Atlantic Meridional Transect

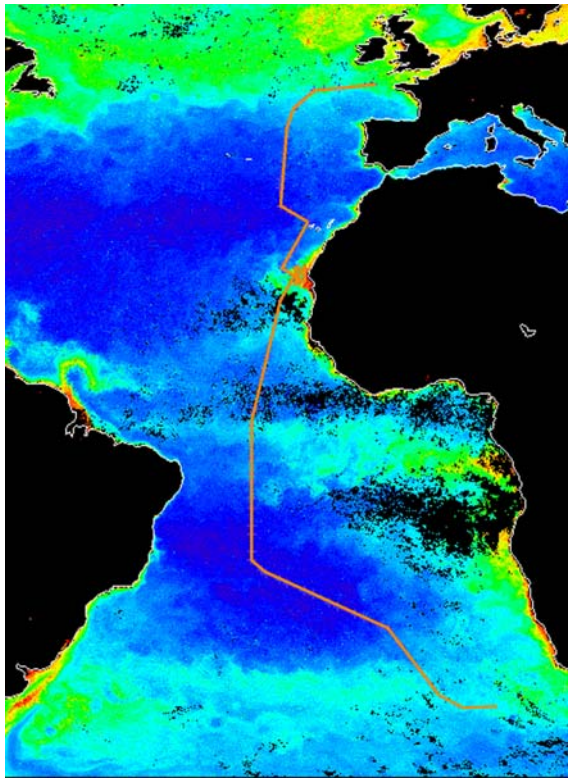
AMT15 Cruise Report

RRS Discovery Cruise 284

17 September - 29 October 2004

Principal Scientist:

Andy Rees (PML)



Plymouth Marine Laboratory

Southampton Oceanography Centre
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University of Plymouth

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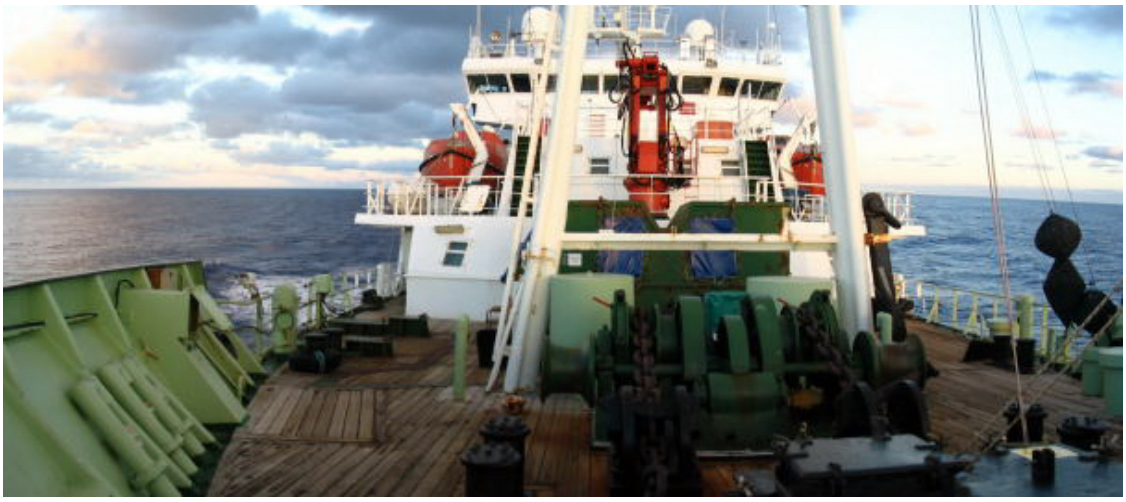
Acknowledgements

This cruise was without doubt a success due to the magnificent team spirit shown by all onboard, our shore based support and in particular to the drive and leadership provided to the whole of the AMT project by Carol Robinson.

Captain Roger Chamberlain and all of his crew were exemplary in the support that they provided, our colleagues from OED as usual were outstanding in their professionalism and fully complemented the RSU effort in providing a first class ship-board service.

Particular thanks are due to Dennis Jakobaufderstroht and Darren Young for the tenacity at which they addressed the endless problems we passed their way. Greg Lewis and Steve Smith maintained the smooth coordination of on-deck activities and John Smyth ran an excellent bar. As usual during these AMT cruises a huge amount of work was going on “behind the scenes” and this cruise wouldn’t have happened without the input of Dawn Ashby, Colin Day, Andy Louch and Malcolm Woodward.

I’d like to add my personal gratitude to Roger Chamberlain, Bernie McDonald, Eddie Staite and Jon Short for their support during what was a fairly arduous voyage.



RRS Discovery (photo by Casper Henriksen)

Cruise Participants

Scientific Party

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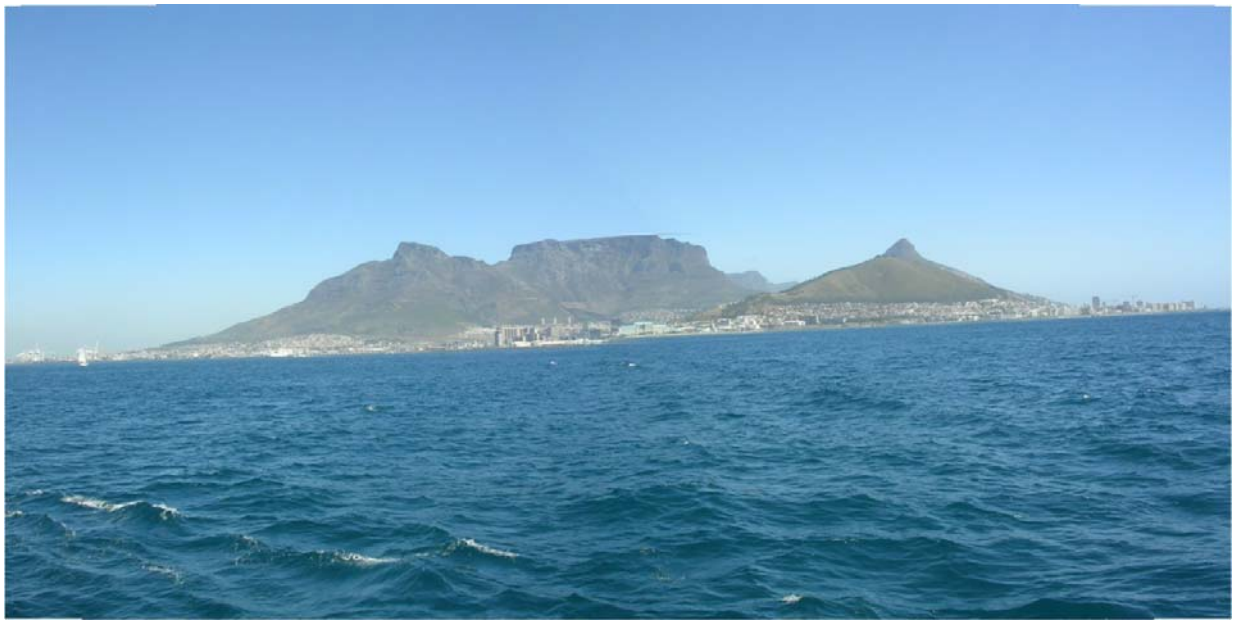
Jon Short Dougal Mountifield Darren Young	*Ocean Engineering Division, Southampton Oceanography Centre, European Way, Empress Dock, Southampton, SO14 3ZH, UK*

AMT 15 participants



Cape Town

Ships' Officers and Crew

Roger Chamberlain	Master
Richard Warner	Chief Officer
Phil Oldfield	2nd Officer
Darcy White	3rd Officer
Bernie McDonald	Chief Engineer
John Clark	2nd Engineer
John Harnett	3rd Engineer
Chris Uttley	3rd Engineer
Dennis Jakobaufderstroht	Electro-Technical Officer
John Smyth	Engine Room Petty Officer
Greg Lewis	Chief Petty Officer – Deck
Steve Smith	Chief Petty Officer – Science
Andy MacLean	Petty Officer – Deck
Bob Spencer	Seaman
Dave Anderson	Seaman
Ian Cantlie	Seaman
Steve Day	Seaman
Eddie Staite	Ships' Catering Manager
Steve Nagle	Chef
Lloyd Sutton	Assistant Chef
Ally Harkness	Steward

Captain Roger Chamberlain

Bernie McDonald, Chris Uttley Dennis Jakobaufderstroht, John Smyth and John Clarke – smoko time

Steve Nagle, Lloyd Sutton, Eddie Staite and Ally Harkness – you don't want to see these chefs naked!

