and F_v/F_m collected from the late morning CTD casts are shown in Figure 1. F_v is equivalent to chlorophyll biomass and exhibits a maximum in surface waters of the equatorial upwelling. A deep subsurface maximum of F_v is present throughout the subtropical gyres, most

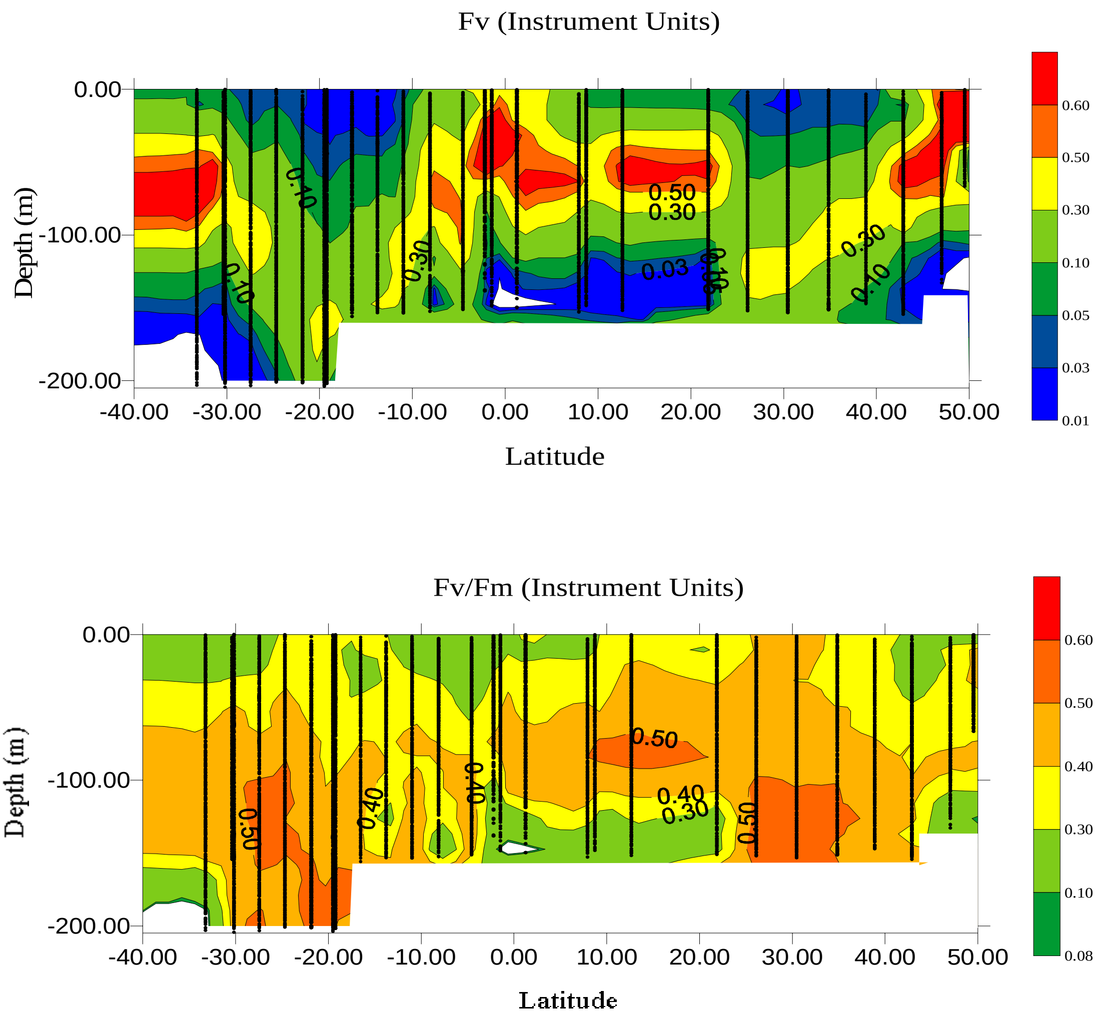


Figure 1. Contour of the variable fluorescence yield (Fv, instrument units) and quantum efficiency of photochemistry (Fv/Fm, dimensionless) measured from the FRRF attached to the optical rig at each CTD station throughout AMT 11.

notably in the south Atlantic. Light driven quenching processes partially account for the lower fluorescence yields in surface waters during the day. F_v/F_m indicates the efficiency by which phytoplankton are able to utilise harvested light and is a function of the nutrient status of a phytoplankton population. As such, surface phytoplankton experience greater photoinhibition of the photosystem where nutrient concentrations are low. The maximum of F_v/F_m throughout the water column is typically observed just below that of F_v. The absolute value of F_v/F_m at the F_v/F_m-maximum is highest in the subtropical gyres and may represent the product of both taxonomic and [relative] physiological change.

Discrete FRRF measurements were also made, using the same criteria as described above, on water samples collected from each pre-dawn CTD cast. These 'dark' data are not affected by quenching processes and are, therefore, not directly comparable with those displayed in Figure 1.

The second (aluminium) FRRF was attached to the ship's non-toxic surface seawater supply and programmed to log data continuously throughout the cruise. Data were collected per 5000ms but logged internally as 1 averaged data point per 42 seconds. All optical windows were cleaned every 2-3 days to reduce any accumulation of fouling material. An example of processed values of underway F_v and F_v/F_m from the northern hemisphere (Fig. 2), show highest values towards the U.K. continental shelf and equatorial upwelling. Lowest values occur throughout the north Atlantic subtropical gyre. A clear diel signal is apparent and corresponds with quenching, photoinhibition and state transition processes between photosystems II and I at dawn and dusk (*sensu* Behrenfeld and Kolber 1998). Both vertical profiled and continuous underway data will contribute towards a greater understanding of basin-scale phytoplankton physiology and production using FRRF data from AMTs 6–11.

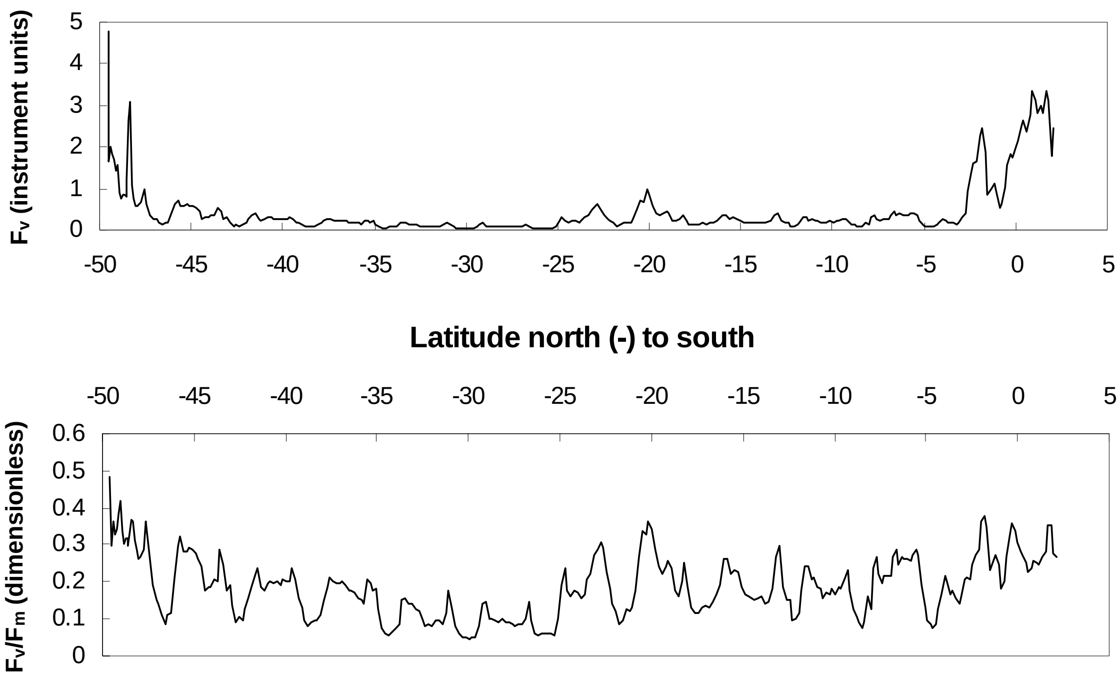


Figure 2. Underway record of variable fluorescence (Fv) and quantum efficiency of photochemistry (Fv/Fm) as measured by the FRRF between the U.K. continental shelf and the equatorial upwelling. Data were recorded from the dark chamber approximately every 42 seconds but are presented here as the binned hourly average.

Deployment field log: Optical/FRRF cast logsheet

Station	Date	GMT	Latitude	Longitude	Depth	Q-factor	Observation
CTD001	14 Sept	09:35	49 36 57	-005 26 11	80	no	
CTD003	15 Sept	09:45	47 08 05	-011 35 03	150	no	
CTD005	16 Sept	10:48	42 58 53	-014 45 01	150	60	
CTD007	17 Sept	10:40	38 57 48	-017 41 37	150	no	
CTD009	18 Sept	10:42	34 56 01	-020 27 16	150	60	
CTD011	19 Sept	10:45	30 33 01	-021 23 18	150	60	
CTD013	20 Sept	10:50	26 13 13	-021 46 53	150	60	No deck cell
CTD015	21 Sept	10:45	21 57 12	-020 59 56	150	60	Deck cell for 2nd cast
CTD016	23 Sept	10:45	12 44 51	-020 39 52	150	60	
CTD018	24 Sept	10:45	08 49 13	-018 58 55	150	60	Very sunny
CTD018a	24 Sept	14:45	08 14.26	-018 34.54	150	no	
CTD020	25 Sept	10:45	05 06 05	-016 56 01	150	60	No FRRF
CTD022	26 Sept	10:50	01 21 01	-014 53 09	150	60	
CTD024	27 Sept	10:08	-02 07 01	-013 08 06	150	60	
CTD026	28 Sept	09:10	-01 21 28	-012 43 05	150	60	
CTD027	29 Sept	10:45	-04 27 56	-012 37 48	150	60	
CTD029	30 Sept	10:45	-08 01 13	-014 50 20	150	60	
CTD031	01 Oct	11:45	-10 54 04	-018 14 39	150	60	
CTD033	02 Oct	11:45	-13 39 56	-021 33 56	150	60	
CTD035	03 Oct	11:45	-16 25 37	-024 54 29	150	60	
CTD037	04 Oct	11:45	-19 07 39	-028 14 38	200	60	
CTD037A	04 Oct	15:00	-19 25 00	-028 35 52	200	60	
CTD039	05 Oct	11:45	-21 44 40	-031 30 59	200	no	Cloud patches
CTD041	06 Oct	12:45	-24 35 41	-035 08 55	200	60	
CTD043	07 Oct	12:45	-27 19 15	-038 42 02	200	60	Big cloud patches
CTD045	08 Oct	13:00	-30 05 11	-042 22 14	200	60	
CTD045A	08 Oct	15:20	-30 16 44	-042 38 08	200	no	
CTD046	09 Oct	12:44	-33 08 42	-046 35 51	200	60	

FRRF dark station logsheet

Station	Date	GMT	Latitude	Longitude	Depth (m)
CTD002	15 Sept	05:00	47 57 29	-010 38 36	0, 10, 20, 30, 40, 50, 65, 80, 100, 250
CTD004	16 Sept	04:30	43 55 15	-014 03 14	4, 20, 30, 45, 60, 70, 90, 160, 250
CTD006	17 Sept	04:30	39 57 31	-016 58 45	4, 20, 30, 40, 55, 70, 75, 80, 90, 150, 160, 250
CTD008	18 Sept	04:43	35 52 17	-019 48 55	4, 25, 40, 60, 80, 95, 110, 140, 250
CTD010	19 Sept	04:45	31 34 18	-021 11 22	4, 20, 40, 80, 105, 115, 120, 130, 160, 180, 250
CTD012	20 Sept	04:48	27 14.73	-021 58 05	4, 30, 50, 90, 110, 120, 150, 180, 250
CTD014	21 Sept	4:45	22 57.64	-021 11 08	4, 25, 50, 60, 70, 80, 90, 110, 160, 250
CTD017	24 Sept	04:42	9 42 36	-019 29 34	4, 15, 25, 40, 50, 60, 80, 100, 160, 250
CTD019	25 Sept	04:45	05 58 41	-017 26 15	4, 20, 40, 55, 59, 62, 80, 100, 160, 250
CTD021	26 Sept	04:50	02 09 28	-015 20 43	1, 20, 40, 60, 80, 85, 90, 120, 160, 250
CTD023	27 Sept	4:34	-01 22 12	-013 12 10	4, 22, 35, 45, 50, 60, 80, 100, 160, 250
CTD025	28 Sept	04:15	-02 08 28	-012 51 07	4, 15, 28, 40, 45, 55, 70, 110, 160, 250
CTD028	29 Sept	4:45	-07 13 38	-014 18 10	4, 30, 60, 80, 90, 100, 120, 150, 180, 250
CTD030	01 Oct	5:45	-10 13 57	-017 26 52	4, 30, 60, 80, 100, 107, 115, 130, 180, 250
CTD032	02 Oct	6:00	-13 01 30	-020 46 50	4, 40, 70, 110, 125, 135, 145, 160, 180, 250
CTD034	03 Oct	5:30	-15 44 56	-024 04 46	4, 50, 100, 130, 160, 165, 170, 180, 200, 250
CTD036	04 Oct	5:30	-18 27 22	-027 24 41	4, 50, 90, 140, 170, 178, 185, 195, 220, 250
CTD038	05 Oct	5:38	-21 03 27	-030 39 37	4, 50, 100, 140, 155, 165, 180, 190, 220, 250
CTD040	06 Oct	6:00	-23 48 17	-034 07 54	4, 40, 80, 100, 110, 125, 150, 190, 220, 250
CTD042	07 Oct	6:00	-26 36 41	-037 45 35	4, 40, 60, 80, 90, 100, 110, 140, 180, 250
CTD044	08 Oct	6:20	-29 28 43	-041 20 41	4, 30, 50, 70, 80, 100, 150, 180, 200, 250

FRRF Underway log

	Start				Finish					
SDY	Time (loc)	Time GMT	Lat (N)	Lon (W)	SDY	Time (loc)	Time GMT	Lat (N)	Lon (W)	File Name
258	12:15	11:15	4933.48	543.75	259	05:10	04:10	4757.47	1030.5	A11UW01
259	06:01	05:01	4757.15	1039.16	259	10:23	09:23	4710.8	1132.39	A11UW02
259	10:43	09:43	4705.39	1137.74	260	04:30	04:30	4355.26	1403.27	A11UW03
260	05:00	05:00	4354.05	1403.94	260	10:42	10:42	4258.03	1445.27	A11UW04
260	12:05	12:05	4252.68	1449.05	261	04:22	04:22	3957.3	1658.7	A11UW05
261	05:08	05:08	3957.54	1658.76	261	10:40	10:40	3857.61	1741.71	A11UW06
261	11:28	11:28	3856.33	1742.4	262	04:40	04:40	3552.26	1948.86	A11UW07
262	05:30	05:30	3551.35	1949.63	262	10:40	10:40	3455.78	2027.23	A11UW08
262	11:27	11:27	3454.48	2028.58	263	10:40	10:40	3032.93	2123.17	A11UW09
263	11:27	11:27	3031.34	2123.89	264	04:43	04:43	2714.72	2158.09	A11UW10
264	05:13	05:13	2714.58	2158.14	264	10:38	10:38	2613.23	2147.06	A11UW11
264	11:28	11:28	2611.89	2147.05	265	04:40	04:40	2257.49	2111.11	A11UW12
265	05:20	05:20	2257.63	2111.24	265	10:42	10:42	2157.15	2100.01	A11UW13
265	11:33	11:33	2154.84	2059.93	266	11:10	11:10	1728.3	2039.86	A11UW14
266	11:10	11:10	1728.26	2039.86	267	10:40	10:40	1244.52	2039.87	A11UW15
267	12:10	12:10	1235.78	2039.73	268	10:40	10:40	848.83	1859.16	A11UW16
268	11:25	11:25	848.4	1858.44	269	10:40	10:40	505.69	1656.11	A11UW17
269	11:30	11:30	505.16	1655.36	270	10:42	10:42	120.98	1453.14	A11UW18
270	11:25	11:25	120.72	1452.63	271	09:37	09:37	-206.68	1307.94	A11UW19
271	10:33	10:33	-207.25	1308.35	272	09:32	09:32	-121.65	1243.31	A11UW20
272	10:28	10:28	-124.58	1243.01	273	10:40	10:40	-428.16	1237.55	A11UW21
273	11:30	11:30	-428.9	1239.11	274	10:39	10:39	-801.4	1450.15	A11UW22
274	11:25	11:25	-801.77	1451.11	275	10:40	11:40	-1054.05	1814.7	A11UW23
275	11:25	12:25	-1054.48	1815.61	276	10:40	11:40	-1339.91	2133.97	A11UW24
276	11:29	12:29	-1340.22	2135.21	277	10:39	11:39	-1625.58	2454.56	A11UW25
277	11:26	12:26	-1625.58	2454.81	278	10:37	11:37	-1907.72	2814.28	A11UW26
278	11:21	12:21	-1907.81	2814.79	279	10:39	11:39	-2144.87	3130.77	A11UW27
279	11:28	12:28	-2145.89	3132.3	280	10:39	12:39	-2435.8	3508.74	A11UW28
280	11:33	13:33	-2436.97	3509.78	281	10:37	12:37	-2719.11	3841.66	A11UW29
281	11:28	12:28	-2719.25	3842.28	282	10:36	12:36	-3004.23	4221.12	A11UW30
282	11:34	13:34	-3005.17	4221.89	283	07:33	10:33	-3307.31	5022.1	A11UW31

Seawater Filtrations

Sandy Thomalla

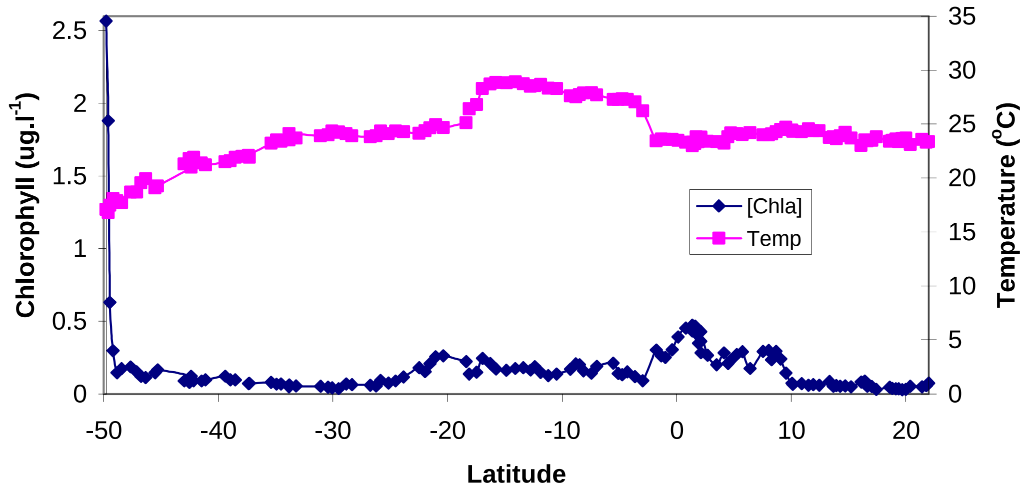
Underway Sampling

A pre-determined volume of water was collected approximately every 4 hours from the ship's nontoxic underway seawater supply. This water was gently filtered through 0.2µm glass fibre filters for the determination of total chlorophyll-a concentration. Each filter was extracted in 10ml of 90% acetone for 24hours in the -20°C walk in freezer. Chlorophyll-a was measured on a 10-AU Turner Design digital fluorometer calibrated against a standard chlorophyll-a stock solution. The chlorophyll concentration was determined from the fluorometer reading as

[Chla] = (volume acetone / volume water filtered) x fluorometer reading

For each underway sample, the time, latitude, longitude, surface temperature, salinity and fluorescence were recorded in the underway log. Figure.1 shows the chlorophyll concentration and temperature for the underway transect.

Figure 1. Underway surface temperature and chlorophyll



CTD Sampling

Two CTD casts were carried out each day. Firstly a pre-dawn CTD at around 04:30 and a second CTD at approximately 11 00. Water samples were taken at 10 depths with 10 litre Niskin bottles between 4 and 250m (typically from above and below the 1% light irradiance depth and included samples from the sub-surface chlorophyll maximum and at least three from across the thermocline). 250ml from each depth was filtered for chlorophyll-a concentration using the same method described above. A second set of filtrations were carried out at five of the CTD depths. Using water taken from the surface, the chlorophyll maximum, between the surface and chlorophyll maximum, and below the chlorophyll maximum. Triplicates of 1500ml were filtered through 0.2µm glass fibre filters and frozen at -80°C, these filters will be analysed on return to the laboratory. One set of filters will be analysed for CHN (carbon, hydrogen and nitrogen) content, while another duplicate set of samples will be analysed for pigments using HPLC (High Pressure Liquid Chromatography). From these pigments it is possible to determine the taxonomic composition of the phytoplankton community, and how this composition changed throughout the cruise. In the oligotrophic waters of the subtropical gyre, single samples of 3000ml were filtered for HPLC instead of duplicate 1500ml samples.

Nitrogen uptake and regeneration

Begona Castro Loehmann and Marta Maria Varela Rozados

Seawater samples were collected at 3 depths from the CTD water bottle rosette in polycarbonate bottles. These samples were tagged with ^{15}N-labelled substrates (ammonium, nitrate and urea) and incubated under percentage of incident irradiance corresponding to the respective depths of origin, for 2 hours, in incubators cooled with underway water supply. At the end of the incubation period the samples were vacuum-filtered through of 0.2 µm GF/F filters: the filters were dried in an oven and they will be analysed in the land laboratory to determine net DIN uptake rate; the filtrate was poisoned with $HgCl_2$, stored in PYREX bottle and it will be analysed in land laboratory to determinate DON regeneration.

Also, other water samples were collected to measure ammonium, nitrate, nitrite and urea. They were stored frozen until transportation to land laboratory.

Bacterial production and abundance

Begona Castro Loehmann and Marta Maria Varela Rozados

Seawater samples were collected at 7 depths from the CTD water bottle rosette in 100 ml polycarbonate bottles.

From each depth, one water sample was processed to determine bacterial production: the seawater was placed in vials and tagged with ^{3}H-Leucine (two control vials were poisoned with TCA-50% to precipitate de proteins). Samples were incubated for 1.5 hours and at the end of the incubation period were centrifuged to remove the ^{3}H-Leucine non-incorporated by bacteria. Finally each sample was filled with scintillation cocktail and counted in the scintillation counter to determine bacterial uptake of leucine. Further experiments of saturation and conversion rate of leucine were developed to estimate the added concentration of leucine and the leucine incorporated to carbon.

Another water sample was processed for quantification of bacteria and flagellates. The seawater samples were fixed with glutaraldehyde 25% and incubated 24h before staining with DAPI and filtering through membrane filters with a vacuum filtration unit. Finally the filters were mounted on microscope slides and stored frozen until land laboratory analysis.

Nitrogen uptake and bacterial production

DATE	TIME	POSITION	STATION	ACTIVITY
14/09/00	09:57	49.36.57N / 5.26.11W	AMT 11-01	Nitrogen uptake
15/09/00	04:18	47.57.29N / 10.38.36W	AMT 11-02	Bacterial production
15/09/00	09:59	47.08.5N / 11.35.3W	AMT 11-03	Nitrogen uptake
16/09/00	04:30	43.55.15N / 14.03.14W	AMT 11-04	Bacterial production
16/09/00	10:48	42.58.53N / 14.45.1W	AMT 11-05	Nitrogen uptake
17/9/00	04:29	39.57.31N / 1658.45W	AMT 11-06	Bacterial production
17/09/00	10:40	38.57.48N / 17.41.37W	AMT 11-07	Nitrogen uptake
18/09/00	04:43	35.52.17N / 19.48.55W	AMT 11-08	Bacterial production
18/09/00	10:42	34.56.1N / 20.27.16W	AMT 11-09	Nitrogen uptake
19/09/00	04:45	31.34.18N / 21.11.22W	AMT 11-10	Bacterial production

DATE	TIME	POSITION	STATION	ACTIVITY
19/09/00	10:45	30.33.1N / 21.23.18W	AMT 11-11	Nitrogen uptake
20/09/00	04:45	27.14.43N / 21.58.5W	AMT 11-12	Bacterial production
20/09/00	10:45	26.13.13N / 21.46.53W	AMT 11-13	Nitrogen uptake, Bacterial production
21/09/00	04:45	22.57.34N / 21.11.01W	AMT 11-14	Bacterial production
21/09/00	10:45	21.57.12N / 20.59.56W	AMT 11-15	Nitrogen uptake, Bacterial production
23/9/00	10:45	12.44.51N / 20.39.52W	AMT 11-16	Nitrogen uptake, Bacterial production
24/9/00	4.45	09.42.25N / 19.29.22W	AMT 11-17	Bacterial production
24/9/00	10:45	08.49.13N / 18.58.55W	AMT 11-18	Nitrogen uptake, Bacterial production
25/9/00	04:45	05.58.41N / 17.26.15W	AMT 11-19	Bacterial production
25/9/00	10:45	05.06.05N / 16.56.1W	AMT 11-20	Nitrogen uptake, Bacterial production
26/9/00	04:50	02.09.28N / 15.20.43W	AMT 11-21	Bacterial production
26/9/00	10:50	01.21.01N / 14.53.09W	AMT 11-22	Nitrogen uptake, Bacterial production
27/9/00	4.34	01.22.12S / 13.12.10W	AMT 11-23	Bacterial production
27/9/00	10:08	02.07.01S / 13.08.06W	AMT 11-24	Nitrogen uptake, Bacterial production
28/9/00	04:05	02.08.28S / 12.51.07W	AMT 11-25	Bacterial production
28/9/00	09:35	01.21.28S / 12.43.05W	AMT 11-26	Nitrogen uptake, Bacterial production
29/9/00	10:45	04.2756S / 12.37.48W	AMT 11-27	Nitrogen uptake, Bacterial production
30/9/00	04:45	07.13.38S / 14.18.10W	AMT 11-28	Bacterial production
30/9/00	10:45	08.01.13S / 14.50.20W	AMT 11-29	Nitrogen uptake, Bacterial production
10/01/2000	05:45	10.13.57S / 17.26.52W	AMT 11-30	Bacterial production
10/01/2000	11:45	10.54.4S / 18.1439W	AMT 11-31	Nitrogen uptake, Bacterial production
10/02/2000	05:45	13.01.30S / 20.46.50W	AMT 11-32	Bacterial production
10/02/2000	11:45	13.39.56S / 21.33.56W	AMT 11-33	Nitrogen uptake, Bacterial production
10/03/2000	05:30	15.44.56S / 24.04.46W	AMT 11-34	Bacterial production
10/03/2000	11:45	16.25.37S / 24.54.29W	AMT 11-35	Nitrogen uptake, Bacterial production
10/04/2000	05:30	18.27.22S / 27.24.41W	AMT 11-36	Bacterial production
10/04/2000	11:45	19.07.39S / 28.14.38W	AMT 11-37	Nitrogen uptake, Bacterial production
10/05/2000	05:30	21.03.27S / 30.39.37W	AMT 11-38	Bacterial production
10/05/2000	11:45	21.44.40S / 31.30.59W	AMT 11-39	Nitrogen uptake, Bacterial production
10/06/2000	06:00	23.48.17S / 34.07.54W	AMT 11-40	Bacterial production
10/06/2000	12:45	24.35.41S / 35.08.55W	AMT 11-41	Nitrogen uptake, Bacterial production
10/07/2000	06:00	26:36.41S / 37.45.35W	AMT 11-42	Bacterial production
10/07/2000	12:45	27.19.15S / 38.42.02W	AMT 11-43	Nitrogen uptake, Bacterial production
10/08/2000	06:15	29.18.43S / 41.20.41W	AMT 11-44	Bacterial production
10/08/2000	13:00	30.05.11S / 42.22.14W	AMT 11-45	Nitrogen uptake, Bacterial production
10/09/2000	12:44	33.08.42S / 46.35.51W	AMT 11-46	Nitrogen uptake, Bacterial production

Phytoplankton-mediated carbon and oxygen flows

Emilio Fernández, Ramiro Varela, Pablo Serret

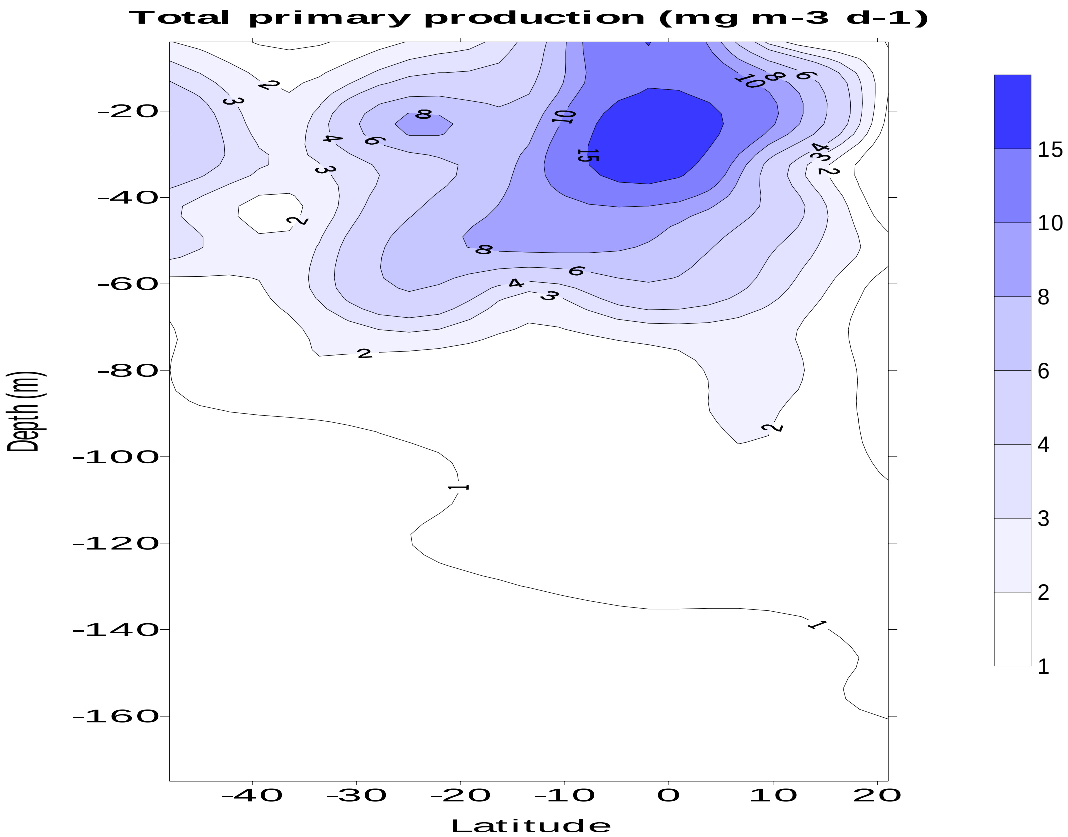
Universidad de Vigo (Spain)

Size-fractionated chlorophyll a and primary production

From each CTD cast, seawater samples (300 cm^3) were drawn from 5-6 selected depths and filtered sequentially through 0.2, 2 and 20 μm polycarbonate filters which were immediately placed in glass vials and 8 ml of 90% added. After extraction at –20 ºC for ca. 20 h, chlorophyll *a* fluorescence was measured with a Turner Designs 10-AU fluorometer.

For the measurement of size-fractionated primary production rates four 70 cm^3 acid-cleaned polypropylene bottles (3 transparent + 1 dark) were filled with water from 5 depths at every early morning CTD cast. Each bottle was inoculated with 333 to 814 kBq (9-22 to μCi) $NaH^{14}CO_3$, depending on the biomass of primary producers, as to yield activities exceeding 3000 dpm. Samples were incubated at dawn in an on-deck incubator at irradiances corresponding approximately to those experienced by the cells at the sampling depths. Incubations lasted 24 h. Samples were then filtered at very low vacuum pressure (< 50 mm Hg) through a cascade of 20, 2 and 0.2 μm polycarbonate filters. Filters were decontaminated by exposure to fumes of concentrated HCl fumes for 20-22 h and placed in plastic scintillation vials and 3 ml of Ultima GOLD XR LSC scintillation cocktail added to each vial. The radioactive activity in the filters was determined with a Beckman LS600SC liquid scintillation counter onboard. Quenching corrections were performed using internal quench correction.

The highest rates of primary production rates during AMT-11 were found at the equatorial region between 10 ºN and 10º S, with maximum values found at shallow subsurface (20-40 m depth) layers where > 15 mg C m^{-3} d^{-1} were measured. Primary production rates in the subtropical gyres were extremely low (< 3 mg C m^{-3} d^{-1}) in the whole water column. Relatively high carbon incorporation rates by phytoplankton were measured at temperate and tropical North Atlantic waters.



Carbon incorporation into photosynthetic products

Samples for the determination of the rates of photosynthetic carbon incorporation into low molecular weight metabolites, lipids, polysaccharides and proteins were collected at the same stations and from the same depths where size-fractionated primary production rates was measured. Each bottle was inoculated with 333 to 814 kBq (9-22 to μCi) $NaH^{14}CO_3$ depending on the biomass of primary producers as to yield activities exceeding 3000 dpm. Samples were incubated at dawn in an on-deck incubator at irradiances corresponding approximately to those experienced by the cells at the sampling depths. Incubations lasted 24 h. Samples were then filtered at very low vacuum pressure (< 50 mm Hg) through Millipore GFF filters which were kept frozen at –80 ºC until further analysis ashore.