.

Steve Smith, Bob Spencer, Richard Warner, Darcy White and Greg Lewis living it up in Tenerife.

Introduction to AMT – Cruise Objectives

The biota of the surface ocean has a profound influence on the global budgets of climatically-active trace constituents in the atmosphere (CO_2, DMS, N_2O, CH_4 and aerosols) and hence climate. Our understanding of how biogeochemical cycling in the oceans affects climate, and of how changes in climate influence the structure and activity of oceanic ecosystems is still incomplete, hindering accurate predictions of the future global environment. Realistic model simulations require new observations of both the spatial and temporal variability of planktonic ecosystem structure, multi-element cycling and exchange processes between ocean and atmosphere.

The Atlantic Meridional Transect Programme (AMT) is a UK National Environment Research Council (NERC) funded project which aims to quantify the nature and causes of ecological and biogeochemical variability in the planktonic ecosystems of the Atlantic Ocean, and the effects of this variability on the biological carbon pump and on air-sea exchange of radiatively active gases and aerosols. The programme continues a series of 12 bi-annual transect cruises between the UK (50^oN) and the Falkland Islands (52^oS) which took place between 1995 and 2000. The cruises measured hydrographic and bio-optical properties, plankton community structure and primary production. Six further cruises will take place between 2003 and 2005 to provide a unique decadal time series of spatially extensive observations on the structure and biogeochemical properties of planktonic ecosystems. The project will allow 45 investigators from 6 partner UK institutions to test nine inter-related hypotheses which fall within the following three scientific objectives :

- To determine how the structure, functional properties and trophic status of the major planktonic ecosystems vary in space and time

The first three hypotheses strive to address the question of linking plankton biodiversity with variability in biogeochemical fluxes, in particular the potential for carbon export to the deep sea and ocean / atmosphere exchange of carbon dioxide. A fourth hypothesis will develop and validate models and empirical relationships to enable the use of remote sensing to interpolate in time between the two AMT sampling periods per year and to extrapolate in space from the single track of *in situ* samples to the basin scale.

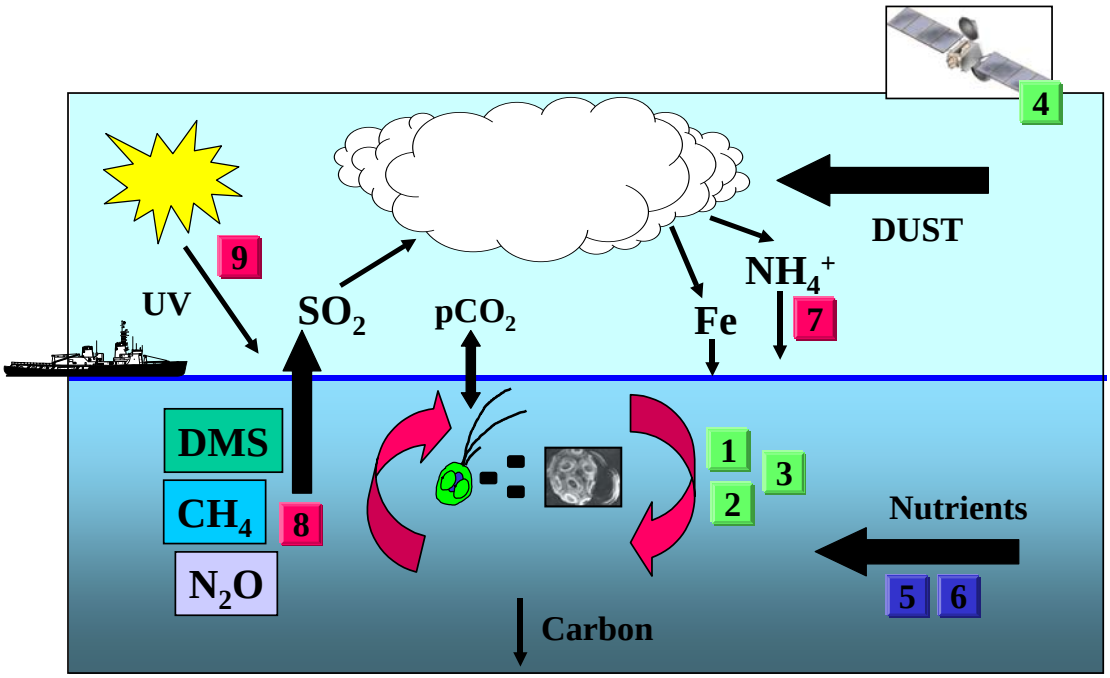
- To determine the role of physical processes in controlling the rates of nutrient supply, including dissolved organic matter, to the planktonic ecosystem

Hypothesis 5 and 6 deal with the physical supply of nutrients on two space and time scales. The programme will derive an indication of lateral transport of nutrients from upwelling regions into the gyres as well as validating models which predict the impact of atmospheric forcing functions on nutrient supply mechanisms.

- To determine the role of atmosphere-ocean exchange and photo-degradation in the formation and fate of organic matter

Hypothesis 7 assesses the impact of atmospheric input of nutrients such as inorganic nitrogen and iron, and hypothesis 8 will further investigate the link between the production of radiatively important gases and plankton community structure with a view to improving basin scale estimates of the fluxes of CO_2, DMS, N_2O and CH_4. Finally hypothesis 9 will determine the magnitude and variability of the photodegradation products of coloured dissolved organic matter.

The schematic shows how the hypotheses follow a climate feedback loop, with plankton community structure and activity impacting gas emissions which influence cloud formation which in turn influence dust solubility and hence deposition of nutrients and so community structure and activity.



The first cruise of the programme occurred in May / June 2003 and aimed to compare and contrast the functioning of the plankton in the North and South Atlantic Gyres. The research carried out on the fourth cruise (AMT15) is described in this cruise report.

The website www.amt-uk.org is the main source of cruise updates, contact information and reports relevant to the project.

Cruise Narrative

A rather grey and miserable SOC was departed at 1215 on Friday 17th September following a fairly frantic mobilisation as equipment for the following two cruises was being loaded at the same time. A brief port call was made into Tenerife on the 27th September and the ship arrived into Cape Town on the afternoon of the 28th October after 41 days at sea. Scientifically this was a successful cruise, though at times it seemed that the world was against us: We endured fairly severe weather for the first week, lost the MVP towed body, had an unexpected detour into Tenerife, spent time locating and recovering a lost mooring, had a failure of the radioisotope fume hood which nearly resulted in a detour to Ascension Island, and had a blackout of the ship as a result of engine failure. Science objectives though, were largely achieved. 72 stations were occupied and 105 CTD deployments made between 48.75°N and 40.0°S. The station log can be found in Appendix 1 and a station summary in Appendix 2. The cruise track and station positions are shown overleaf and a summary of "notable" events listed here:

17 September	Depart Southampton
21 September	Loss of MVP fish
27 September	Port call, Santa Cruz de Tenerife
27 September	Pick up 'lost' mooring
30 Sep – 03 Oct	Upwelling survey
08 October	Ship 'blacks out'
10 October	Cross Equator – 0425
17 September	CTD wire off sheave
28 September	Alongside Cape Town

Prior to the cruise there was concern over the amount of time that would need to be spent on station – on all previous AMTs up to 3 wires had been deployed simultaneously from the James Clark Ross, standard procedure for the Discovery is for one wire only to be used. As weather and sea conditions improved the use of two wires was approved and happened at most stations, so that mean time on station was of the order of 3.5 hours per day which proved sufficient to complete netting operations during the pre-dawn cast and optics deployment at mid-day in addition to CTD casts.

There were a large proportion of people onboard who were either new to AMT or completely new to sea-going science, all are to be congratulated on their preparation and attitude. There were a small number of "team forming" exercises required in the early days, though these occurred without too much objection. As noted on previous cruises there was a problem with ill prepared filtration equipment and the incubation cooler was put onboard not working and with no spares/alternative. Without the input of a lot of time from the OED technicians this would not have worked.

A major aim of this cruise was to investigate the upwelling waters off of North Africa, to this end diplomatic clearance was requested for working in the territorial waters of Morocco, Mauritania, Senegal and the Cape Verdes. Permission was granted by Morocco at the very last minute and by Mauritania approximately 1 week after we had left the area. A large amount of time and effort was invested by the Master and shore based staff in chasing these clearances. To ensure success of future cruises to these areas, efforts should be made at the appropriate level to secure these permissions well in advance of the ship sailing.

The work of one group of scientists suffered almost continuous hindrance: Initially they were delayed by approximately 24 hours in their mobilisation efforts as two radio-nuclide containers had been placed in the wrong (due to emergency exit provision) positions on the ship, requiring recall of a shore-side crane capable of doing the lift. Once at sea, it soon became apparent that the air

conditioning unit was not functional in this radionuclide (RN#1) container on aft deck starboard, attempts were made to remedy this by OED staff and ships engineers, including fitting of valves collected in Tenerife. This proved unsuccessful so that this container was unusable due to high temperatures during most of the cruise. The two scientists who were initially working in this container both suffered from a series of complaints which included headaches, nausea, sore throats and tightness of the chest; this was investigated by myself, Captain and Chief engineer. It was considered that these effects were not caused by chemicals being used and that they could have been attributed in part to working long hours in the extreme temperatures experienced. There was a suspicion that there may have been an association between their symptoms and exhaust gases from the ships stack, this is an obvious unknown at this stage but should be monitored in the future. The two people involved in this were then required to move their equipment into the RN container (RN#2) sited on the foc'sle deck. A significant part of their work required the use of a fume cupboard. The fume hood in RN#2 wasn't supplied with filters and so it was necessary for them to endure further inconvenience by having to work between the two containers. However the fume hood in RN#1 failed due to a faulty motor. A temporary repair was made by ship and OED staff. There was also an ongoing problem with the air conditioning unit in this container, which although worked, a design fault meant that water from condensation within the unit collected within an electrical supply causing regular shorting and requiring regular maintenance. It is thought that the taps fitted in RN#2 are inappropriate and possibly dangerous due to the nature of the work done therein. These taps are a push to deliver type, which result in a fast, high pressure supply with no/little control possible, not recommended when working with radioisotopes and other toxic and corrosive chemicals. The third, trace metal clean container (aft deck, port side) was also supplied with no functional air conditioning which required a port call into Tenerife and resulted in the loss of a number of stations which were required in the North Atlantic Gyre.

Contingency time was sufficient so that the southern section of the cruise track could be extended beyond initial plans. However there were a small number of lost stations. The port call to Tenerife (27.09.04) to pick up spares for the air conditioning units resulted in the loss of two sampling stations (one days science time). An engine failure on 08.10.04 resulted in the loss of one sampling station only.

Figure 1. Cruise track overlaid on SeaWiFS chlorophyll composite for September 2004

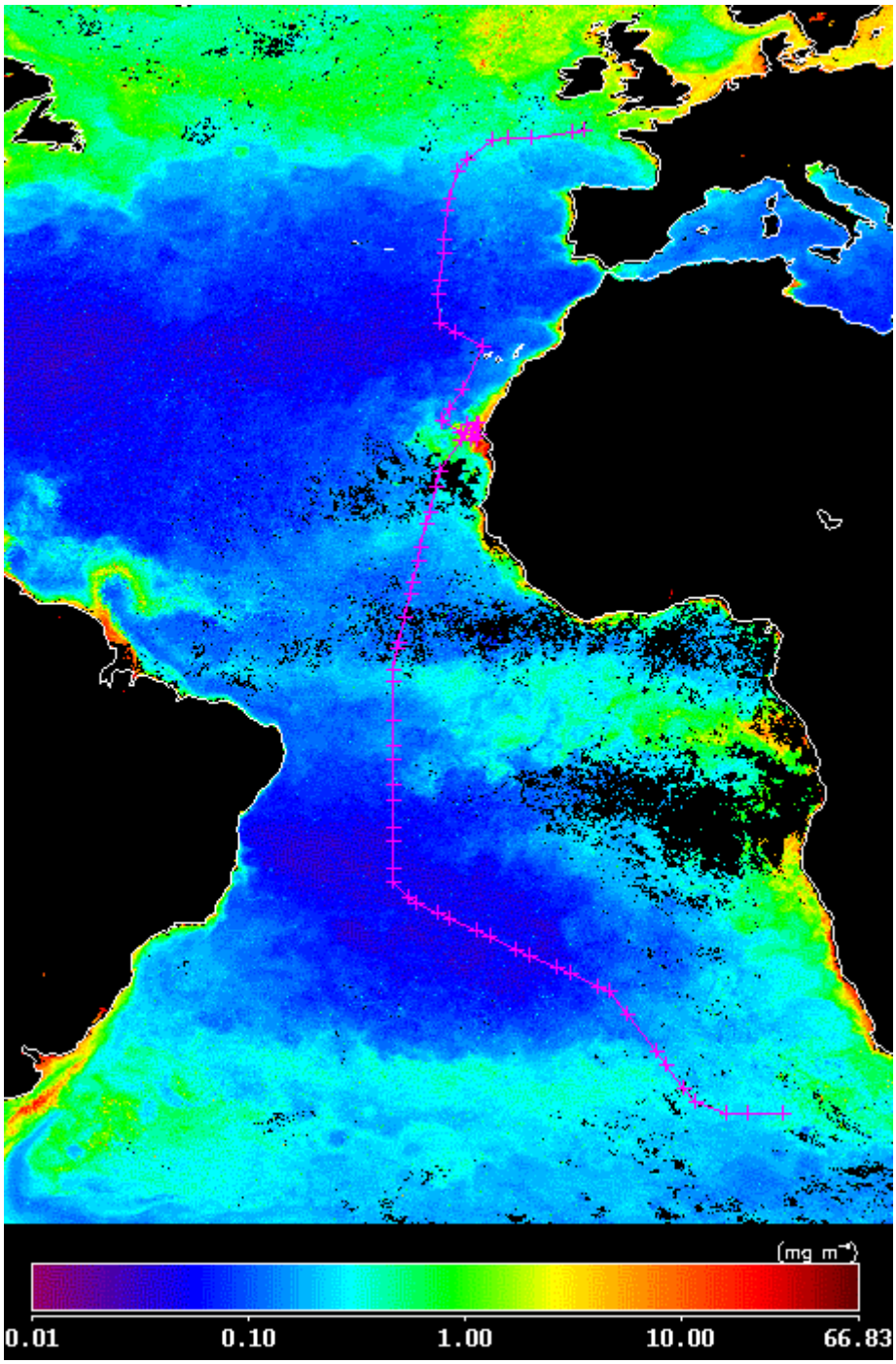
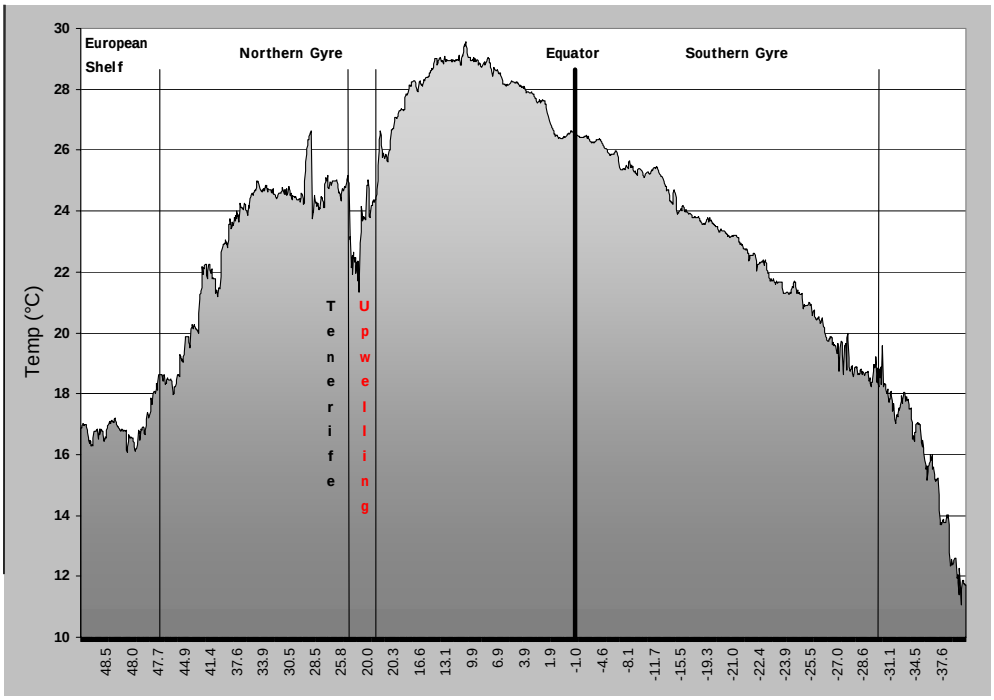