Photosynthesis-irradiance (P-I) curves

The relationship between irradiance and the rate of carbon incorporation by phytoplankton was evaluated at 3 depths every late-morning station, 3 different depths down to the deep chlorophyll maximum. 13 Corning bottles were filled from each depth, inoculated with 333 to 814 kBq (9-22 to μCi) $NaH^{14}CO_3$ and incubated with halogen near solar lamps for approximately 2 hours. The incubators were cooled with near sea-surface water (18.5-23ºC). The PAR irradiance (μE m^{-2} s^{-1}) of each incubator cell (corresponding to the light each Corning bottle is about to receive) was measured before every incubation with a LI-COR 1000 quantometer equipped with a LI-COR plate sensor. The last Corning bottle from each depth was protected against light with aluminium foil and used as a dark reference. After the incubation time, samples were removed from the incubator and filtered through Millipore GF/F filters, which were processed as described above for the determination of size-fractionated primary production rates.

Total particulate matter absorption spectra

Total particulate matter absorption spectra were measured on GFF filters fitted with an opal glass on a single beam Beckman DU650 scanning (350-750 nm) spectrophotometer. 1.5 to 3 ml of seawater were filtered through Millipore GFF glass fibre filter and a modified opal-glass technique was used to determine the optical density OD(λ) of the particles retained on the filter. An identical glass fibre filter soaked in filtered seawater was used as a blank. The optical density at 750 nm was subtracted from OD(λ) and the phytoplankton absorption coefficients $a_p(\lambda)$ were estimated according to the relationship:

$$a_p = \frac{2.3 \cdot OD(\lambda) \cdot s}{V \cdot \beta(\lambda)}$$

where *V* is the volume of filtered seawater, *s* the filtering area of the GF/F filter and the beta factor $\beta(\lambda)$ was estimated as:

$$\beta(\lambda) = 1.63 \cdot OD(\lambda)^{-0.22}$$

The light absorption by particulate detritus $a_d(\lambda)$ was estimated numerically following the method of Bricaud and Strawski (1990) improved for low detritus content (Varela et. al. 1998).

References

BRICAUD, A., and D. STRAMSKI. 1990. Spectral absorption coefficients of living phytoplankton and nonalgal biogenous matter: A comparison between the Peru upwelling area and the Sargasso Sea. Limnol. Oceanogr. 35: 562-582.

VARELA, R.A..; FIGUEIRAS, F.; AGUSTÍ, S. and B. ARBONES 1998 Determining the contribution of pigments and the non-algal fraction to total absorption: toward a global algorithm. Limnol. Oceanogr ., 43(3) :449-457

Rates of O_2 production and consumption

Gross production (GP), net community production (NCP) and dark community respiration (DCR) were determined from *in vitro* changes in dissolved oxygen. At each early morning station, 125 cm^3

borosilicate glass bottles were filled from 5-6 depths. From each depth, five zero time replicates were fixed immediately, and a further ten replicate bottles were incubated in surface water cooled light and dark deck incubators for 24 hours. Light incubators were covered with polycarbonate screens incorporating neutral density acrylic of differing transmission to give a range of irradiances which simulated those experienced by the cells in their original environment. The dark incubators were covered with opaque screens. Production and respiration rates were calculated from the difference between the means of the replicate light and dark incubated and zero time analyses.

Microplankton nets

Vertical hauls (100 m) were carried out with a 20 μm microplankton net at every mid morning station. The sample was transferred to a 250 ml measuring cylinder and divided into 2 aliquots. A 100 ml subsample was placed in a glass bottle and fixed with buffered formalin for the further quantification ashore of the biomass of microplankton species by image analysis of the biomass. 25 to 100 ml of the remaining sample was filtered through a Millipore GFF filter and kept frozen (-80 ºC) for the further determination of particulate C and N concentration ashore.

Station	Size-fractionated Chlorophyll *a*	Size-fractionated PP	Carbon incorporation	P-I curves	POM absorption spectra	O_2 production and consumption	Microplankton nets
11-1	X						
11-2	X	X	X			X	
11-3	X			X	X		
11-4	X	X	X			X	
11-5	X			X	X		X
11-6	X	X	X			X	
11-7	X			X	X		X
11-8	X	X	X			X	
11-9	X			X	X		X
11-10	X	X	X			X	
11-11	X			X	X		X
11-12	X	X	X			X	
11-13	X			X	X		X
11-14	X	X	X			X	
11-15	X			X	X		X
11-16	X			X	X		X
11-17	X	X	X			X	
11-18	X			X	X		X
11-19	X	X	X			X	
11-20	X			X	X		X
11-21	X	X	X			X	
11-22	X			X	X		X
11-23	X	X	X			X	
11-24	X			X	X		X
11-25	X	X	X			X	
11-26	X			X	X		X
11-27	X			X	X		X
11-28	X	X	X			X	
11-29	X			X	X		X
11-30	X	X	X			X	
11-31	X			X	X		X
11-32	X	X	X			X	
11-33	X			X	X		X
11-34	X	X	X			X	
11-35	X			X	X		X
11-36	X	X	X			X	
11-37	X			X	X		X
11-38	X	X	X			X	
11-39	X			X	X		X
11-40	X	X	X			X	
11-41	X			X	X		X
11-42	X	X	X			X	
11-43	X			X	X		X
11-44	X	X	X			X	
11-45	X			X	X		X

Macro-nutrient depth profiles - CDOM depth profiles

Vassilis Kitidis

Scientific rationale

The purpose of this work is to study the concentration dynamics of macro-nutrients and chromophoric dissolved organic matter (CDOM) in the top 250 metres along the cruise transect as it crosses distinct, contrasting biogeographical regions. These data add to the AMT time series and form part of the core research programmes of PML/CCMS.

Samples were collected daily from vertical CTD casts and analysed for the concentrations of plant macro-nutrients, nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+) phosphate (PO_4^{3-}) ions and silicate (SiO_2). These macro-nutrients are essential for phytoplankton growth and usually depleted in the mixed layer, in oceanic environments, due to their uptake by primary producers. A sharp increase in the macro-nutrient concentrations is found below the mixed layer. As phytoplankton growth is nutrient limited in the upper mixed layer (UML), and light limited below, primary producers concentrate near the pycnocline that separates the UML from the water below. This ensures optimal growth in the nutrients vs. light availability trade-off. Biological activity acts as a source of organic matter (particulate and dissolved), while the pycnocline forms a physical barrier for organics which are aggregated and thereby support local bacterial populations at the pycnocline. The re-mineralisation of organic matter is evident from the ammonium and nitrite concentration profiles which peak below the pycnocline and chlorophyll maximum. Ammonium ion is produced in the excreta of the biota and from 'sloppy-feeding' of zooplankton on phytoplankton. Nitrite is produced as an intermediate product of nitrification the conversion of ammonium to nitrite, by nitrifying bacteria. A typical profile of these three inorganic nitrogen species is shown in figure 1. Note the succession of ammonium peak to nitrite peak to high nitrate with increasing depth.

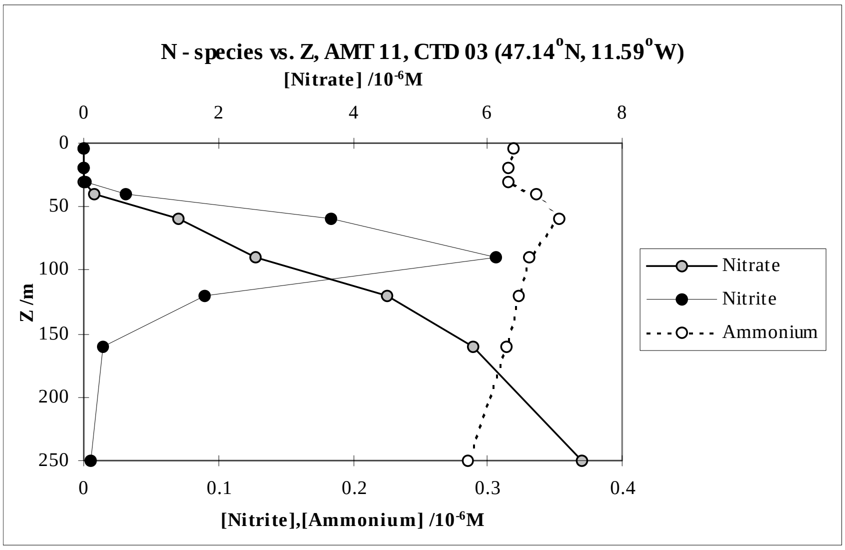


Figure 1. Depth profile of nitrite, nitrate and ammonium ions from station 03 (47.14°N, 11.59°W) of AMT11 research cruise. Ammonium (empty circles) concentration, peaks at approximately 70m depth as a result of biological excretion. This is converted to nitrite and subsequently nitrate, by nitrifying bacteria. This succession is visible from the distribution of nitrite (black circles) concentration which peaks just below and ammonium and finally the nitrate (grey circles) nutricline, below.

Regions of differing nutrient regimes and biogeochemistry are highlighted in figure two. This is a compilation of data from the first 18 stations. A progression can be seen as one moves from north to south along the cruise-track. The fairly mixed water column at the shelf edge, off the higher latitudes, is succeeded by a stratified system with a nutricline which becomes progressively deeper as the cruise track transects the edge of the oligotrophic-north-Atlantic gyre. This is followed by the upwelling regions, off the coasts of west-Africa, where the highest concentrations are encountered and the UML becomes shallower again. This area is far more productive, something that was apparent from the increased biological activity in the water during stations.

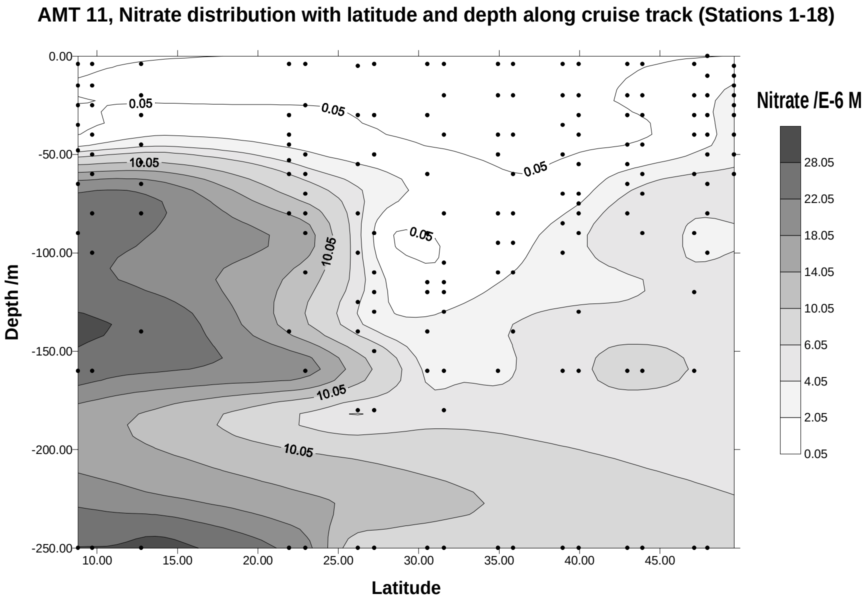


Figure 2: The distribution of nitrate along the AMT 11 cruise track with northern latitude and depth. Dots represent data points. Note the low concentrations in the nutrient depleted UML, followed by a sharp increase in concentration with depth (nutricline). Contrasting biogeochemical regions here are the edge of the north-Atlantic gyre (between 27^{o}-40^{o} N) with a deep UML and the lowest concentrations and the west-African upwelling regions (between 8^{o}-25^{o} N) with a shallower UML and sharp nutricline.

Depth profiles of chromophoric dissolved organic matter (CDOM) are of importance to ocean optics and remote sensing. CDOM absorption spectra provide some information on the source of the material, allowing to distinguish 'old' material from deeper waters, 'fresh' material from the chlorophyll maximum and photodegraded material from surface waters. As with macro-nutrients, distribution of CDOM along the cruise transect is of particular interest between the different biogeochemical provinces. This work was also carried out on AMT 9 (*JR* 45) and AMT 10 (*JR* 49), thus the data will collected on the present cruise will complement the set already available.

Analytical

Macro-nutrient analysis was carried out using air-segmented-flow, colorimetric techniques, with a Technicon Autoanalyzer II. For the determination of ammonium ion concentrations, a nanomolar sensitivity, fluorometric method was used. Samples for nutrient analysis were collected in 60 ml HDPE (Nalgene) bottles and analysed immediately after collection. Samples for spectrophotometric analysis were collected in 200 ml analytical grade glass, volumetric flasks. Absorption spectra were taken with a Shimadzu double beam UV/visible spectrophotometer, using 10 cm path length optically paired cuvettes. Samples were also pressure filtered through 0.7 μm filters (Whatman, GF/F), but filtering introduced precision errors and was therefore abandoned. The absorption coefficient at 350 nm and spectral slope of the decay between 290 and 350 nm are used as measures of concentration and origin respectively.

AutoFlux Trials

Margaret J. Yelland and Robin W. Pascal

This report describes the work undertaken on the "AutoFlux" system by SOC staff on the RRS *James Clark Ross* during the U.K. to Falklands passage between 11 September and 17 October 2000. This work coincided with the Atlantic Meridional Transect (AMT) 11 cruise (JR52) which ended on 11 October 2000, and is described elsewhere (Woodward, 2000). The SOC presence on the ship was sponsored by John King (BAS) as part of his Q3 (Antarctic Climate Processes) science program.

The aim of the cruise was to test and develop the AutoFlux air-sea interaction system and its associated prototype instrumentation. The system is intended to provide real-time air-sea fluxes of momentum, sensible heat, latent heat and CO2, in addition to the usual mean meteorological parameters. The fluxes are calculated via the "inertial dissipation" method (Yelland *et al.*, 1998), using data from various fast-response instruments. Most of the instruments used in the system have been well proved during SOC research cruises over the last 10 years or more, but the dedicated sonic temperature sensor and the infra-red H2O/CO2 sensor are prototype instruments developed by colleagues involved in the AutoFlux project (MAST project MAS3-CT97-0108). Likewise, the logging and processing system is itself based on software systems which have been developed at SOC/IOS since the 1980s, but many aspects of the system are new and were tested and developed further during the cruise. By the fourth week of the cruise the system was automatically producing hourly direct measurements of the air-sea fluxes and was sending summary messages of the data back to SOC via the ORBCOMM satellite communications system in near real time.

Acknowledgements

Thanks are due to the officers and crew of the RRS *James Clark Ross*, particularly the navigation officers for their diligence over the cloud observations, to John King (BAS) for sponsoring our presence on the ship, and to the AMT science team for making the SOC gatecrashers welcome on their cruise. We are also grateful to our AutoFlux colleagues who made the sonic temperature and the H2O/CO2 sensors available to us, as well as to Dave Hosom and Co. from Woods Hole Oceanographic Institute for the loan of their sea surface temperature system.

1. Introduction

The Southampton Oceanography Centre's JRD Meteorology Team took part in the U.K. to Falklands passage on the RRS *James Clark Ross* in order to trial the "AutoFlux" air-sea interaction system and its associated prototype instrumentation. The SOC presence on the cruise was sponsored by John King (BAS) as part of his Q3 science program. This work coincided with the Atlantic Meridional Transect (AMT) 11 cruise (JR52) which ended on 11 October 2000, and is described elsewhere (Woodward, 2000).

The AutoFlux system is intended to provide real-time air-sea fluxes of momentum, sensible heat, latent heat and CO2, in addition to the usual mean meteorological parameters (AutoFlux Group, 1996). The fluxes are calculated via the "inertial dissipation" method (Yelland *et al.*, 1998), using data from various fast-response instruments. Most of the instruments used in the system have been well proved during SOC research cruises over the last 10 years or more, but the dedicated sonic temperature sensor (Gill Instruments Ltd.) and the infra-red H2O/CO2 sensor (Mierij Co. and the Royal Netherlands Meteorological Institute "KNMI") are prototype instruments developed by colleagues involved in the AutoFlux project (MAST project MAS3-CT97-0108). In addition to these fast response prototype instruments, the cruise also provided an opportunity to test the Woods Hole Oceanographic Institute (WHOI) sea surface temperature system. The AutoFlux logging and processing system is itself based on software systems which have been developed at SOC/IOS since the 1980s, but many aspects of the system are new and were tested and developed further during the cruise.

The AutoFlux system was set up while the ship was still in Grimsby and logged data continuously from the time of departure (0400 GMT on 12 September, day 256). The ship called in to Portsmouth for about 12 hours (from 0700 to 1900 on day 257) and in to Montevideo for just over 2 days (from 1200 day 285 to 1900 day 287). The system was shut down on 16 October at 1500 GMT, about 20 hours before docking in Stanley. Figure 1 shows the ship track from Portsmouth to the point at which the system was shut down. A wide range of conditions were experienced; 1 minute averages of U_{10N} varied from calm to 20 m/s with a mean of 7 m/s, sea surface temperatures varied from 5° to 30°, air temperatures from 5° to 30°, and the air-sea temperature difference ranged from –4° to 4°.