Figure 2. Changes (30 minute resolution) to surface water properties with latitude. a) temperature (°C), b) Chlorophyll fluorescence (mV)

a)



b)

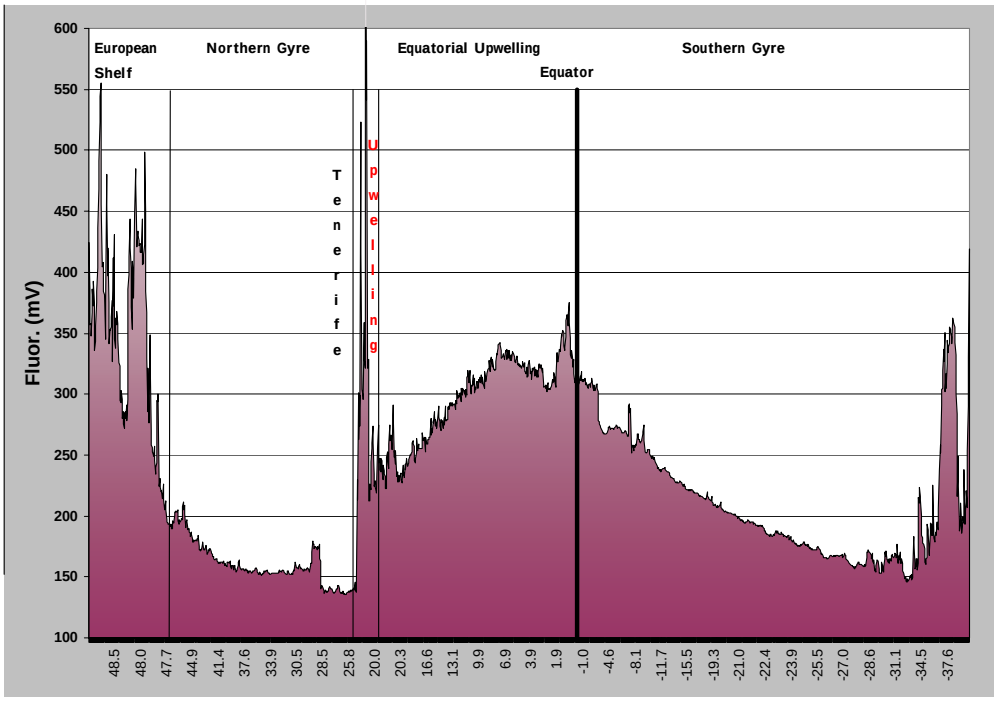
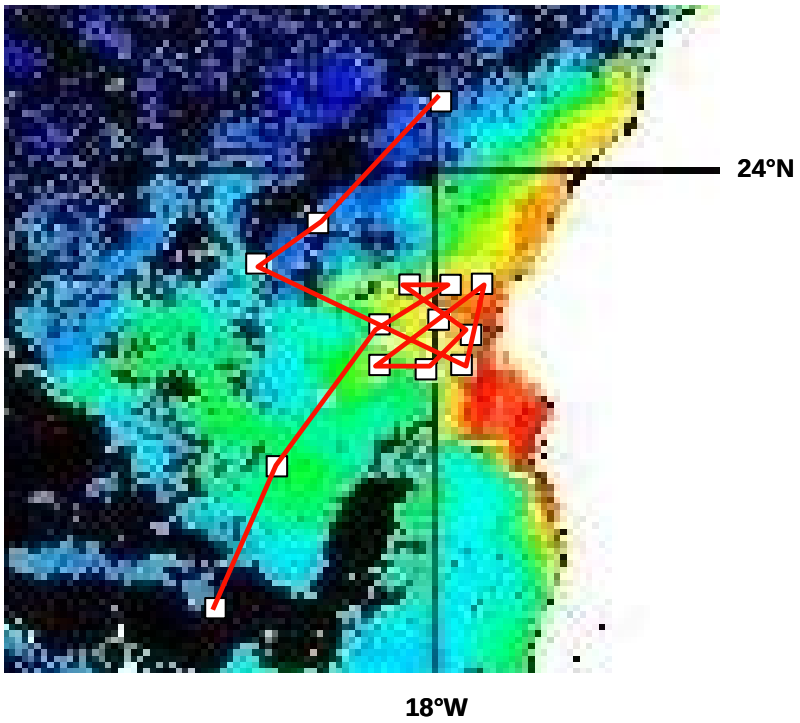
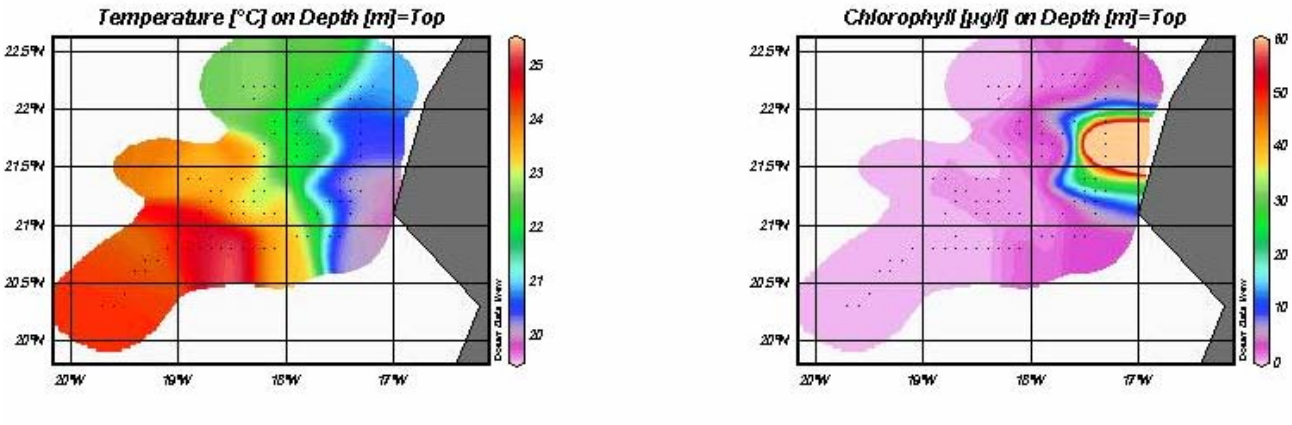


Figure 3. Cruise track during survey of the North West African Upwelling overlaid onto SeaWiFS chlorophyll image for 04.10.2004



Between 1200 on 30.09.04 and 0200 on 03.10.04 9 stations were occupied in Moroccan waters of the North West African upwelling.

Figure 4. Surface contours (30 minute resolution) of temperature and chlorophyll for North West African Upwelling



Timetable of Events D284 / 04

Date	Time (UT)	Event
16/09/04	1400	Familiarisation of newly joined personnel
17/09/04	0930 0955-1015 1030 1040 1106 1116 1129 1231 1242 1412 1425 1512	Emergency and Lifeboat Muster for all hands Critical equipment and instrumentation tested Chernikieff Log Technician aboard (Mr. G. Crystal) Pilot embarked at Empress Dock, Southampton Tug 'Wyeforce' made fast aft. Vessel cleared berth Tug 'Wyeforce' Let go Pilot disembarked Commenced calibration of the chernikieff Log Calibration of log completed. Mr. G. Crystal disembarked to launch 'Will Venture' Full away at Needles Fairway Buoy
18/09/04	0000 1200 1216 1230 1336 1524	Position Latitude 50º07.2'N Longitude 03º17.4'W Position Latitude 49º25.7'N Longitude 05º34.4'W PES Fish outboard 49º25.0'N 05º37.0'W TMS (Trace Metal Sampler) Fish outboard – Resumed Passage TMS Fish recovered 49º23.2'N 05º44.6'W TMS Fish cast outboard 49º16.6'N 06º05.0'W
19/09/04	0000 0100 0105-35 0158-0206 0222-57 0315-30 0330-0410 0410 1000-12 1025-1100 1114-29 1330-44	Position Latitude 48º47.0'N Longitude 07º38.6'W Vessel Hove to on Station No. 1 48º44.0'N 07º50.0'W **Station 1 #1–CTD cast outboard to 120 m. 48º44.1'N 07º50.5'W** **Station 1 #2–NET cast outboard 48º44.5'N 07º51.1'W** **Station 1 #3–CTD cast outboard to 140 m. 48º44.9'N 07º51.5'W** **Station 1 #4–NET cast outboard 48º45.7'N 07º51.9'W** changing cable on CTD Set Course 253 T 48º46.7'N 07º51.2'W **Station 2 #1–HYPERPRO outboard 48º30.6'N 08º54.8'W** **Station 2 #2–CTD cast outboard 48º29.5'N 08º55.5'W** **Station 2 #3–Optics probe cast outboard 48º29.0'N 08º55.7'W** CTD cast outboard for test purposes 48º25.5'N 09º19.6'W
20/09/04	0000 0100 1025-1130 1835	Position Latitude 48º05.0'N Longitude 11º16.4'W Station cancelled due to bad weather **Station 3 #1–CTD cast outboard to 1000 m. 48º02.7'N 12º32.8'W** MVP (Moving Vessel Profiler) deployed 48º03.4'N 13º11.7W
21/09/04	0000 0100 0109-37 0149-0220 0226-0316 0326-45 0355-0400 0500 0520 0541 1000 1115-1221 1237-1304	Position Latitude 47º56.2'N Longitude 14º25.6'W Hove to on station 4 – MVP hauled to surface **Station 4 #1–CTD cast outboard to 152 m 47º54.8'N 14º36.9'W** **Station 4 #2–NET cast outboard 47º55.2'N 14º36.8'W** **Station 4 #3–CTD cast outboard to 300 m 47º55.4'N 14º36.7'W** **Station 4 #4–NET cast outboard 47º55.5'N 14º36.7'W** **Station 4 #5–NET cast outboard 47º55.5'N 14º36.7'W** MPV deployed 47º55.2'N 14º46.6'W Course 250 G Heavy roll – altered course to 270 G 47º54.1'N 14º50.5'W **LOSS OF MVP FISH 47º53.94'N 14º54.49'W** Altered course to 220 T 47º50.2'N 15º51.1'W **Station 5 #1–CTD cast outboard to 500 m 47º42.0'N 15º59.8'W** **Station 5 #2–Optics Rig cast outboard 47º41.5'N 15º59.9'W**

22/09/04	0000	Position Latitude 46º18.0'N Longitude 18º08.1'W
	0205-33	**Station 6 #1–CTD cast outboard to 150 m 45º59.1'N 18º23.7'W**
	0240-58	**Station 6 #2–NET cast outboard 45º59.1'N 18º23.7'W**
	0305-51	**Station 6 #3–CTD cast outboard to 300 m 45º58.9'N 18º23.6'W**
	0357-0415	**Station 6 #4–NET cast outboard 45º58.9'N 18º23.9'W**
	0415	Set course to 211 T 47º58.8'N 18º23.9'W
	1100-10	**Station 7 #1–HYPERPRO outboard 44º56.0'N 19º14.1'W**
	1113-1220	**Station 7 #2–CTD cast outboard to 300 m 44º55.5'N 19º13.8'W**
	1117-1220	**Station 7 #3–Optics Rig cast outboard 44º55.5'N 19º13.8'W**
	1224	Set course to 200 T 44º55.2'N 19º13.7'W
	1620	TMS Fish recovered 44º12.2'N 19º31.9'W
	1900	TMS Fish cast outboard 43º46.6'N 19º39.4'W
23/09/04	0000	Position Latitude 42º52.9'N Longitude 19º47.4'W
	0202-34	**Station 8 #1–CTD cast outboard to 151 m 42º32.9'N 19º50.3'W**
	0211-43	**Station 8 #2–NET cast outboard**
	0254-0314	**Station 8 #3–NET cast outboard**
	0322-0410	**Station 8 #4–CTD cast outboard to 300 m 42º33.4'N 19º50.1'W**
	0322-40	**Station 8 #5–NET cast outboard**
	0410	Set course to 186 T 42º33.7'N 19º50.1'W
	1105-1232	**Station 9 #1–CTD cast outboard to 300 m 41º22.5'N 20º00.7'W**
	1112-1204	**Station 9 #2–Optics Rig cast outboard**
	1236	Set course to 186 T 41º22.9'N 20º01.0'W
24/09/04	0000	Position Latitude 39º13.2'N Longitude 20º19.3'W
	0202-28	**Station 10 #1–CTD cast outboard to 151 m 38º53.8'N 20º21.1'W**
	0210-28	**Station 10 #2–NET cast outboard**
	0237-0304	**Station 10 #3–NET cast outboard**
	0306-56	**Station 10 #4–CTD cast outboard to 301 m 38º53.6'N 20º21.2'W**
	0400	Set course to 186 T 38º53.5'N 20º21.4'W
	1100-09	**Station 11 #1–HYPERPRO outboard 37º38.8'N 20º31.1'W**
	1115-1241	**Station 11 #2–CTD cast outboard to 1000 m 37º38.7'N 20º30.7'W**
	1116-1221	**Station 11 #3–Optics Rig cast outboard**
	1248	Set course to 186 T 37º39.0'N 20º30.0'W
25/09/04	0000	Position Latitude 35º27.5'N Longitude 020º48.9'W
	0203-39	**Station 12 #1–CTD cast outboard to 150 m 35º06.0'N 20º51.1'W**
	0208-37	**Station 12 #2–NET cast outboard**
	0247-0307	**Station 12 #3–NET cast outboard**
	0314-35	**Station 12 #4–NET cast outboard**
	0325-0415	**Station 12 #5–CTD cast outboard to 300 m 35º05.7'N 20º50.9'W**
	0415	Set course to 186 T 35º05.6'N 20º50.6'W
	1100-12	**Station 13 #1–HYPERPRO outboard 33º52.7'N 21º00.4'W**
	1114-1209	**Station 13 #2–CTD cast outboard to 500 m 33º52.7'N 21º00.3'W**
	1115-1207	**Station 13 #3–Optics Rig cast outboard**
	1212	Set course to 186 T 33º52.6'N 21º00.2'W
	1800	altered course to 180 T 32º46.9'N 21º08.2'W
	2045	altered course to 161 T 32º14.2'N 21º07.2'W
26/09/04	0000	Position Latitude 31º36.8'N Longitude 20º52.5'W
	0202-30	**Station 14 #1–CTD cast outboard to 150 m 31º15.6'N 20º43.0'W**
	0210-31	**Station 14 #2–NET cast outboard**
	0238-0300	**Station 14 #3–NET cast outboard**
	0305-55	**Station 14 #4–CTD cast outboard to 300 m 31º15.5'N 20º43.2'W**
	0400	Set course to 130 T 31º15.5'N 20º43.2'W
	0820	altered course to 122 T 30º42.8'N 19º57.7'W
	1112-1233	**Station 15 #1–CTD cast outboard to 1000 m 30º27.8'N 19º28.1'W**
	1113-1215	**Station 15 #2–Optics Rig cast outboard**
	1236	Set course to 122 T 30º28.0'N 19º28.3'W