This report discusses the AutoFlux instrumentation (Section 2) and the AutoFlux logging system (Section 3). Data from the ship's navigation and scientific instrumentation were also obtained (Section 4). Hourly visual cloud observations (Section 5) were also taken throughout the cruise as part of a separate SOC Meteorology Team study into the parameterisation of downwelling longwave radiation from Voluntary Observing Ship cloud observations. Section 6 describes the performance and reliability of the AutoFlux system and associated instrumentation. Section 7 discusses the initial comparisons made between the AutoFlux and ship data streams, and includes a "first look" at the longwave parameterisation (Section 7.2). Finally, Section 8 summarises the major AutoFlux system developments achieved during the cruise. All times in this report are given as GMT.

More information on air-sea fluxes and the AutoFlux project in particular can be found under; http://www.soc.soton.ac.uk/JRD/MET/AUTOFLUX

2. Instrumentation

The SOC Meteorology Team instrumented the JCR with a variety of meteorological sensors, plus a GPS navigation system. The mean meteorological sensors (Table 1) measured air temperature and humidity, air pressure, sea surface temperature, incoming shortwave (300-3000 nm) radiation and incoming longwave (4-50 micron) radiation. The surface fluxes of momentum, heat, moisture and CO_2 were obtained using the fast-response instruments in Table 2. The HS sonic anemometer provided mean wind speed and direction data in addition to the momentum flux estimates. The AutoFlux system also incorporates navigation instruments (Table 3) in order to obtain ship's position and to correct the meteorological data for ship speed and heading.

The positions of the instruments are indicated in Figure 2. Most of the instruments were mounted on the ship's foremast in order to obtain the best exposure. The psychrometers and the fast response sensors were all located on the foremast platform and the radiation sensors were mounted on the "bird table" at the top of the foremast extension. The heights relative to the ship's waterline of the instruments on the foremast platform were; HS sonic anemometer, 15.75 m; psychrometers. 15.40 m; sonic temperature sensor, 15.75 m (both positions); IFM H_2O/CO_2 sensor 15.55 m (first position) and 15.30 m (second position). The sonic temperature and the IFM sensors were both moved on day 277 at around 1200 GMT.

The sea surface temperature (SST) "soap" (thermistor) was trailed over the port side of the ship (not the starboard as illustrated). The Woods Hole hull contact SST sensor was located in the void space next to the transducer space on the starboard side of the ship, about 3.5 m below the water line.

Sensor	Channel, variable name	Address	serial no.	Calibration $Y = C0 + C1*X + C2*X^2 + C3*X^3$	Sensor position	Parameter (accuracy)
Psychrometer	1 pds2	$ARD	IO2002 DRY	C0 -10.10419 C1 3.687167e-2 C2 4.437374 e-6 C3 -1.244586-10	Foremast platform. To stbd of HS sonic.	wet- and dry-bulb air temperatures, and humidity (0.05º)
Psychrometer	2 pws2	$ERD	IO2002 WET	C0 -10.15374 C1 3.847717-2 C2 2.047162-6 C3 -1.487345-10		
Psychrometer	3 pdp1	$VRD	IO2003 DRY	C0 -10.27104 C1 3.757243 e-2 C2 3.514678-6 C3 -8.593494-10	Foremast platform. To port of HS sonic.	wet- and dry-bulb air temperatures, and humidity (0.05º)
Psychrometer	4 pwp1	$WRD	IO2003 WET	C0 -10.11169 C1 3.79443e-2 C2 3.070856 -6 C3 -6.940979-10		
SST "soap" to day 269 10:50	5 soap SST	$XRD	PD0002/52	C0 70.01189 C1 -0.1188988 C2 1.404794e-4 C3 -1.003271e-7	Over port side of foredeck	sea surface temperature (0.1º)
SST "soap" from day 269 10:50	5 soap SST	$XRD	PD0005/53	C0 71.34180732 C1 -0.127521707 C2 1.57588211e-4 C3 -1.172824837e-7	Over port side of foredeck	sea surface temperature (0.1º)
Eppley LW Dome	6, Td1	$HRD	31170	C1 1	foremast top forwards position	incoming LW radiation
Body	7, Ts1	$QRD	31170	C1 1		
Thermopile	8, E1	$2RD	31170	C1 1		
Eppley LW Dome	9, Td2	$BRD	27225	C1 1	foremast top aft position	incoming LW radiation
Body	10, Ts2	$6RD	27225	C1 1		
Thermopile	11, E2	$CRD	27225	C1 1		
Kipp & Zonen SW	12 SWm	$1RD	27225	C1 1	foremast top, port side	incoming SW radiation
Vaisala Pressure	13 press	n/a	ptb220	1	UIC	air pressure
WHOI hull SST	sstMEAN	n/a		n/a	void space	sea surface temp.

Table 1. The mean meteorological sensors. Left to right, the columns show; sensor type, channel number and variable name, rhopoint address, serial number of instrument, calibration applied, position on ship, and the parameter measured.

Sensor	Program	Location	Data Rate	Sections	derived flux
Gill Horizontally Symmetrical Research Ultrasonic Anemometer	gillhs	Port side of foremast platform	20 Hz	64	momentum and heat
Gill dedicated sonic temperature sensor	stemphs	Port (to day 277 12:00) then stbd side of platform	20 Hz	64	heat
IFM IR H20/CO2 sensor	ifmhs	Port side of foremast platform	10 Hz	32	H2O and CO2

Table 2. The fast response sensors.

Instrument	Acquisition program	Position	Sampling rate	Parameters
CSI LGBX - PRO GPS receiver	gps6	aerial on aft rail of wheelhouse deck	1 or 0.5 Hz	GPS time, lat, lon, sog, cog and QC information
KVH fluxgate compass	gps6	UIC lab	1 Hz	ship's heading (magnetic)

Table 3. The navigation instruments.

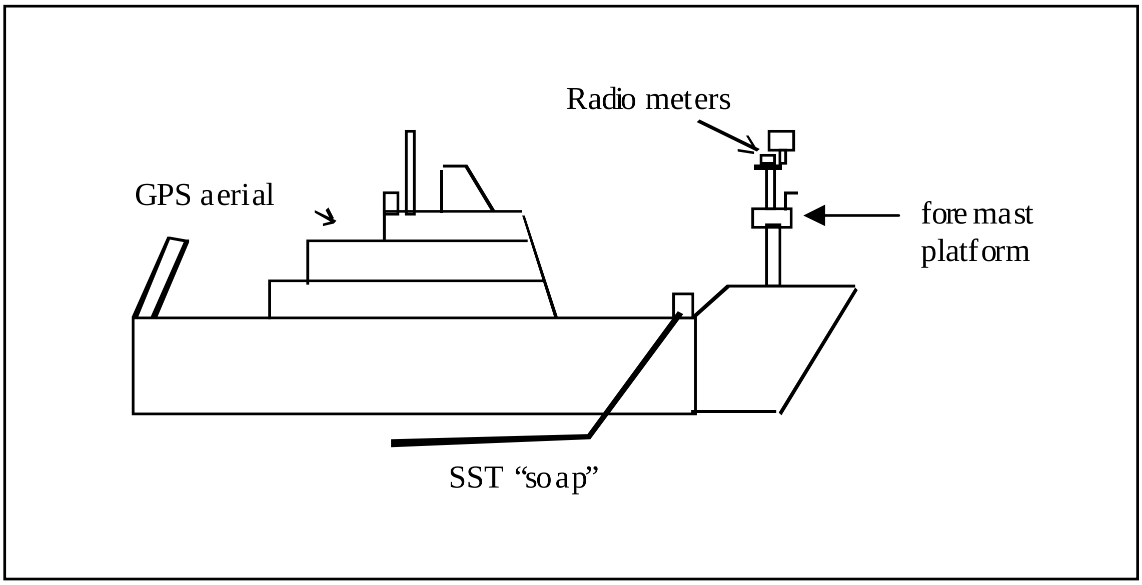


Figure 2a. Schematic of the instrument locations.

3. The AutoFlux logging system.

3.1 System management

All the SOC instruments were logged via the AutoFlux system (Pascal *et al.*, 2000). The exception to this was the WHOI hull sensor which was only received at SOC on the day of departure to the ship. The hull sensor was initially logged via a PC, but a UNIX management program was written and the sensor was integrated into the AutoFlux system on day 272. The AutoFlux system was based on one Unix workstation, named "southerly" (SO). A second identical workstation ("southeasterly", SE) was used for system development. Both workstations were networked but were set up in stand-alone mode and not integrated into the ship's system. Each workstation was cross-mounted with the other, allowing easy transfer of data and software between them and the sharing of devices installed on either station. Backups of both were performed weekly to CD (via the CD writer on SO) and exabyte (via the drive on SE). Table A1.1 (Appendix 1) lists the various modifications to the logging system that took place during the cruise.

The AutoFlux data acquisition system on SO ran multiple real time data acquisition and system programs, and this workstation was equipped with 8 extra serial ports for the multiple serial communications required. Both workstations had a variety of extra features, such as an auto-boot function and other system software designed to make the data acquisition as robust and reliable as possible. These applications were;

Powerchute:- Both systems were attached to uninterruptible power supplies (UPSs) which were managed by UPS powerchute software. This monitors UPS loads, utility supply etc. and includes a background process which provides orderly shutdown of the host computer in the event of an extended AC power failure.

Program Monitor:- Runs the data acquisition programs and continues to monitor that they are currently active. If an acquisition program crashes it is automatically re-started and an indicator is set. As additional data analysis programs were written and implemented these were also managed by the Program Monitor.

Time Sync:- This program acquires time from the GPS receiver and adjusts the workstation time if the error is greater than 1 second. Jumps greater than 10 seconds are flagged and control is passed to the user before any adjustments are made.

3.2 Data acquisition

Data were acquired continuously throughout the cruise using various logging programs on SO. These were;

"Gmet2" – This acquires the mean meteorological variables and was set up to sample the 13 channels of data listed in Table 1. Each sensor is attached to a Rhopoint module which converts the sensor output into digital data, and communicates it to the logging system via an RS485 network. The sensors were interrogated once every 10 seconds.

"Gillhs", "stemphs" and **"ifmhs"** – These programs logged and processed data from the HS sonic anemometer, the sonic temperature sensor and the IFM fast-response H2O/CO2 sensor respectively. The programs are very similar. To take the HS sonic as an example, 64 sections of data were obtained every hour, each section consisting of 1024 data samples which are output from the anemometer at a rate of 20 Hz. At the end of the 64 sections the data are processed to produce spectra and quality control parameters. The different data rates of the three instruments and the number of sections obtained every hour are listed in Table 2.

"GPS6" - This managed the GPS differential navigation system and the fluxgate compass. Data were logged continuously at a rate of 1 Hz. This data rate was unnecessarily high and was reduced to 0.5 Hz on day 276.

"acm" - This was the UNIX management program written for the WHOI hull sensor. This sensor communicates data via two modems, one placed near the sensor and the other placed in the Gravimeter Room. The two modems communicate acoustically via the ship's frame. From the Gravimeter Room the data were transmitted via the ship's scientific wiring. To conserve battery life, the modems were sent to sleep for 10 minutes at a time and then interrogated for sea surface temperature data from the hull sensor, which returned three values on each interrogation.

3.3 Data processing and fluxes

The following UNIX scripts were written during the cruise in order to process the data streams and produce the surface fluxes. These scripts utilise a suite of "pexec" FORTRAN programs. The scripts were managed by the CVI program "scp" which ran them hourly (except for "scrp.daily" which is run once a day).

"scrp.amet" – reads the calibrated mean meteorological data into a PEXEC file, applies basic quality control criteria and selects which psychrometer data to use. Also calculates the longwave radiation from the 3 channels output by the Epply sensors.

"scrp.anav" – reads the GPS and gyro information into a PEXEC file and converts heading and direction variables into north and east components prior to averaging.

"scrp.HULL" – reads the WHOI data into a PEXEC file and applies basic quality control criteria.

"scrp.HS" – reads the "*.mws" summary files from the HS sonic anemometer into a PEXEC file.

"scrp.IFM" - reads the "*.mws" summary files from the IFM sensor into a PEXEC file.

"scrp.STEMP" - reads the "*.mws" summary files from the sonic temperature sensor into a PEXEC file.

"scrp.flux" – merges the 6 separate data streams above into one file (averaging the mean meteorological and navigation data, and interpolating the WHOI SST data). If any data streams are absent they are replaced by dummy data files. Further quality control is applied and then true wind speed, true wind direction and surface fluxes are calculated.

"scrp.plot" – writes out an ASCII file of processed data, fluxes and quality control parameters for use in the AutoFlux display and the ORBCOMM message.

"scrp.daily" – appends the hourly files from each data stream and the hourly flux files into separate daily files which are moved to an archive directory. The previous day's hourly files are then removed once the daily files have been created successfully.

4. Ship data streams

Some of the ship's data streams were logged for comparison with the AutoFlux data. These data streams were;

adcp	(acoustic doppler current profiler - to correct wind speed relative to surface currents)
anemom	(ship's anemometer on the "bird table")
dop_log	(doppler log - to correct wind speed relative to surface currents)
em_log	(electromagnetic log - to correct wind speed relative to surface currents)
gps_nmea	(navigation stream - to check AutoFlux navigation system)
gyro	(gyro compass - to check AutoFlux compass system)
oceanlog	(thermosalinograph data plus air pressure and other mean met data)
CTD	(temperature channels obtained in order to calibrate the other SST sensors)

Initial examination of the ship's data streams showed that;

1) The adcp did not produce sensible data while the ship was underway, and the data did not improve sufficiently to be useful while on station.

2) The doppler log worked intermittently to start with and was then turned off.

3) The em log has yet to be examined, but, as it only measures one component of ship velocity relative to the water and there is a lack of comparison data due to the failure of the adcp and doppler log, it's usefulness will be very limited.

4) The ship's anemometer worked (Section 7.3)

5) The ship's navigation data streams had no problems beyond initial time jumps when the ship's clock was being set. The Level C time stamp occasionally produced time jumps around midnight due to rounding errors when converting between seconds and decimal jday. A comparison with the AutoFlux navigation data is given in Section 7.3.

6) The oceanlogger data were primarily logged for the sea surface temperature from the thermosalinograph (TSG) which will be discussed in Section 7.1 However, it was noticed that neither the PAR sensor nor the humidity sensor were working. Both of these instruments need attention, as does the junction box on the foremast platform.

5. Visual cloud observations

Two independent sets of visual cloud observations were made every hour by a) the ship staff on the bridge, and b) by the SOC staff (supplemented by early morning observations by Don Bonner, Pippa Bradbury and Steve Mee). These were used as part of a separate project aimed at parameterising the downwelling longwave radiation in terms of cloud cover and possibly type. Initial results are shown in Section 7.2.

6. Instrument problems and system downtime.

Data logging was begun on day 256.0 while still in Grimsby, and continued during the port call in Portsmouth (day 257 from 07:00 to 20:00). The system was stopped for data backups. These took place during days;

262 (12:00 - 14:20)

269 (13:00 - 14:00)

275 (18:00 - 21:00)

285 (13:00) - Montevideo. System off while in port. Restarted on 287 (19:00)

290 (15:00) - system off

Other system interruptions are listed in Table A1.2 in Appendix 1. The system performed reliably throughout, with interruptions to the logging caused only by system modifications or backups.

The battery in the **WHOI hull sensor** went flat on day 275 at around 06:00. This was a new battery at the start of the cruise and should have lasted for 6 months. Access to the sensor in the void space was obtained while on the CTD station on day 276 at 11:00 and the dead battery was replaced with the spare. The system was back on line at 12:20. The batteries in the remote modem (in the void space) gave out around 03:00 on day 284. These were replaced on day 285 when the ship arrived in Montevideo. Apart from these problems with the batteries, the system functioned very well throughout the cruise. The success rate for a returned SST measurement when the sensor was interrogated was over 95 %. Table A1.3 in Appendix 1 lists problems and developments for both the WHOI hull sensor and the SOC "soap".

The **SST "soap"** data suggested a near-surface cooling which reached a maximum around 15:00 on successive afternoons during the early part of the cruise. This was shown to be a spurious signal (Section 7.1) caused possibly by heating of the electronics unit on deck. The soap was replaced by a different sensor and electronics unit on 269 at 10:50. During the night of day 271/272 the electronics unit was ripped from its support, presumably by seas taken on over the bow, and the connector to the soap itself became detached. The soap was brought in board by Luke Trussler during the night. The connector was repaired and the same soap re-deployed on day 272 at 13:40.