27/09/04	0000	Position Latitude 29º19.3'N Longitude 17º19.6'W
	0207-29	**Station 16 #1–NET cast outboard**
	0218-42	**Station 16 #2–CTD cast outboard to 150 m 29º07.7'N 16º58.0'W**
	0235-54	**Station 16 #3–NET cast outboard**
	0258-0345	**Station 16 #4–CTD cast outboard to 300 m 29º07.5'N 16º58.1'W**
	0301-17	**Station 16 #5–NET cast outboard**
	0348	Set course to 122 T 29º07.3'N 16º58.3'W
	0840	altered course to 180 T 28º38.3'N 16º03.6'W
	0917	altered course to 249 T 28º32.1'N 16º03.1'W
	1010-1436	PORT TIME – Santa Cruz de Tenerife
	1448	Set Course 200 T 28º25.8'N 16º13.9'W
	1614	altered course to 212 T 28º08.7'N 16º20.7'W
	1700	altered course to 254 T 28º00.2'N 16º26.6'W
	2116	Commenced ARGOS Buoy search 27º46.8'N 17º17.8'W
	2145	Argos buoy found – recovering commences
	2200	surface buoy and current meter aboard
	2215	Cable parted at splice 27º47.5'N 17º17.5'W
	2215	Set Course 231 T
28/09/04	0000	Position Latitude 27º35.7'N Longitude 17º31.8'W
	0118	altered course to 208 T 27º27.0'N 17º44.2'W
	1100	**Station 17 #1–HYPERPRO outboard 25º47.9'N 18º42.2'W**
	1105-1207	**Station 17 #2–CTD cast outboard to 500 m 25º48.1'N 18º42.2'W**
	1110-1209	**Station 17 #3–Optics Rig cast outboard**
	1135	PES and Trace Meta Fishes cast outboard
	1212	Set course to 208 T 25º48.5'N 18º42.5'W
29/09/04	0000	Position Latitude 23º50.9'N Longitude 19º49.6'W
	0200-34	**Station 18 #1–CTD cast outboard to 300 m 23º33.2'N 19º59.5'W**
	0206-31	**Station 18 #2–NET cast outboard**
	0238-0301	**Station 18 #3–NET cast outboard**
	0308-26	**Station 18 #4–NET cast outboard**
	0315-0400	**Station 18 #5–CTD cast outboard to 300 m 23º33.4'N 19º59.6'W**
	0406	Set course to 208 T 23º33.5'N 19º59.5'W
	1100-09	**Station 19 #1–HYPERPRO outboard 22º27.6'N 20º37.1'W**
	1110-1223	**Station 19 #2–CTD cast outboard to 500 m 22º27.6'N 20º36.9'W**
	1115-1205	**Station 19 #3–Optics Rig cast outboard**
	1230	Set course to 208 T 22º27.6'N 20º37.2'W
	1438	altered course to 112 T 22º06.6'N 20º49.0'W
30/09/04	0000	Position Latitude 21º29.8'N Longitude 19º09.6'W
	0203-28	**Station 20 #1–NET cast outboard**
	0208-44	**Station 20 #2–CTD cast outboard to 150 m 21º22.3'N 18º49.6'W**
	0234-0302	**Station 20 #3–NET cast outboard**
	0330-0412	**Station 20 #4–CTD cast outboard to 300 m 21º22.6'N 18º50.1'W**
	0412	Set course to 112 T 21º22.8'N 18º50.4'W
	1200-13	**Station 21 UP01 #1 –HYPERPRO outboard 20º51.9'N 17º27.5'W**
	1217-32	**Station 21 UP01 #2 – Optics Rig cast O/B 20º51.9'N 17º27.5'W**
	1217-40	**Station 21 UP01 #3 – CTD cast O/B to 50 m 20º51.8'N 17º27.6'W**
	1242	Set course to 008 T 20º51.8'N 17º27.7'W
	2100-33	**Station 22 UP02 #1 – CTD cast O/B to 60 m 22º14.4'N 17º14.0'W**
	2133	Set course to 226 T 22º14.2'N 17º14.0'W

01/10/04	0204-29	**Station 23 UP03 #1 – NET cast outboard**
	0209-37	**Station 23 UP 03 #2 – CTD cast O/B to 150m 21°41.2'N 17°50.4'W**
	0240-0304	**Station 23 UP03 #3 – NET cast outboard**
	0311-20	**Station 23 UP03 #4– NET cast outboard**
	0325-0404	**Station 23 UP 03 #5 – CTD cast O/B to 300m 21°41.6'N 17°49.6'W**
	0406	Set course to 226 T 21 41.6'N 17 49.5'W
	1130-45	**Station 24 UP04 #1 –HYPERPRO outboard 20°45.3'N 18°51.8'W**
	1145-1257	**Station 24 UP 04 #2 – CTD cast O/B to 1000m 20°45.5'N 18°51.9'W**
	1150-1257	**Station 24 UP04 #3 – Optics Rig cast O/B**
	1300	Set course to 086 T 20°45.6'N 18°51.9'W
	1755-1845	**Station 25 UP 05 #1 – CTD cast O/B to 500m 20°47.0'N 18°00.5'W**
02/10/04	0224-34	**Station 26 UP06 #1 – NET cast outboard**
	0229-48	**Station 26 UP 06 #2 – CTD cast O/B to 50m 21°21.5'N 17°22.2'W**
	0241-53	**Station 26 UP06 #3 – NET cast outboard**
	0325-48	**Station 26 UP 06 #4 – CTD cast O/B to 60m 21°21.3'N 17°22.4'W**
	0354	Set course to 311 T 21°21.2'N 17°22.4'W
	0950-1000	Stopped vessel to take surface samples 21°54.9'N 18°05.5'W
	1200-08	**Station 27 UP07 #1 –HYPERPRO outboard 22°09.5'N 18°22.5'W**
	1210-1318	**Station 27 UP 07 #2 – CTD cast O/B to 1000m 22°09.5'N 18°22.6'W**
	1212-15	**Station 27 UP07 #3 – Optics Rig cast O/B**
	1318	Set course to 081 T 22°09.4'N 18°22.6'W
	1800-40	**Station 28 UP 08 #1 – CTD cast O/B to 500m 22°16.4'N 17°29.9'W**
	1840	Set course to 226 T 22°16.2'N 17°29.9'W
03/10/04	0205-30	**Station 29 UP 09 #1 – CTD cast O/B to 150m 21°18.2'N 18°34.8'W**
	0207-46	**Station 29 UP 09 #2 – NET cast outboard**
	0253-0311	**Station 29 UP 09 #3 – NET cast outboard**
	0308-48	**Station 29 UP 09 #4 – CTD cast O/B to 300m 21°18.4'N 18°35.6'W**
	0316-29	**Station 29 UP 09 #5 – NET cast outboard**
	0348	Set course to 226 T 21°18.5'N 18°35.8'W
	0840	Reduced Revs for Engine oil change 20°40.0'N 19°16.4'W
	1042	Oil change completed – resumed full speed 20°27.2'N 19°30.1'W
	1200	Position Latitude 20°16.5N Longitude 019°41.9'W
04/10/04	0000	Position Latitude 18°09.6N Longitude 20°44.6'W
	0200-20	**Station 30 #1–NET cast outboard**
	0205-26	**Station 30 #2–CTD cast outboard to 150 m 17°49.8'N 20°52.5'W**
	0229-51	**Station 30 #3–NET cast outboard**
	0301-39	**Station 30 #4–CTD cast outboard to 300 m 17°50.4'N 20°53.7'W**
	0342	Set course to 196 T 17°50.4'N 20°53.7'W
	1102-1221	**Station 31#1–Optics Rig cast outboard**
	1108-1220	**Station 31 #2–CTD cast outboard to 1000m 16°34.1'N 21°13.3'W**
	1224	Set course to 193 T 16°34.4'N 21°13.6'W
05/10/04	0000	Position Latitude 14°36.6N Longitude 21°39.5'W
	0200-26	**Station 32 #1–CTD cast outboard to 150 m 14°18.0'N 21°45.2'W**
	0205-51	**Station 32 #2–NET cast outboard**
	0257-0317	**Station 32 #3–NET cast outboard**
	0305-46	**Station 32 #4–CTD cast outboard to 300m 14°17.7'N 21°45.6'W**
	0323-41	**Station 32 #5–NET cast outboard**
	0348	Set course to 193 T 14°17.8'N 21°45.7'W
	1100-06	**Station 33 #1 –HYPERPRO outboard**
	1103-58	**Station 33 #2–CTD cast outboard to 500 m 13°06.0'N 22°01.0'W**
	1106-1219	**Station 33 #3–Optics Rig cast outboard**
	1219	Set course to 193 T 13°05.9'N 22°01.4'W