The starboard **psychrometer wet bulb** dried out periodically, and had to be manually wetted to make the wick work. This did not cause analysis problems because the processing automatically compares the two wet bulb values and uses the lowest available.

The **IFM H2O/CO2** sensor hung periodically (Table A1.4 in Appendix 1). System checks were implemented which reduced the frequency of this problem, but further modifications need to be made. The mirror and lenses were cleaned every day by jets of distilled water which could be activated from the UIC. The effectiveness of this has yet to be judged.

The **HS sonic anemometer** data acquisition would lose sync periodically, but this would only affect one 1024 sample section at a time, with sync usually being re-established on the next section. Modifications were made to the serial port configuration file to increase the default buffer size from 64 bytes to 1024, but this failed to cure the problem.

7. Initial results.

7.1 Sea surface temperature measurements.

There were four SST sensors in use; the CTD (various depths, accuracy of 0.001°), TSG (intake at 7 m, accuracy 0.01°), soap (surface, accuracy 0.1°) and WHOI sensor (depth of 3.5 m, accuracy unknown). From day 259 to 266, the soap was raised to the surface during the second CTD cast of the day (around 11:00 GMT), but for the first cast at around 05:00 the soap was not raised and would sink to a depth of 4 to 7 m. The CTD data from the first 10 casts were each averaged into ten 1m depth bins, from zero to 10 m. The files included data from both the up- and the down-casts. The depth bins spanned a time period of around 30 seconds, and this interval was used to average the 10 second values from the soap.

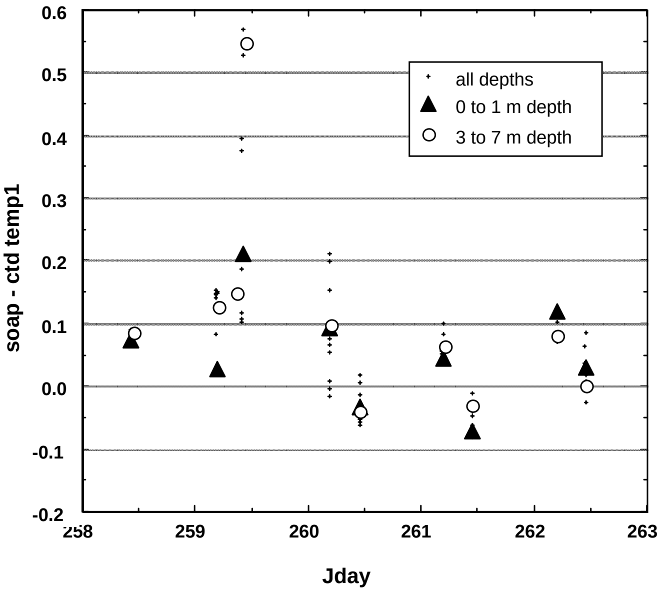


Figure 3. Soap - CTD temp1 SST differences for the first nine CTD casts.

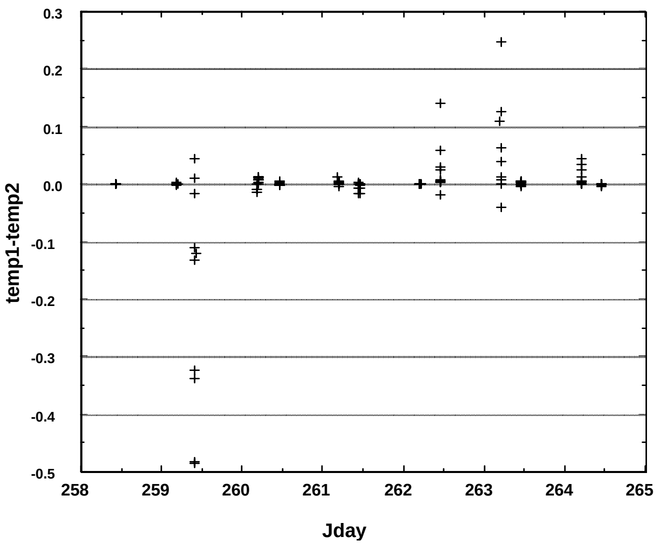


Figure 4. Difference in the CTD sensor temperatures against Jday.

Figure 3 shows the difference between the soap and CTD (temp1 channel) temperatures from the various depths. The data is scattered by about 0.1°, but there is not enough data to show any significant offset. The large difference which occurred during day 259 was thought to be due to a problem with the CTD rather than the soap data. Figure 4 shows the difference between the SST data from the two temperature sensors on the CTD.

The two sensors usually agree to within 0.003° but there are periods when the difference reaches 0.5°. A -0.5° offset in the CTD temp sensor 1 would be consistent with the disparities seen in Figures 3 and 4.

This offset is confirmed by the comparison between the ship's thermosalinograph (TSG) temperatures and that from the CTD temp1 sensor (Figure 5). However, the scatter which occurs in Figure 4 during days 262 and 263 does not occur in either the soap or TSG comparisons, which suggests that on these occasions the CTD temp2 sensor may be at fault. This is confirmed in Figure 6 which shows the difference between the TSG and the CTD temp2 sensor. Finally, replaying the CTD casts showed that on cast 3 (day 259) the temp1 channel on the upcast lagged behind the temp2 channel. It was concluded that on this occasion the pumped flow to the temp1 sensor may have become blocked. No further examination of the CTD casts were made during the cruise, but it is recommended that both channels should be examined for every cast to check for recurrences of the problem.

A direct comparison between the TSG and the soap is shown in Figure 6. It can be seen that the difference between the two varied with time of day. As the day progressed, the soap SST became increasingly colder compared to the TSG, reaching a maximum offset of -0.2° at around 15:00 GMT. This is the opposite trend which would occur if the water temperature at 7 m stays relatively constant, and the surface waters are heated up during the day. Also shown is a comparison of the soap SST with the WHOI SST for one day; the same trend is seen which confirms that it is due to the soap data rather than the TSG. The cool surface "skin effect" is only seen in the first few microns, and can not be the cause of the cooling seen by the soap at a depth of a few cm or more. It was thought that there may have been a problem due to heating of the soap electronics unit on deck. This will not be confirmed until post-cruise calibrations have been performed. However, the AMT PSO kindly agreed to perform an extra CTD dip during the afternoon of day 268 at about 15:00 which confirmed that the surface cooling effect was indeed spurious; repeated shallow surface profiles with the CTD proved that there was no surface cooled layer.

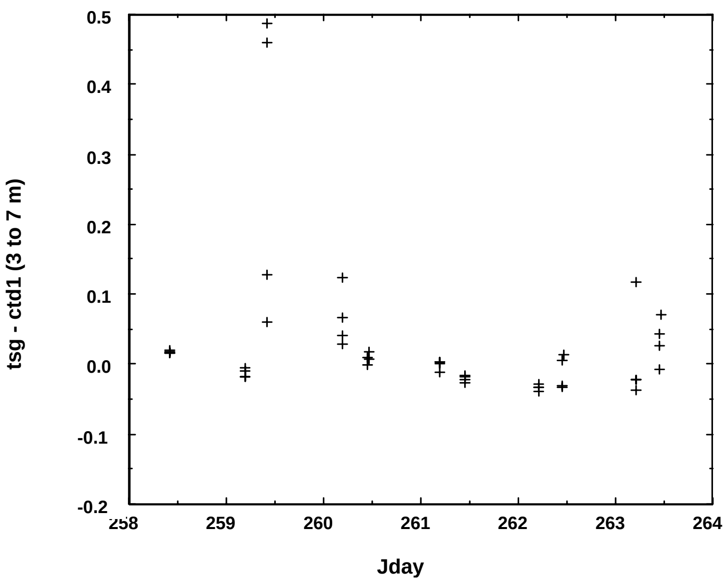


Figure 5. TSG - CTD temp1 SST differences between 3 and 7 m.

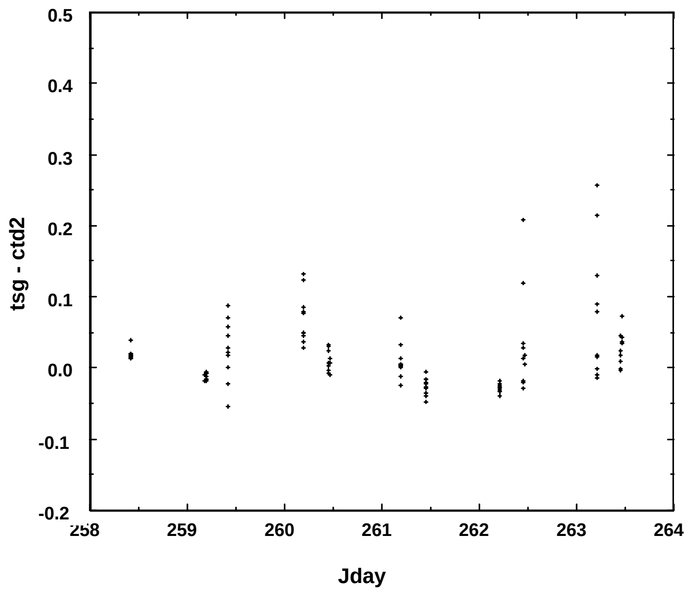


Figure 6. TSG - CTD temp2 SST differences against time.

The night-time offset of about +0.05° in the soap data may be real. Post-cruise comparisons of soap night-time surface data (obtained while the ship steams) with that during the 05:00 CTD stations during which the soap sinks to a few meters or more should confirm this.

Discounting periods where the CTD temperature sensors behaved erratically, the conclusion drawn from this initial examination are;

a) The two CTD sensors agree to within 0.003° (s.d. 0.010°).

b) The TSG data reads about 0.01° high (s.d. 0.03°)

c) The soap SST is scattered and depends on both depth and time of day.

Post-cruise analysis of the data will be done to examine the various sensors for time drifts and/or temperature-dependent offsets.

The fourth SST sensor was the prototype hull contact system, kindly loaned to SOC by Dave Hosom of the Woods Hole Oceanographic Institute. This will be the main SST sensor for future deployments of the AutoFlux system, especially on merchant ships which do not have a TSG and from which it would be impractical to deploy a "soap". The hull sensor is attached magnetically to the inside of the outer hull (about 3.5m below the water line) and communicates with the AutoFlux logging system via acoustic modems. The TSG data is used here as the standard of comparison for the WHOI sensor since 1) it was also at a depth of more than a meter or so, 2) it compared better with the CTD data than the soap did. Figure 8 shows a scatter plot of the three SST values obtained from the WHOI sensor every 10 minutes against the TSG SST data. It can be seen that the WHOI sensor overestimates the SST by about 0.1°. Again, post cruise comparisons of WHOI sensor data with the full set of CTD surface temperatures will be performed to examine the WHOI sensor for time- and/or temperature-dependent drifts.

7.2 Longwave parameterisation from cloud observations

The two independent sets of hourly cloud observations were compared. More than 50% of the coincident observations agreed exactly for total cloud fraction, and 80% agreed to within one okta. Observations which disagreed by more than one okta were discarded in this initial analysis. The total cloud fraction was used to derive a downwelling longwave radiation flux (Josey *et al.,* 1997) and this is compared in Figure 7 to the measured downwelling longwave radiation (Pascal and Josey, 2000) from one of the Eppley pyrgeometer sensors on the "bird table". The comparison is good across most of the longwave range encountered.

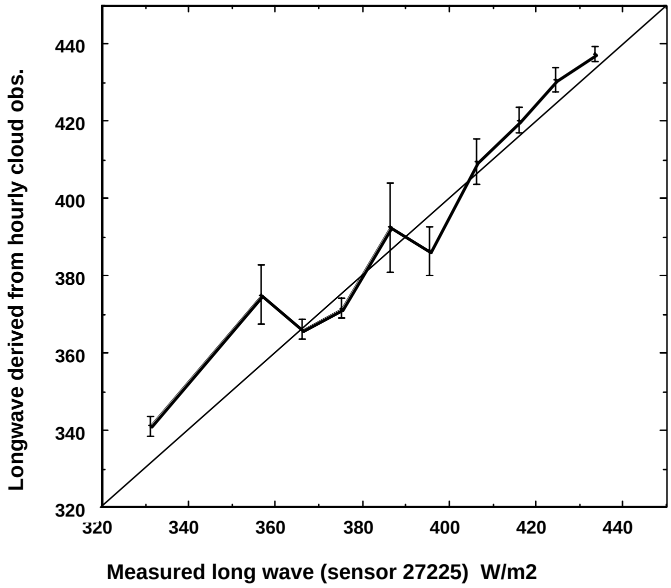


Figure 7. Comparison of longwave radiation derived from the hourly cloud observations against that measured by the Eppley instrument.

7.3 Mean met parameters

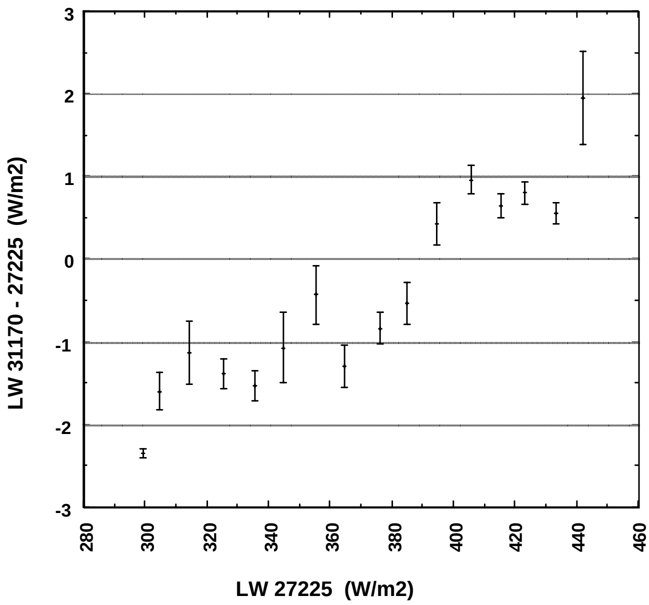


Figure 8. The difference in longwave radiation from the two pyrgeometers. The error bars indicate the standard deviation of the mean.

An initial comparisons of the two **pyrgeometers** suggested that the SOC calibration value of 4.42 for the sensitivity for sensor 27225 was too high. Using the manufacturer's value of 4.17 resulted in a better agreement between the two sensors. This is shown in Figure 8, where the mean difference between the two pyrgeometers is averaged against downwelling longwave radiation. There is still a longwave-dependent trend, but the over-all agreement to within 3 W/m^2 is excellent.

A comparison of **air pressures** from the ship's digital barometer with those from the AutoFlux barometer gave good agreement, with the ship barometer reading 0.04 mb higher on average (standard deviation 0.05 mb). Both instruments are situated in the UIC lab and neither have a correction applied for height above sea level (7 m).

A comparison between the ship's **air temperature** sensor and the dry bulb temperature from the psychrometers shows that the ship's sensor under-estimates the temperature by 0.4 degrees on average (s.d. 0.1 degrees). During the 1999 ARCICE cruise to the Arctic, the ship's sensor underestimated by 0.8

degrees (s.d. 0.2) which suggests a temperature-dependent calibration error on the ship's sensor. The difference between the two psychrometer dry bulbs was 0.03 (s.d. 0.09).

Data from the ship's **anemometer** were compared to that from the HS sonic anemometer. It was thought that the HS anemometer was not oriented exactly for-aft, and that it was pointed to port by about 5 degrees. This was confirmed by a comparison of relative wind direction from the two instruments, which suggested a 7 degree offset on the HS sonic relative wind direction for winds directly onto the bow, i.e. the relative wind directions from the HS overestimate by 7 degrees. A comparison of relative wind speeds show that the ship's anemometer reads high by about 6% compared to the HS. The ship anemometer is mounted at a height of 20 m whereas the HS is at 16 m. This height difference would result in the ship anemometer reading high by 3 % (due to the logarithmic vertical profile of wind speed), i.e. it is thought that the ship anemometer has a calibration error of about 5% (the HS sonic was calibrated prior to the cruise).

7.4 Navigation systems

A comparison of the ship's heading from the gyro (true heading) data stream with that from the AutoFlux fluxgate compass (magnetic heading) showed reasonable agreement in the mean. Fifteen minute averaged data showed a scatter of 8 degrees (standard deviation). Ship speed over the ground from the nmea data stream and the AutoFlux GPS agreed very well on average (to within a few cm/s). However, there was one period when the two differed by up to 2 m/s. This is shown in Figure 11, which displays a time series of ship speed from the two systems from day 276 to day 279. It can be seen that the data from the AutoFlux navigation system is overestimating by up to 2 m/s during the latter part of day 277. This period coincided with the time that alterations were made to the sampling rate of the AutoFlux navigation system, but further investigation is needed to confirm the cause of the erroneous speeds.

8. Summary.

By the fourth week of JR52 the system was automatically producing hourly direct measurements of the air-sea fluxes and was sending summary messages of the data back to SOC via the ORBCOMM satellite communications system in near real time.

Major system developments achieved during the cruise included;

- The ORBCOMM communication system was fully integrated into the AutoFlux system and automatically sent hour summary data back to SOC. The ORBCOMM management program "orby" performed reliably.
- The WHOI sea surface temperature system was installed successfully and was also fully integrated into the AutoFlux system using the program "acm".
- The system time synchronisation program was merged into the GPS management program in order to free up a serial port which was required for the ORBCOMM system.
- A suite of nine UNIX scripts were written to process all the data streams, merge them together and calculate the surface fluxes. Execution of these scripts was managed by the program "scp", which ran the UNIX scripts every hour.

Other system developments are listed in Table A1.1 in Appendix 1.

A new full-screen display was produced to plot the calculated surface fluxes as well as the mean meteorological parameters in near-real time (using data which are 30 to 60 minutes old). This is illustrated in Figure 12. The performance of the prototype IFM H2O/CO2 sensor and the sonic temperature sensor will be examined thoroughly post-cruise, as will the quality of the fluxes produced by these instruments.

Time series of the mean meteorological conditions and the calculated surface fluxes are displayed in the Figures in Appendix 2.

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Autoflux report: appendix 1.

Table A1.1. List of system modifications.

day	System modification
261	Reset comms timeout for reading data to 0.1 sec when comms restarting. This is set to 5 sec while acquiring the SST and should have been reset afterwards.
262	Sonic temp program now does error checks and adds error bits to ".log" file. HS sonic program now plots PSD (rather than log PSD) so that spikes are more visible. Also done for both sonic temp and IFM sensors.
266	Both the Gmet and Navigation programs have been modified to make hourly data files which are stored in a daily directory.
271	HS sonic, IFM and sonic temp programs create ".mws" files hourly (rather than daily). Scripts to run these programs modified accordingly.
272	Flux processing script implemented. Script program modified to run Hullcom script, order now: 05 min - Navigation, Met, Hullcom 10 min - IFM, STEMP, HS 15 min - flux 30 min - flux display and ORBCOMM message
273	Modification to stc.conf file to increase the serial buffer 'drain_size' from 64 bytes to 1024 in the hop that this would make the HS sonic less likely to lose sync. Hullcom program altered to produce hourly data files, and this system integrated on southerly.
274	First attempt to run longwave/cloud obs program name bulklw.F.
276	scprog altered so that it manages to do the 2300 file of the previous day (needed day-1 as well as hour -1) Changed GPS nav program to incorporate the system time synchronisation. Altered time sync function to take 2 consecutive 10 sec time errors before setting an alert. GPS modified for 2 s (rather than 1 s) sample rate from GPS (program starts with line com write "$PASHsNME,PER,2\n" to set GPS output to 2 seconds). Data acquisition line also modified so that if comms "time out" then try again once (this will work for both 1 & 2 sec sampling)
278	GPS navigation program crashed, variable size error. Increased variable size and restarted.
279	Activate scripts to write ASCII flux data out to a file for AutoFlux display
281	Updated script program to run "daily" script. Updated ORBCOMM to read Plot.jjjhh file and transmit data hourly.
282	Changed scrp.flux to use pintrp.F on WHOI ssts - were getting absent data at start of the hourly file due to 10 minute sampling interval - this was making U10n absent in the 15 minute averages and making the plots messy.... Daily script not working as trying to update today's file not yesterday's. Program modified (now jday –1), and also includes check for first day of year i.e. jday(1) -1 equals 365. This of course also has to include leap years when jday will equal 366. ORBCOMM not working as running before plot script. Now set to 35 past hour and all OK.
284	ORBCOMM program altered to get pressure in mb-900 and RH/10

Table A1.2. List of events for system shut-downs, psychrometers and other instruments.

day, time (GMT)	System and other instrument events
256 0400	Sailed from Grimsby
257 0700	Arrived in Portsmouth LW sensors not good – OK after switching 10 kOhms resistors on in box in lab.
257 1900	Sailed from Portsmouth.
259 1100	System time slow by more than 10 s (may have been due to copying across large amounts of data). System clock correction overshot - reset manually.
260 0800	GPS "DIFF" (differential) was OFF
262 1200	Southerly stopped for backup. Restarted at 1417.
263 1216	Increased psychrometer fan power. Thought lack of flow to the stbd psy. was causing stbd dry bulb temp to read high by up to 0.5°. Increase in power made no difference.
264 1100	Up foremast. Psychrometer bottles little used, port psy had used more than stbd..
265 2030	Psy fan power lower still - one may be duff.
266 1300	Removed stbd psy fan (not working). 1340 new fan installed.
267 1045	Changed mean met sampling to 5 channels (meant to change to 5 sec sampling rather than 10 but cocked it up). Back to normal at 11:20.
269 0850	Southerly halted for data back up - restarted 1005
269 1257	Southerly halted again for further backups - restarted at 1358.
269	Noticed that stbd psychrometer wet bulb had not been wicking since the previous evening.
270 1330	Went up foremast to get the stbd psychrometer wet bulb to wick.
274	Starboard wet bulb drying out again in the early hours...
275 1800	Southerly halted for backups. Restarted 2055
277 1130	Up foremast. Wetted stbd wet bulb, wick was hard against bar inside so pulled more through, hopefully now will stay wet.
277 1235	Left foremast after MOVING SONIC TEMP SENSOR to stbd fore corner.
285 1200	Docked in Montevideo System halted 1300 for backups etc.
287 1400	Up mast - wetted wet bulb wicks, filled bottles etc.
287 1455	AutoFlux system restarted
287 1900	Sailed from Montevideo
287 200	Wet bulb not wicking despite manual wetting earlier in the day
288	Data from LWs had edit limits set too low/high, so have had unnecessary absent data in processed files since day 285 - will need to reprocess.
289 1555	Went head to wind (just for us) until 1705.
289 2135	ORBCOMM failed -"message not received"
290 1500	Wind light and from astern. Foggy. Stopped logging. system off.

Table A1.3. List of events for the "soap" and WHOI ("Hullcom") SST sensors.

day, time (GMT)	"Soap" or WHOI Hullcom event	comment
257 2100	Soap deployed	
259 1000	Soap lifted to surface during CTD station	
259 1230	Stopped Hullcom for software mods. Restarted about 1430.	
260 1100	Soap to surface during CTD station.	
261 0800	Hullcom stopped for mods. Started 0900	
261 1100	Soap to surface	
262 1100	Soap to surface.	
263 1100	Soap to surface	
263 0830	Hullcom stopped for mods. Started 1100	
264 1100	Soap to surface	
265 1100	Soap to surface	
266 1400	No CTDs. Took bucket temps.	Test for 0.2 deg changes with depth (cooler at surface).
266 1450	Soap on deck to adjust weights Back in 1515 ish.	Soap towed more deeply under water.
267 1045	Soap on deck about 1045. Temperature profiles with soap from 1050 to 1110.	Test for 0.2 deg changes with depth (cooler at surface).
268	Left soap to hang deep during both CTD stations.	
268 1500	Soap and CTD surface temp profiles from 1450 to 1525	Test for 0.2 deg changes with depth (cooler at surface).
269 1050	Soap PD002 and electronics 52 were replaced by PD005 and elecs 53. Cal file changed.	Suspected problem with heating of electronics unit 52.
270	Soap left full depth during CTD stations	
273 1800	Hullcom modified for hourly data files. Restarted at 1838 Crashed then ran OK from 1920 onwards.	
275 0615	Hullcom not working.	Modems OK. Problem with sensor.
276 1115	RWP to void space to replace sensor batteries. Restarted logging at 1220.	Batteries were new and should have lasted 6 months.
278 1110	Hullcom time reset. Modified to accept different cycle times.	
281 2130	ORBCOMM mods caused Hullcom to perform badly for an hour or so until problem solved.	When first run ORBCOMM looked at Hullcom serial port.
282 0100	Soap not working from midnight.	
282 0800	Ship side brought soap inboard. Seas had ripped electronics off support and disconnected cable	
282 1340	Connector repaired and (same) soap out.	

Table A1.3 (continued). List of events for the "soap" and WHOI ("Hullcom") SST sensors.

day, time (GMT)	"Soap" or WHOI Hullcom event	comment
284 0250	Hullcom remote modem batteries dying.	
284 2205	Soap brought inboard ready for arrival in Montevideo.	
285 1600	Hullcom remote modem batteries replaced in Montevideo.	
287 1800	Hullcom set to 10 minutes	
287 1940	Soap deployed (sailed 1900)	
287 2020	Hullcom program altered: flushes serial port when first activates read data.	
288	Hullcom data had edit limits set too low/high since day 285.	- will need to reprocess data.

Table A1.4. List of events for the IFM H2O/CO2 sensor.

day, time (GMT)	IFM H2O/CO2 event	comment
259 1154	washed lenses and mirror.	
260 0906	washed lenses and mirror.	
260 1500	IFM failed to start at 1500 and again at 1600.	Program didn't crash, but seemed to fail to complete processing in time for 1500 - don't know why it didn't start at 1600.
260 1600		
260 1615	Program restarted.	
261 0942	washed	
262 0907	washed	
263 0600	Program hung.	Had completed the processing of the data run started at 0500 but failed to restart the data stream for the next period at 0600.
263 0820	Program halted, data stream checked with xterm / tip then restarted.	
263 1038	washed	
263 1330 to 1345	washed MANUALLY	reservoir had lots of water, should squirt for longer
264 1100 ish	washed MANUALLY	
265 1237	washed for 20 sec	
266 1230-1300	washed MANUALLY	
266 1700	Hung at start of data acquisition at 1700,	Quit program, start data with xterm, started program 1750
267 1126	washed	
268 1045	washed	
269 0955	washed	
270 0941	washed	
270 1340	washed MANUALLY	
271 0800	Failed to start at 0800 -	Quit program, start data with xterm, started program 1750
271 1255	New version of program for hourly ".mws" files launched.	Mws files had previously been daily.
272 1951	washed	
273 1053	washed	
274 1156	washed	
275 1100	Hung at start of acquisition.	Quit prog, used tip to verify data stream ok, then restarted prog.
275 1200	Hung at 1200. (OK at 1300)	
275 1107	washed	
276 1259	washed	
277 1130	washed MANUALLY	
277 1235	SENSOR MOVED FURTHER TO PORT	See Figure 2b
278 1335	washed	

Table A1.4 (continued). List of events for the IFM H_2O/CO_2 sensor.

day, time (GMT)	**IFM H_2O/CO_2 event**	**comment**
278 2100	Missed 2100 start time. Left it to see if it would catch the next hour - it did indeed.	due to measured humidity of ~300 g/m3? – may have had difficulty processing
280 1253	washed MANUALLY and braced sensor with string	
281 2207	washed	water reached the lenses or at least interrupted the path - head wind with relative speed of 18 m/s
282 1058	washed	
283 1806	washed	
284 0000 284 0300	0245 – saw that program had hung at 0000 trying to acquire data. Hung while "acquiring data" at 0300.	Quit program, ran xterm checked data stream ok then restarted.
284 1211	washed	
287 1400	washed MANUALLY prior to leaving Montevideo	IFM comms problem sorted when southerly re-booted.
287 1956	washed	
288 1159	washed	
288 1500	Noticed that H2O values OK on acquisition display, but become garbage when written to the "mws" data file. Problem caused by dimension of binary variable. Program modified and restarted at 1500.	Problem began on day 285 about 1130. Caused when the binary H2O data cast from double to short which has a maximum of 32768 which was exceeded by the reference value. Raw data OK and will be replayed post-cruise
288 1800	Noticed processed CO2 values low by about 50% compared to the real time display. The processed data had a different temp (20°) for the temp compensation value (display value 25°).	Will replay data with new software to use last hours air temp.
289 1521	washed?	no evidence on display that water was reaching path
289 1548	washed?	no evidence on display that water was reaching path

Marine Geophysics

Alex Cunningham & Neil Mitchell

British Antarctic Survey/Oxford and Cardiff Universities

In addition to the AMT–11 core science programme, marine geophysical data were collected by scientists from the BAS Geological Sciences Division and Cardiff University (RRS *James Clark Ross* cruise JR53). This section provides a brief description of our activities and achievements. A more detailed account is included in the BAS JR53 Cruise Report. During JR53, we had two main objectives:

(1) To collect marine geophysical data opportunistically on passage between AMT–11 stations. This work constitutes the start of a proposed long-term project to collect data on passage to and from the Antarctic. Existing studies suggest that data collected on transit by RRS *James Clark Ross* could provide new insights into diverse topics such as plate motion history, mid-ocean ridge processes, continental margin processes, volcanic island morphology, slope stability and failure, and deep-sea sediment transport.

(2) To survey a short section of the Mid-Atlantic Ridge near $1^{o}30'$S. Marine geophysical data collected in this region would provide insights into the structure, morphology and tectonic evolution of spreading ridge segments south of the Chain Fracture Zone.

In order to meet these objectives, swath bathymetry and side-scan sonar data were collected using the Simrad EM 120 multibeam sonar which was installed on RRS *James Clark Ross* earlier in the year. The recorded EM 120 signal is used to form an array of 191 1^{o} by 1^{o} beams, making it one of the highest resolution hull-mounted deep water sonars available to academic researchers. Multibeam soundings were depth converted using sea water velocity–depth profiles obtained from XBTs or from the Applied Microsystems velocity profiler installed on the ship. In addition, we collected high-resolution acoustic reflection profiles using the Simrad TOPAS sub-bottom profiler, and magnetic data using shipboard three-component magnetometers.

Scientific Highlights

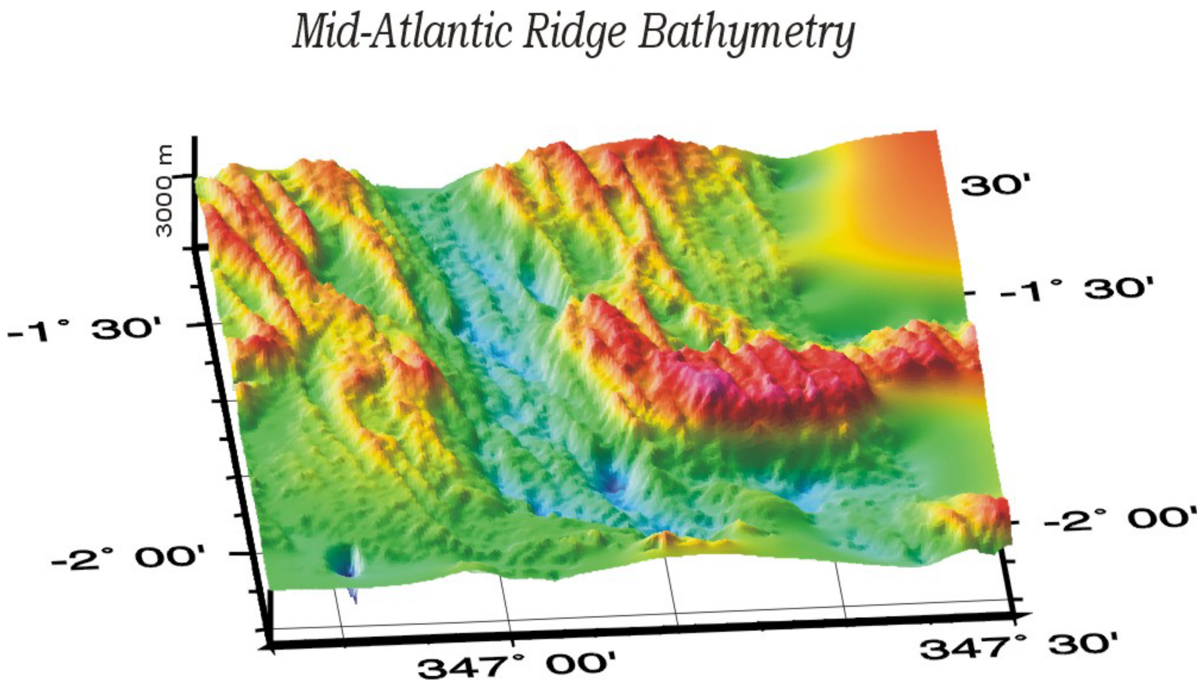
Upon leaving the UK, our first scientific target was the continental margin in the Southwest Approaches, where we imaged canyons at the base of the continental slope. Here, the multibeam sonar provided some exciting new data on shelf edge canyons, showing three orders of geomorphological slope incision. Following some sedimentary structures within the Bay of Biscay, we recorded abyssal hills west of Iberia before crossing the Gloria Fault, the plate boundary between Europe and Africa.

To the west of the Canary Islands and Africa, we crossed some channels shown by previous IOS work to be caused by turbidity currents transporting sediments from the African margin, and subtle topography of the Canary and Saharan debris flows. Following a period without recording within the Cape Verdes 200 nmi EEZ, we resumed recording and collected multibeam data over some further turbidity current channels south of the islands, shown by Gebco charts to be sourced on the African margin. From there to the ridge area, we crossed a mostly featureless area, although a number of seamounts were identified on the Sierra Leone Rise.