06/10/04	0000	Position Latitude 11º16.5N Longitude 22º26.8'W
	0202-28	**Station 34 #1–CTD cast outboard to 150m 10º59.9'N 22º30.5'W**
	0205-24	**Station 34 #2–NET cast outboard**
	0232-59	**Station 34 #3–NET cast outboard**
	0308-49	**Station 34 #4–CTD cast outboard to 300m 11º00.1'N 22º30.9'W**
	0354	Set course to 193 T 11º00.0'N 22º31.0'W
	1100-08	**Station 35 #1 –HYPERPRO outboard**
	1104-1218	**Station 35 #2–CTD cast outboard to 1000m 09º55.0'N 22º46.4'W**
	1113-1227	**Station 35 #3–Optics Rig cast outboard**
	1230	Set course to 193 T 09º54.6'N 22º47.1'W
07/10/04	0000	Position Latitude 08º07.6N Longitude 23º09.9'W
	0201-40	**Station 36 #1–CTD cast outboard to 150m 07º50.8'N 23º13.8'W**
	0206-15	**Station 36 #2–NET cast outboard**
	0224-37	**Station 36 #3–NET cast outboard**
	0252-0312	**Station 36 #4–NET cast outboard**
	0317-0403	**Station 36 #5–CTD cast outboard to 300m 07º51.6'N 23º13.9'W**
	0406	Set course to 193 T 07º51.7'N 23º13.9'W
	1100-57	**Station 37 #1–CTD cast outboard to 500m 06º51.9'N 23º26.3'W**
	1105-1200	**Station 37 #2–Optics Rig cast outboard**
	1200	Set course to 193 T 06º51.9'N 23º25.9'W
08/10/04	0000	Position Latitude 05º02.3N Longitude 23º51.4'W
	0201-23	**Station 38 #1–CTD cast outboard to 150m 04º45.4'N 23º55.4'W**
	0205-24	**Station 38 #2–NET cast outboard**
	0230-44	**Station 38 #3–NET cast outboard**
	0257-0326	**Station 38 #4–NET cast outboard**
	0300-46	**Station 38 #5–CTD cast outboard to 300m 04º45.9'N 23º54.6'W**
	0348	Set course to 193 T 04º46.0'N 23º54.2'W
	0800-0938	**SHIP BLACKS OUT onto emergency power** 04º08.2'N 24º03.5'W
	0938	Set course to 193 T at 6.5 knots 04º08.9'N 24º03.3'W
	1200	Position Latitude 03º55.7N Longitude 024º06.7'W
09/10/04	0000	Position Latitude 02º42.8N Longitude 24º23.2'W
	0207-28	**Station 39 #1–CTD cast outboard to 150m 02º30.5'N 24º26.1'W**
	0237-58	**Station 39 #2–NET cast outboard**
	0308-35	**Station 39 #3–NET cast outboard**
	0346-0430	**Station 39 #4–CTD cast outboard to 300m 02º30.6'N 24º26.1'W**
	0430	Set course to 193 T at 6.5 knots 02º30.6'N 24º25.9'W
	1100-1214	**Station 40 #1–Optics Rig cast outboard**
	1111-1204	**Station 40 #2–CTD cast outboard to 500m 01º51.3'N 24º35.5'W**
	1218	Set course to 193 T at 6.5 knots 01º51.3'N 24º35.5'W
	1500	Increased Speed to 8.5 Knots 01º35.3'N 24º38.5'W
10/10/04	0000	Position Latitude 00º19.6N Longitude 24º55.3'W
	0203-26	**Station 41 #1–CTD cast outboard to 150m 00º03.9'N 24º58.9'W**
	0215-39	**Station 41 #2–NET cast outboard**
	0244-57	**Station 41 #3–NET cast outboard**
	0302-42	**Station 41 #4–CTD cast outboard to 300m 00º04.1'N 24º58.5'W**
	0305-30	**Station 41 #5–NET cast outboard**
	0342	Set course to 193 T at 8.5 knots 00º04.1'N 24º58.3'W
	0425	Altered course to 180 T 00º00.5'S 25º00.0'W
	0840	Increased speed to full speed 00º35.4'S 25º00.0'W
	1100-08	**Station 42 #1 –HYPERPRO outboard**
	1108-1208	**Station 42 #2–CTD cast outboard to 500m 00º58.6'S 24º59.8'W**
	1115-1221	**Station 42 #3–Optics Rig cast outboard**
	1224	Set course to 180 T 00º58.4'S 24º59.7'W
	1700-35	Hove to – to Salute King Neptune in fancy dress 01º45.2'S 24º58.6'W
11/10/04	0000	Position Latitude 02º48.7'S Longitude 25º00.0'W
	1100-1202	**Station 43 #1–Optics Rig cast outboard**
	1105-1221	**Station 43 #2–CTD cast outboard to 1000m 04º38.9'S 24º58.8'W**
	1224	Set course to 180 T 04º38.6'S 25º00.0'W

12/10/04	0000	Position Latitude 06º31.1'S Longitude 25º00.4'W
	0202-28	**Station 44 #1–CTD cast outboard to 150m 06º50.8'S 25º00.4'W**
	0207-32	**Station 44 #2–NET cast outboard**
	0242-0303	**Station 44 #3–NET cast outboard**
	0307-51	**Station 44 #4–CTD cast outboard to 300m 06º50.8'S 25º00.7'W**
	0310-29	**Station 44 #5–NET cast outboard**
	0354	Set course to 180 T 06º50.8'S 25º00.9'W
	1105-1212	**Station 45 #1–CTD cast outboard to 500m 08º04.0'S 24º59.9'W**
	1212	Set course to 180 T 08º04.2'S 25º00.3'W
13/10/04	0000	Position Latitude 10º06.3'S Longitude 25º00.0'W
	0205-28	**Station 46 #1–CTD cast outboard to 150m 10º25.0'S 24º59.8'W**
	0209-30	**Station 46 #2–NET cast outboard**
	0237-56	**Station 46 #3–NET cast outboard**
	0258-0338	**Station 46 #4–CTD cast outboard to 300m 10º24.5'S 24º59.6'W**
	0342	Set course to 180 T 10º24.3'S 24º59.9'W
	1100-09	**Station 47 #1 –HYPERPRO outboard**
	1106-1230	**Station 47 #2–CTD cast outboard to 1000m 11º41.7'S 24º59.7'W**
	1116-1216	**Station 47 #3–Optics Rig cast outboard**
	1236	Set course to 180 T 11º41.7'S 24º59.4'W
14/10/04	0000	Position Latitude 13º49.3'S Longitude 24º59.8'W
	0203-26	**Station 48 #1–CTD cast outboard to 150m 14º10.6'S 24º59.7'W**
	0209-46	**Station 48 #2–NET cast outboard**
	0253-0316	**Station 48 #3–NET cast outboard**
	0259-0339	**Station 48 #4–CTD cast outboard to 300m 14º10.6'S 24º59.4'W**
	0321-42	**Station 48 #5–NET cast outboard**
	0342	Set course to 180 T 14º10.7'S 24º59.3'W
	1100-08	**Station 49 #1 –HYPERPRO outboard**
	1104-58	**Station 49 #2–CTD cast outboard to 500m 15º29.8'S 24º59.4'W**
	1110-1215	**Station 49 #3–Optics Rig cast outboard**
	1218	Set course to 180 T 15º29.8'S 24º59.5'W
	1519	TMS Fish recovered 16º01.3'S 25º00.0'W
	1545	TMS Fish re-deployed 16º04.0'S 25º00.2'W
15/10/04	0000	Position Latitude 17º36.4'S Longitude 24º59.8 'W
	0205-36	**Station 50 #1–CTD cast outboard to 200m 17º57.2'S 25º00.0'W**
	0207-29	**Station 50 #2–NET cast outboard**
	0238-58	**Station 50 #3–NET cast outboard**
	0312-53	**Station 50 #4–CTD cast outboard to 300m 17º56.9'S 24º59.7'W**
	0354	Set course to 180 T 17º56.8'S 24º59.7'W
	1100-07	**Station 51 #1 –HYPERPRO outboard**
	1105-1236	**Station 51 #2–CTD cast outboard to 1000m 19º14.2'S 24º59.8'W**
	1112-1214	**Station 51 #3–Optics Rig cast outboard**
	1236	Set course to 180 T 19º14.0'S 24º59.8'W
	1704	Altered Course to 117 T 20º00.1'S 24º59.6'W
16/10/04	0000	Position Latitude 20º36.4'S Longitude 24º59.8'W
	0200-38	**Station 52 #1–CTD cast outboard to 250m 20º38.3'S 23º40.3'W**
	0206-29	**Station 52 #2–NET cast outboard**
	0240-0301	**Station 52 #3–NET cast outboard**
	0307-38	**Station 52 #4–NET cast outboard**
	0314-51	**Station 52 #5–CTD cast outboard to 300m 20º38.2'S 23º40.1'W**
	0354	Set course to 117 T 20 38.2'S 23 40.1'W
	1008-1346	**Station 53 #1–CTD cast outboard to 5000m 21º02.3'S 22º50.1'W**
	1055-1146	**Station 53 #2–Optics Rig cast outboard**
	1348	Set course to 117 T 21º02.7'S 22º50.3'W