Within the Mid-Atlantic Ridge area proper, we first crossed the inactive section of the Romanche Transform and the active Chain Transform, before beginning our box-shaped survey. The multibeam data (Fig. 1) cover both sides of an axial rift valley and inside corner high (a shallow region at the intersection of a rift valley with a short-offset transform to another rift valley). In contrast to many inside corner highs in the North Atlantic, this one does not show a surface with crenulations oriented parallel to spreading, which are evidence for large-offset detachment faulting, but rather it seems to have a similar fabric to 'normal' sea floor. Upon leaving the box survey, we ran single lines further down the ridge, covering some parts of other sections of rift valley floor and inside-corner highs, again showing no evidence of crenulations.

Upon leaving the survey area, we made one opportunistic line across the SW flank of Ascension Island, crossing a satellite volcano to the main Ascension Island edifice, while still remaining more than 12 nmi beyond the coastline as required by the MOD. Further west in the Brazil Basin, we covered mostly abyssal hill terrain, although seamounts and migrating sediment waves were imaged occasionally in this area.

Figure 1. Multibeam bathymetry of the Mid-Atlantic Ridge near 1°30'S.



Appendix 1: Noon Positions AMT-11, Sept/Oct 2000

DATE	LAT	LONG	AVER SPEED	DISTAN CE	WIND	SEA
12/9/00	52^0 59.7'N	01^{0}28.2'E	10.58		WNW 3	Slight
13/9/00	POMPEY					
14/9/00	49^0 34.47'N	05^{0}39.1'W	12.38	196	SW 3	Slight
15/9/00	47^0 02'N	11^{0}40.1'W	12.21	293	N 4	Moderate
16/9/00	42^0 53.4'N	14^{0}48.5'W	11.4	285	E 4	Moderate
17/9/00	38^0 50.7'N	17^{0}46.5'W	11.63	279	NxE 5	Moderate
18/9/00	34^0 48.4'N	20^{0}30.3'W	12.37	277	N 4	Moderate
19/9/00	30^0 25.0'N	21^{0}25.0'W	11.95	268	N 4	Moderate
20/9/00	26^{0}06.2'N	21^{0}45.9'W	11.69	263	NxE 4	Slight
21/9/00	21^{0}50.2'N	20^{0}59.1'W	11.74	261	ENE 4	Moderate
22/9/00	17^{0}18.7'N	20^{0}39.9'W	11.58	274	NE 4/5	Moderate
23/9/00	12^{0}37.6'N	20^{0}39.7'W	12.18	282	NxE 3	Slight
24/9/00	8^{0}42.8'N	18^{0}55.3'W	11.77	263	SW 3	Slight
25/9/00	5^{0}00.3'N	16^{0}52.8'W	11.74	256	SxW 4	Moderate
26/9/00	1^{0}15.3'N	14^{0}50.9'W	11.56	258	SSE 3/4	Slight
27/9/00	1^{0}51.9'S	13^{0}08.0'W	11.65	256	SSE 3	Slight
28/9/00	1^{0}42.6'S	12^{0}43.0'W	11.75	263	SxE 3	Slight
29/9/00	4^{0}32.7'S	12^{0}43.1'W	11.59	268	SxE 4	Slight
30/9/00	8^{0}05.8'S	14^{0}55.6'W	11.38	254	SE 3/4	Slight
1/10/00	10^{0}58.4'S	18^{0}20.3'W	11.45	266	SSE 3	Slight
2/10/00	13^{0}43.7'S	21^{0}39.2'W	11.52	256	SE 4/5	Moderate
3/10/00	16^{0}27.2'S	24^{0}56.9'W	11.47	252	ExS 5	Moderate
4/10/00	19^{0}11.6'S	28^{0}19.3'W	11.42	254	N 3/4	Slight
5/10/00	21^{0}49.2'S	31^{0}36.4'W	11.59	244	NW 3	Slight
6/10/00	24^{0}37.4'S	35^{0}09.8'W	11.19	261	NW 4	Slight/Mod.
7/10/00	27^{0}21.9'S	38^{0}45.9'W	11.55	255	WxS 6	Rough.
8/10/00	30^{0}06.8'S	42^{0}24.2'W	11.55	253	SW 5	Mod/Rough
9/10/00	33^{0}12.8'S	46^{0}42.0'W	12.93	288	NE 5	Rough
8/10/00	35^{0}05.8'S	52^{0}11.5'W	12.52	313	SWxW 5	Rough

Appendix 2: AMT-11, Salinity Bottles, Analysed on the AUTOSAL, 8/10/00

Standard Seawater, IAPSO. Batch p137, 09-dec-99
K15=0.99995,
Salinity=34.998

Colour	Number	Value 1	Value 2	Value 3	Value 4	
Blue	5:18	2.0354	2.03548	2.0355	2.0355	
Blue	S:16	2.04365	2.04365			
Blue	S:3	2.0563	2.05628			
Blue	S:4	2.07374				
Blue	S:5	2.09624				
Blue	S:8	2.08075	2.08069	2.08075		
Blue	S:7	2.08837	2.08833	2.08826		
Blue	S:6	2.10036	2.13306			
Blue	S:17	2.08132	20.8132			
Blue	S:14	2.09863	2.09862			
Blue	S:13	2.075	2.04749			
Blue	S:2	2.07246	2.07232	2.07235		
Blue	S:10	2.0186	2.0186			
Blue	S:11	2.04777	2.04776			
Blue	S:12	2.05743	2.05742			
Blue	S:23	1.97852	1.97849	1.97846		
Blue	S:1	2.00651	2.00648			
Blue	S:19	2.01235	2.01233			
Blue	S-15	2.04628	2.04626			
Blue	S-20	2.00084	2.0084			
Blue	S:21	2.02701	2.02693	2.02692		
Blue	S:22	2.01149	2.01145			
Blue	S:9	2.01551	2.01544	2.01538		
Blue	S:24	2.03079	2.03082			
Red	02:02	2.04892	2.04901	2.04903		
	02:01	2.00086	2.00086			
	02:04	2.04178	2.04174			
	02:05	2.04174	2.04176			
	02:07	2.04531	2.04531			
	02:10	2.01468	2.01468			
	02:08	2.09648	2.09647			
	02:09	2.09504	2.09498			
	02:12	2.02998	2.02998			
	02:11	2.11153	2.11131	2.11127	2.1114	2.11139
	02:13	2.06477	2.06477			
	02:14	2.04535	2.04534			
	02:15	2.02123	2.02123			
	02:16	2.02579	2.02579	2.02579		
	02:17	2.05536	2.05536			

Appendix 3: XBT deployment log

DATE	GMT	LAT	LON	SST	Salinity	Probe	Filename
14/9/00	1126	49°32.78'N	5°47.74'W	17.2	35.27	T7	T7_01029
14/9/00	1700	49°03.17'N	7°22.25'W	18.0	35.25	T7	T7_01030
15/9/00	0520	47°55.22'N	10°44.78'W	18.7	35.62	T7	T7_01034
15/9/00	1119	46°59.21'N	11°42.45'W	19.4	35.66	T5	T5_01035
15/9/00	1632	46°01.99'N	12°12.55'W	19.9	35.71	T5	T5_01036
15/9/00	2158	45°17.15'N	13°02.18'W	20.0	35.64	T7	T7_01037
15/9/00	2204	45°17.15'N	13°02.18'W	20.1	35.64	T7	T7_01038
16/9/00	1123	42°58.22'N	14°45.02'W	21.3	35.79	T5	T5_01039
16/9/00	1206	42°52.38'N	14°49.33'W	21.4	35.77	T7	T7_01040
16/9/00	1909	41°38.31'N	15°46.02'W	21.5	35.85	T7	T7_01041
16/9/00	2340	41°07.39'N	16°08.88'W	21.1	35.95	T7	T7_01042
17/9/00	0530	39°54.45'N	17°01.07'W	21.4	36.21	T7	T7_01043
17/9/00	1122	38°57.49'N	17°42.02'W	21.6	36.42	T5	T5_01044
17/9/00	2345	36°45.53'N	19°12.88'W	22.2	36.32	T7	T7_01045
18/9/00	0638	35°38.79'N	19°57.66'W	22.6	36.47	T7	T7_01046
18/9/00	1112	34°55.81'N	20°27.56'W	23.5	36.85	T5	T5_01047
18/9/00	2340	33°48.99'N	20°43.26'W	24.1	36.84	T7	T7_01049
19/9/00	0600	31°27.53'N	21°12.80'W	23.9	36.95	T7	T7_01050
19/9/00	1121	30°32.43'N	21°23.60'W	24.0	36.93	T5	T5_01051
19/9/00	1718	29°24.48'N	21°37.03'W	24.2	37.15	T7	T7_01052
19/9/00	2344	28°20.82'N	21°49.30'W	23.9	37.01	T7	T7_01053
20/9/00	0613	27°04.10'N	21°56.21'W	23.9	37.16	T7	T7_01055
20/9/00	1117	26°13.09'N	21°47.18'W	23.9	37.16	T5	T5_01056
20/9/00	2340	24°22.95'N	21°26.65'W	24.3	36.64	T7	T7_01058
21/9/00	0604	22°50.44'N	21°10.20'W	24.0	36.36	T7	T7_01059
21/9/00	1127	21°56.52'N	21°00.11'W	24.5	36.24	T5	T5_01061
21/9/00	1622	21°03.71'N	20°51.26'W	24.8	36.28	T5	T5_01064
21/9/00	1956	20°23.97'N	20°44.43'W	24.7	36.23	T5	T5_01066
21/9/00	2342	18°22.23'N	20°36.32'W	25.2	36.24	T5	T5_01067
23/9/00	1122	12°44.47'N	20°39.90'W	28.5	36.07	T5	T5_01068
23/9/00	1715	11°38.84'N	20°33.79'W	28.5	35.52	T7	T7_01069
23/9/00	2345	10°32.40'N	19°56.29'W	28.4	34.93	T7	T7_01070
24/9/00	0809	09°14.61'N	19°13.66'W	27.5	34.07	T7	T7_01071
24/9/00	1120	08°49.00'N	18°58.46'W	27.5	34.36	T5	T5_01072
24/9/00	1732	07°52.92'N	18°28.48'W	27.8	34.58	T7	T7_01073
24/9/00	2342	06°59.18'N	17°59.64'W	27.7	34.26	T7	T7_01074
25/9/00	1122	05°06.06'N	16°55.86'W	27.3	34.95	T5	T5_01075
25/9/00	1741	04°01.59'N	16°21.46'W	27.2	35.53	T7	T7_01076
25/9/00	2353	02°58.22'N	15°47.11'W	26.2	35.55	T7	T7_01077
26/9/00	0602	02°06.00'N	15°19.03'W	24.3	35.56	T7	T7_01078
26/9/00	1122	01°21.15'N	14°52.81'W	23.6	35.81	T5	T5_01079
26/9/00	1754	00°16.17'N	14°18.55'W	23.5	36.00	T7	T7_01080
27/9/00	0529	01°23.65'S	13°12.03'W	23.2	35.87	T7	T7_01081
27/9/00	1036	02°07.24'S	13°08.38'W	23.5	35.89	T5	T5_01082
27/9/00	1735	01°50.87'S	13°02.99'W	23.5	35.87	T7	T7_01083
27/9/00	2350	01°25.20'S	12°55.98'W	23.3	35.87	T7	T7_01084
28/9/00	0504	02°08.55'S	12°48.83'W	23.4	35.82	T7	T7_01085

DATE	GMT	LAT	LON	SST	Salinity	Probe	Filename
28/9/00	1008	01°21.78'S	12°43.29'W	23.1	35.77	T5	T5_01086
28/9/00	1736	01°45.00'S	12°37.59'W	23.6	35.85	T5	T5_01087
28/9/00	2352	02°40.63'S	12°12.04'W	23.4	35.82	T7	T7_01088
29/9/00	1123	04°38.40'S	12°38.41'W	23.9	35.87	T5	T5_01089
29/9/00	1730	05°20.22'S	13°21.85'W	24.1	35.96	T5	T5_01090
29/9/00	2345	06°55.79'S	14°08.98'W	24.2	35.90	T7	T7_01091
30/9/00	0545	07°17.17'S	14°20.07'W	24.0	35.85	T7	T7_01092
30/9/00	0910	07°50.04'S	14°36.82'W	24.0	35.82	T5	T5_01093
30/9/00	1125	08°01.75'S	14°51.08'W	24.0	35.82	T5	T5_01094
30/9/00	1748	08°48.33'S	15°45.91'W	24.2	35.89	T5	T5_01095
30/9/00	2341	09°31.90'S	16°37.60'W	24.7	36.19	T7	T7_01096
1/10/00	0630	10°15.86'S	17°29.55'W	24.5	36.43	T7	T7_01097
1/10/00	1225	10°54.30'S	18°15.38'W	24.4	36.60	T5	T5_01098
1/10/00	1817	11°37.40'S	19°06.97'W	24.5	36.64	T7	T7_01099
1/10/00	2345	12°24.41'S	20°03.40'W	24.4	36.67	T7	T7_01100
2/10/00	0727	13°09.20'S	20°56.47'W	23.8	36.99	T7	T7_01101
2/10/00	1225	13°39.87'S	21°34.72'W	23.8	36.87	T5	T5_01102
2/10/00	1229	13°40.31'S	21°35.22'W	23.8	36.87	T5	T5_01103
2/10/00	1825	14°24.10'S	22°27.42'W	24.1	36.95	T5	T5_01105
2/10/00	2319	15°08.55'S	23°21.14'W	23.7	36.99	T7	T7_01106
3/10/00	0610	15°45.43'S	24°05.42'W	23.2	36.97	T7	T7_01107
3/10/00	1244	16°25.70'S	24°54.95'W	23.5	37.04	T5	T5_01108
3/10/00	1823	17°06.47'S	25°44.59'W	23.5	37.08	T5	T5_01109
3/10/00	2347	17°53.38'S	26°42.52'W	23.5	37.06	T7	T7_01110
4/10/00	0615	18°28.00'S	27°25.92'W	23.7	37.11	T7	T7_01111
4/10/00	1230	19°08.23'S	28°15.31'W	23.6	37.17	T5	T5_01112
4/10/00	1822	19°42.17'S	28°57.82'W	23.6	37.13	T5	T5_01113
4/10/00	2345	20°29.24'S	29°48.16'W	23.1	37.07	T7	T7_01114
5/10/00	0614	21°04.22'S	30°40.64'W	23.1	37.07	T7	T7_01115
5/10/00	1234	21°46.29'S	31°32.76'W	23.3	37.05	T5	T5_01116
5/10/00	1831	22°29.02'S	32°26.24'W	23.6	37.06	T5	T5_01117
5/10/00	2347	23°10.16'S	33°18.98'W	23.2	35.08?	T7	T7_01118
6/10/00	0647	23°49.34'S	34°09.14'W	23.4	37.13	T7	T7_01119
6/10/00	1328	24°36.13'S	35°08.91'W	22.4	36.92	T5	T5_01120
6/10/00	1933	25°18.18'S	36°03.36'W	22.0	36.69	T5	T5_01121
6/10/00	2345	26°05.10'S	37°04.40'W	21.8	36.73	T7	T7_01122
7/10/00	0645	26°37.57'S	37°46.43'W	21.9	36.76	T7	T7_01123
7/10/00	1336	27°19.62'S	38°42.79'W	20.6	36.18	T5	T5_01124
7/10/00	1923	27°58.94'S	31°33.97'W	20.1	36.24	T5	T5_01125
7/10/00	2345	28°44.12'S	40°34.15'W	20.7	36.50	T7	T7_01126
8/10/00	0515	29°21.56'S	41°24.50'W	19.9	36.46	T7	T7_01127
8/10/00	1343	30°05.36'S	42°22.04'W	18.3	36.03	T5	T5_01128
8/10/00	1935	30°48.09'S	43°21.31'W	18.2	36.02	T7	T7_01129
8/10/00	2355	31°40.64'S	44°32.69'W	17.8	35.96	T7	T7_01130
9/10/00	1332	33°09.55'S	46°37.81'W	16.6	35.63	T5	T5_01131
9/10/00	1337	33°09.92'S	46°38.29'W	16.6	35.60	T5	T5_01132
9/10/00	1928	33°57.36'S	47°43.41'W	16.9	35.83	T7	T7_01133

Appendix 4. Underway night watch, sampling and observation

Date	Time		Latitude	Longitude	Temperature	Salinity	Fluorescence		Sample No. Chl	Volume filtered Chl (ml)	[Chla] µg/l
	Local	GMT					O/L	TIF			
14/09/00	0806	0706	49°47.79'N	04°37.49'W	17.10	35.07	20.9	2.2	001	200	51.3
14/09/00	1328	1228	49°27.43'N	06°08.81'W	17.46	35.36	10.7	1.1	002	200	12.6
14/09/00	1628	1528	49°10.96'N	07°00.84'W	18.10	35.21	7.5	0.8	003	200	5.95
14/09/00	2006	1906	48°50.47'N	07°59.51'W	17.89	35.42	6.6	0.6	004	200	2.92
15/09/00	0001	2301	48°26.89'N	09°08.58'W	17.70	35.52	9.3	1.0	005	200	3.47
15/09/00	0802	0702	47°39.33'N	11°08.89'W	18.70	35.63	6.3	2.3	006	200	3.74
15/09/00	1334	1234	46°44.97'N	11°52.51'W	19.54	35.68	52.7	5.2	007	200	2.41
15/09/00	1554	1454	46°19.46'N	12°12.58'W	19.91	35.72	51.0	5.2	008	200	2.28
15/09/00	2019	1919	45°32.12'N	12°50.72'W	19.09	35.68	53.1	5.4	009	200	2.92
15/09/00	2315	2215	45°17.67'N	13°02.18'W	15.25	35.63	56.4	1.8	010	200	3.32
16/09/00	0803	0803	42°07.29'N	14°28.70'W	21.00	35.71	53.4	1.7	011	200	2.45
16/09/00	1405	1405	47°32.46'N	15°06.15'W	21.80	35.79	47.0	1.5	012	200	1.56
16/09/00	1614	1614	42°10.05'N	15°23.89'W	21.90	35.88	46.1	1.5	013	200	1.84
16/09/00	2006	2006	41°27.56'N	15°53.96'W	21.40	35.94	55.0	1.8	014	200	1.79
16/09/00	2355	2355	41°07.39'N	16°08.88'W	21.20	35.90	50.0	1.6	015	200	1.94
17/09/00	0822	0822	39°23.99'N	17°23.42'W	21.50	36.21	49.3	1.55	016	200	2.44
17/09/00	1344	1344	38°31.36'N	18°00.83'W	21.70	36.39	46.7	1.5	017	200	1.93
17/09/00	1700	1700	37°56.73'N	18°24.19'W	22.00	36.45	45.7	1.5	018	200	
17/09/00	2043	2043	37°17.66'N	18°50.54'W	21.90	36.29	45.5	1.5	019	200	1.47
17/09/00	2352	2352	37°21.17'N	18°48.06'W	22.10	36.30	45.4	1.5	020	200	1.41
18/09/00	0801	0801	35°23.29'N	20°07.64'W	23.20	36.56	44.7	1.4	021	200	1.61
18/09/00	1321	1321	34°32.43'N	20°34.27'W	23.40	36.73	43.0		022	200	1.37
18/09/00	1658	1658	33°49.12'N	20°43.29'W	23.50	36.71	44.2	1.4	023	200	1.23
18/09/00	2001	2001	33°12.55'N	20°50.82'W	23.70	36.70	43.4	1.4	024	200	1.10
18/09/00	2350	2350	33°49.99'N	20°43.26'W	24.10	36.80	44.1	1.4	025	200	0.99
19/09/00	0755	0755	31°04.03'N	21°16.82'W	23.90	36.94	43.3	1.4	026	250	1.32
19/09/00	1345	1345	30°04.80'N	21°28.74'W	24.35	37.18	41.5	1.4	027	250	1.07
19/09/00	1650	1650	29°29.83'N	21°35.91'W	24.24	37.26	42.0	1.4	028	250	0.92
19/09/00	2011	2011	28°51.16'N	21°43.87'W	24.10	37.08	43.4	1.4	029	250	1.72
19/09/00	2356	2356	28°20.81'N	21°49.29'W	23.90	37.02	42.6	1.4	030	250	1.60
20/09/00	0758	0758	26°43.78'N	21°52.66'W	23.80	37.24	42.3	1.35	031	250	1.51
20/09/00	1329	1329	25°50.44'N	21°42.22'W	24.33	37.03	43.4	1.4	032	250	2.33

Date	Time		Latitude	Longitude	Temperature	Salinity	Fluorescence		Sample No. Chl	Volume filtered Chl (ml)	[Chla] µg/l
	Local	GMT					O/L	TIF			
20/09/00	1707	1707	25°09.44'N	21°34.72'W	24.16	37.10	44.6	1.4	033	250	1.85
20/09/00	2020	2020	24°31.97'N	21°27.91'W	24.33	36.78	44.2	1.4	034	250	2.25
20/09/00	2357	2357	23°50.37'N	21°20.24'W	24.30	36.60	45.6	1.4	035	250	2.91
21/09/00	0754	0754	22°28.56'N	21°06.23'W	24.15	36.42	51.4	1.6	036	250	4.50
21/09/00	1344	1344	21°32.85'N	20°55.07'W	24.64	36.29	51.9	1.6	037	250	5.20
21/09/00	1638	1638	21°01.41'N	20°51.02'W	24.92	36.27	55.0	1.7	038	250	6.40
21/09/00	2007	2007	20°22.15'N	21°44.20'W	24.68	36.22	57.2	1.9	039	250	6.55
21/09/00	2356	2356	18°22.23'N	20°36.32'W	25.10	36.20	55.0	1.6	040	250	5.57
22/09/00	0129	0129	19°32.10'N	20°40.53'W	25.40	36.20	52.6	1.65	041	250	4.12
22/09/00	0745	0745	18°06.27'N	20°40.00'W	26.40	36.26	49.4	1.6	042	250	3.42
22/09/00	1110	1110	17°28.06'N	20°39.86'W	26.80	36.20	45.1	1.4	043	250	3.75
22/09/00	1348	1348	16°57.79'N	20°39.62'W	28.30	36.09	48.2	1.55	044	250	6.10
22/09/00	1723	1723	16°16.65'N	20°39.87'W	28.70	35.67	51.7	1.6	045	250	5.26
22/09/00	1956	1956	15°45.58'N	20°40.04'W	28.86	35.81	48.3	1.5	046	250	4.30
22/09/00	2357	2357	14°51.69'N	20°39.18'W	28.80	35.60	46.8	1.5	047	250	4.05
23/09/00	0400	0400	14°05.13'N	20°40.05'W	28.92	35.12	47.8	1.5	048	250	4.37
23/09/00	0729	0729	13°22.24'N	20°40.15'W	28.74	35.42	46.2	1.5	049	250	4.50
23/09/00	1316	1316	12°23.08'N	20°39.76'W	28.53	36.03	47.1	1.5	050	250	4.68
23/09/00	1559	1559	11°52.12'N	20°40.16'W	28.67	35.66	44.9	1.4	051	250	3.71
23/09/00	1957	1957	11°11.61'N	20°18.28'W	28.32	35.02	46.9	1.5	052	250	3.15
23/09/00	0006	0006	10°28.67'N	19°54.14'W	28.30	34.80	48.4	1.5	053	250	3.44
24/09/00	0755	0755	09°16.16'N	19°14.55'W	27.60	34.20	48.6	1.5	054	250	4.23
24/09/00	1315	1315	08°29.82'N	18°48.14'W	27.73	34.41	46.6	1.5	055	250	5.01
24/09/00	1559	1559	08°08.50'N	18°36.66'W	27.88	34.50	49.2	1.55	056	250	3.95
24/09/00	2002	2002	07°27.38'N	18°14.52'W	27.90	34.62	48.9		057	250	3.57
24/09/00	2351	2351	06°59.18'N	17°54.08'W	27.70	34.20	52.2	1.65	058	250	4.75
25/09/00	0802	0802	05°32.19'N	17°11.37'W	27.30	34.55	52.9	1.65	059	250	5.28
25/09/00	1324	1324	04°45.29'N	16°45.56'W	27.33	35.19	49.0	1.5	060	250	3.29
25/09/00	1557	1557	04°19.33'N	16°31.64'W	27.29	35.34	52.4	1.6	061	250	3.78
25/09/00	1956	1956	03°38.52'N	16°08.64'W	27.04	35.38	49.4	1.6	062	250	2.95
25/09/00	2355	2355	02°57.46'N	15°46.50'W	26.20	35.40	49.7	1.6	063	250	2.28
26/09/00	0804	0804	01°46.53'N	15°08.08'W	23.43	35.65	50.4	1.6	064	250	7.57
26/09/00	1332	1332	01°00.13'N	14°42.49'W	23.59	35.88	37.2	1.2	065	250	6.31
26/09/00	1706	1706	00°23.93'N	14°22.78'W	23.58	35.98	49.5	1.4	066	250	7.62

Date	Time		Latitude	Longitude	Temperature	Salinity	Fluorescence		Sample No. Chl	Volume filtered Chl (ml)	[Chla] µg/l
	Local	GMT					O/L	TIF			
26/09/00	2009	2009	00°07.25'S	14°05.85'W	23.47	36.00	64.7	1.4	067	250	9.79
27/09/00	0002	0002	00°47.14'S	13°44.10'W	23.30	35.80	31.7	1.05	068	250	11.3
27/09/00	0753	0753	01°51.67'S	13°11.99'W	23.34	35.87	27.1	2.4	069	250	10.6
27/09/00	1210	1210	01°49.95'S	13°08.01'W	23.58	35.86	50.1	1.6	070	250	10.3
27/09/00	1641	1641	01°40.98'S	13°03.01'W	23.83	35.88	61.6	2.0	071	250	10.4
27/09/00	1950	1950	02°06.31'S	12°56.00'W	23.77	35.88	77.8	2.4	072	250	7.1
27/09/00	2353	2353	01°21.39'S	12°53.13'W	23.30	35.80	44.0	1.4	073	250	11.8
28/09/00	0757	0757	01°36.46'S	12°47.00'W	23.19	35.81	28.9	0.95	074	250	11.7
28/09/00	1300	1300	01°54.21'S	12°42.98'W	23.73	35.82	59.0	1.8	075	250	8.73
28/09/00	1640	1640	01°47.81'S	12°29.76'W	23.71	35.87	80.1	2.5	076	250	11.2
28/09/00	1953	1953	02°06.41'S	12°35.81'W	23.71	35.84	40.8	1.3	077	250	10.7
28/09/00	2356	2356	02°41.56'S	12°11.31'W	23.40	35.80	41.2	1.3	078	250	6.65
29/09/00	0359	0359	03°28.81'S	12°04.14'W	23.38	35.76	31.9	1.2	079	250	5.00
29/09/00	0757	0757	04°08.05'S	12°14.54'W	23.21	35.71	25.8	0.9	080	250	7.05
29/09/00	1323	1323	04°43.39'S	12°54.80'W	24.17	35.97	61.2	1.9	081	250	5.81
29/09/00	1654	1654	05°14.52'S	13°18.80'W	24.11	35.96	74.9	2.4	082	250	6.80
29/09/00	1950	1950	05°43.61'S	13°33.14'W	24.02	35.98	87.2	2.8	083	250	7.24
29/09/00	2348	2348	06°24.19'S	13°53.13'W	24.20	35.90	20.9	0.7	084	250	4.36
30/09/04	0756	0756	07°39.69'S	14°31.39'W	23.99	35.83	63.8	2.1	085	250	7.29
30/09/04	1378	1328	08°16.46'S	15°08.56'W	24.07	35.82	53.8	1.7	086	250	5.90
30/09/04	1643	1643	08°40.49'S	15°36.48'W	24.29	35.82	62.5	2.1	087	250	7.34
30/09/04	1955	1955	09°03.62'S	16°03.58'W	24.48	36.02	58.0	2.0	088	250	6.00
30/09/04	2350	2350	09°32.37'S	16°38.26'W	24.70	36.20	43.8	1.4	089	250	3.60
01/10/04	0759	0859	10°34.43'S	17°51.67'W	24.43	36.44	31.7	1.0	090	250	1.84
01/10/04	1322	1422	11°08.66'S	18°32.75'W	24.31	36.75	27.5	0.9	091	250	1.66
01/10/04	1614	1714	11°29.90'S	18°57.94'W	24.55	36.72	26.1	0.9	092	250	1.50
01/10/04	1950	2050	11°55.73'S	19°79.06'W	24.40	36.64	26.1	0.9	093	250	1.58
01/10/04	0001	0101	12°26.41'S	20°06.60'W	24.40	36.60	24.3	0.8	094	250	1.50
02/10/04	0800	0900	13°20.50'S	21°10.91'W	23.74	36.69	22.9	0.7	095	250	2.15
02/10/04	1335	1435	13°56.04'S	21°53.60'W	23.62	36.96	66.7	2.1	096	250	1.43
02/10/04	1620	1720	14°16.27'S	22°17.77'W	23.91	36.95	63.6	2.2	097	250	1.34
02/10/04	1953	2053	14°41.86'S	22°48.68'W	24.21	36.95	62.0	2.0	098	250	1.36
03/10/04	0004	0104	15°12.52'S	23°26.23'W	23.70	36.90	59.9	1.9	099	250	1.22
03/10/04	1757	0857	16°05.65'S	24°30.66'W	23.02	36.97	58.1	1.9	100	250	2.05

Date	Time		Latitude	Longitude	Temperature	Salinity	Fluorescence		Sample No. Chl	Volume filtered Chl (ml)	[Chla] µg/l
	Local	GMT					O/L	TIF			
03/10/04	1321	1421	16°37.17'S	25°08.79'W	23.42	37.04	53.6	1.7	101	250	1.34
03/10/04	1633	1733	17°01.00'S	25°37.91'W	23.47	37.08	53.8	1.7	102	250	1.29
03/10/04	1949	2049	17°24.66'S	26°06.67'W	23.81	37.13	50.9	1.6	103	250	0.80
04/10/04	0003	0104	18°34.06'S	26°35.07'W	23.40	37.10	47.2	1.5	104	250	1.13
04/10/04	0757	0857	18°48.10'S	27°50.31'W	23.47	37.09	47.6	1.5	105	250	0.94
04/10/04	1352	1452	19°21.91'S	28°35.86'W	23.36	37.09	46.3	1.5	106	250	0.88
04/10/04	1649	1749	19°39.30'S	28°53.42'W	23.65	37.15	45.9	1.5	107	250	0.74
04/10/04	1943	2043	19°59.95'N	29°18.90'W	23.69	37.17	45.4	1.5	108	250	0.76
05/10/04	0004	0104	20°23.09'N	29°48.10'W	23.10	37.00	47.5	1.5	109	250	1.134
05/10/04	0753	0853	21°24.46'N	31°05.16'W	23.57	37.19	46.6	1.5	110	250	1.21
05/10/04	1317	1417	21°59.05'N	31°48.68'W	23.35	37.07	46.8	1.5	111	250	1.87
05/10/04	1626	1726	22°21.80'N	32°17.29'W	23.65	37.07	48.7	1.5	112	250	1.58
05/10/04	1955	2055	22°44.52'N	32°46.22'W	23.26	37.02	47.5	1.5	113	250	1.92
05/10/04	0001	0101	23°19.32'N	33°30.76'W	23.20	37.06	50.0	1.5	114	250	2.26
06/10/04	0759	0959	24°14.35'N	34°41.18'W	23.01	37.08	48.9	1.6	115	250	2.70
06/10/04	1333	1533	24°48.83'N	35°24.63'W	22.76	36.95	50.0	1.6	116	250	3.03
06/10/04	1645	1845	25°12.49'N	35°55.96'W	22.38	36.91	55.3	1.7	117	250	3.75
06/10/04	1950	2150	25°35.17'N	36°25.79'W	21.33	36.53	52.8	1.6	118	250	2.52
07/10/04	0011	0211	26°08.50'N	37°08.90'W	21.60	36.60	54.1	1.8	119	250	3.34
07/10/04	0753	0953	27°00.35'N	38°16.65'W	20.93	36.31	54.3	1.7	120	250	3.20
07/10/04	1357	1557	27°36.42'N	39°04.23'W	20.32	36.25	55.8	1.7	121	250	2.94
07/10/04	1426	1826	27°52.66'N	39°25.74'W	20.39	36.36	56.0	1.7	122	250	3.20
07/10/04	1957	2157	28°17.27'N	39°58.49'W	20.21	36.29	59.0	1.9	123	250	3.85
08/10/04	0002	0202	28°46.40'N	40°37.30'W	20.50	36.30	57.6	1.9	124	250	2.63
08/10/04	0753	0953	29°41.86'N	41°51.59'W	18.70	36.09	70.0	2.3	125	250	5.69
08/10/04	1322	1522	30°16.73'N	42°38.13'W	18.85	36.10	75.0	2.4	126	250	7.35
08/10/04	1631	1831	30°39.33'N	43°09.51'W	18.26	35.98	82.1	2.6	127	250	6.58
08/10/04	1948	2148	31°06.57'N	43°46.73'W	19.05	36.22	28.7	1.0	128	250	7.05
08/10/04	2348	0148	31°40.09'N	44°31.91'W	17.80	35.90	35.4	1.1	129	250	7.82
09/10/04	0754	1954	32°46.49'N	46°04.65'W	16.55	35.69	34.6	1.1	130	250	5.99
09/10/04	1400	1600	33°29.84'N	47°05.32'W	17.10	35.68	38.4	1.2	131	250	10.80