17/10/04	0000	Position Latitude 21º47.0'S Longitude 21º16.5'W
	0203-0307	**Station 54 #1–CTD cast outboard to 250m 21º55.2'S 20º58.9'W**
	0205-30	**Station 54 #2–NET cast outboard**
	0239-0302	**Station 54 #3–NET cast outboard**
	0330	Set course to 117 T 21º55.0'S 20º59.1'W
	1100-1200	**Station 55 #1–CTD cast outboard to 500m 22º28.2'S 19º49.5'W**
	1104-1209	**Station 55 #2–Optics Rig cast outboard**
	1212	Set course to 117 T 22º28.4'S 19º49.2'W
18/10/04	0000	Position Latitude 23º24.8'S Longitude 17º40.0'W
	0202-39	**Station 56 #1–CTD cast outboard to 275m 23º33.9'S 17º30.2'W**
	0204-37	**Station 56 #2–NET cast outboard**
	0244-0303	**Station 56 #3–NET cast outboard**
	0311-0400	**Station 56 #4–CTD cast outboard to 300m 23º33.7'S 17º29.9'W**
	0313-37	**Station 56 #5–NET cast outboard**
	0400	Set course to 117 T 23º33.6'S 17º29.8'W
	1100-10	**Station 57 #1 –HYPERPRO outboard**
	1105-1222	**Station 57 #2–CTD cast outboard to 1000m 24º07.8'S 16º17.0'W**
	1113-1206	**Station 57 #3–Optics Rig cast outboard**
	1230	Set course to 117 T 24º08.0'S 16º16.8'W
19/10/04	0000	Position Latitude 25º04.4'S Longitude 14º15.9'W
	0207-44	**Station 58 #1–CTD cast outboard to 250m 25º14.0'S 13º55.3'W**
	0210-30	**Station 58 #2–NET cast outboard**
	0236-56	**Station 58 #3–NET cast outboard**
	0320-58	**Station 58 #4–CTD cast outboard to 300m 25º14.1'S 13º54.6'W**
	0400	Set course to 117 T 25º14.1'S 13º54.4'W
	1100-12	**Station 59 #1 –HYPERPRO outboard**
	1104-1200	**Station 59 #2–CTD cast outboard to 500m 25º47.2'S 12º43.8'W**
	1117-1215	**Station 59 #3–Optics Rig cast outboard**
	1218	Set course to 117 T 25º47.3'S 12º43.5'W
20/10/04	0000	Position Latitude 26º43.5'S Longitude 10º40.2'W
	0203-38	**Station 60 #1–CTD cast outboard to 250m 26º53.1'S 10º20.2'W**
	0204-26	**Station 60 #2–NET cast outboard**
	0233-50	**Station 60 #3–NET cast outboard**
	0255-0327	**Station 60 #4–NET cast outboard**
	0316-0400	**Station 60 #5–CTD cast outboard to 300m 26º52.7'S 10º20.0'W**
	0400	Set course to 117 T 26º57.0'S 10º19.9'W
	1100-15	**Station 61 #1 –HYPERPRO outboard**
	1105-1222	**Station 61 #2–CTD cast outboard to 1000m 27º26.3'S 09º07.2'W**
	1120-1202	**Station 61 #3–Optics Rig cast outboard**
	1224	Set course to 117 T 27º26.2'S 09º06.9'W
	2300	Position Latitude 28º20.1'S Longitude 007º08.4'W
21/10/04	0205-35	**Station 62 #1–CTD cast outboard to 250m 28º35.0'S 06º34.3'W**
	0208-25	**Station 62 #2–NET cast outboard**
	0231-50	**Station 62 #3–NET cast outboard**
	0306-50	**Station 62 #4–CTD cast outboard to 300m 28º34.9'S 06º34.1'W**
	0350	Set course to 117 T 28º34.7'S 06º34.0'W
	1000-10	**Station 63 #1 –HYPERPRO outboard**
	1007-55	**Station 63 #2–CTD cast outboard to 500m 29º04.6'S 05º28.1'W**
	1014-1118	**Station 63 #3–Optics Rig cast outboard**
	1118	Set course to 117 T 29º04.0'S 05º28.5'W
	1142	Altered Course to 148 T 29º08.5'S 05º23.1'W

22/10/04	0000	Position Latitude 31º01.0'S Longitude 04º01.0 'W
	0103-31	**Station 64 #1–CTD cast outboard to 200m 31º08.4'S 03º55.3'W**
	0108-45	**Station 64 #2–NET cast outboard**
	0151-0208	**Station 64 #3–NET cast outboard**
	0210-48	**Station 64 #4–CTD cast outboard to 300m 31º07.8'S 03º55.8'W**
	0213-24	**Station 64 #5–NET cast outboard**
	0248	Set course to 148 T 31º07.4'S 03º56.0'W
	1000-07	**Station 65 #1 –HYPERPRO outboard**
	1002-1111	**Station 65 #2–CTD cast outboard to 1000m 32º16.4'S 03º04.6'W**
	1011-1115	**Station 65 #3–Optics Rig cast outboard**
	1118	Set course to 148 T 32º16.9'S 03º04.4'W
	1430	TMS Fish recovered 32º48.9'S 02º40.5'W
	1448	TMS Fish re-deployed 32º50.5'S 02º39.3'W
23/10/04	0000	Position Latitude 34º30.6'S Longitude 01º22.8 'W
	0109-38	**Station 66 #1–CTD cast outboard to 150m 34º30.9'S 01º22.8'W**
	0112-30	**Station 66 #2–NET cast outboard**
	0140-0201	**Station 66 #3–NET cast outboard**
	0215-54	**Station 66 #4–CTD cast outboard to 300m 34º31.3'S 01º22.5'W**
	0254	Set course to 148 T 34º31.4'S 01º22.4'W
	0917	TMS Fish recovered 35º35.3'S 00º32.0 'W
	1000-10	**Station 67 #1 –HYPERPRO outboard**
	1005-55	**Station 67 #2–CTD cast outboard to 500m 35º39.8'S 00º27.6'W**
	1015-1112	**Station 67 #3–Optics Rig cast outboard**
	1112	Set course to 148 T 35º39.6'S 00º27.6'W
	1254	TMS Fish re-deployed 35º54.4'S 00º17.9'W
24/10/04	0000	Position Latitude 37º41.4'S Longitude 01º06.9'E
	0102-29	**Station 68 #1–CTD cast outboard to 150m 37º49.7'S 01º13.6'E**
	0105-26	**Station 68 #2–NET cast outboard**
	0133-50	**Station 68 #3–NET cast outboard**
	0155-0206	**Station 68 #4–NET cast outboard**
	0202-39	**Station 68 #5–CTD cast outboard to 300m 37º50.0'S 01º14.0'E**
	0242	Set course to 148 T 37º50.1'S 01º14.2'E
	1000-05	**Station 69 #1 –HYPERPRO outboard**
	1002-1117	**Station 69 #2–CTD cast outboard to 1000m 39º01.0'S 02º11.7'E**
	1010-1108	**Station 69 #3–Optics Rig cast outboard**
	1118	Set course to 148 T 39º01.1'S 02º11.7'E
	1708	Altered Course to 090 T 39º59.8'S 02º59.1'E
25/10/04	0000	Position Latitude 40º00.1'S Longitude 04º47.3'E
	0101-18	**Station 70 #1–CTD cast outboard to 99m 40º00.1'S 05º00.9'E**
	0106-24	**Station 70 #2–NET cast outboard**
	0133-0215	**Station 70 #3–CTD cast outboard to 300m 40º00.2'S 05º00.9'E**
	0218	Set course to 090 T 40º00.1'S 05º01.0'E
	1005-1112	**Station 71 #1–CTD cast outboard to 500m 39º59.9'S 06º53.8'E**
	1025-1102	**Station 71 #2–Optics Rig cast outboard**
	1112	Set course to 090 T 40º00.0'S 06º53.9'E
	2354	Hove to awaiting station deployment time 40º00.1'S 10º00.0'E
26/10/04	0103-46	**Station 72 #1–CTD cast outboard to 300m 40 00.9'S 10 01.8'E**
	1010-32	**Station 72 #2–NET cast outboard**
	0148	Set course to 048 T 40º00.9'S 10º02.3'E
	1200	Position Latitude 38º45.4'S Longitude 011º46.1'E
27/10/04	0000	Position Latitude 37º12.2'S Longitude 013º55.3'E
	0617	PES and TMS Fish inboard **END OF SCIENCE** 36º27.0'S 14º57.7'E
	1200	Position Latitude 35º48.9'S Longitude 015º49.6'E

Cruise Reports

Autotrophic community structure and dynamics

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Cruise Objectives

1. Continued collection of core AMT measurements (chlorophyll *a*, primary production, pigments, phytoplankton identification, particulate organic carbon and dissolved organic carbon, nitrogen and phosphorus) [TA, WB, LH, AH, AP].
2. A basin scale investigation of mineralisation (inorganic carbon) rates in relation to community structure, and standing stocks [TA, WB, AH].
3. Investigation of photosynthetic parameters derived from traditional carbon-14 photosynthesis *vs*. irradiance incubations and those derived from discrete fast-repetition-rate-fluorometer (FRRF) measurements [AH].
4. Deployment of a new phycoerythrin fluorometer (Cyclops-7) provided by Turner Designs to detect cyanobacteria.
5. Collection of underway (approximately every 3 hours) samples for analysis of chlorophyll, phytoplankton pigments, particulate organic carbon (POC), particulate inorganic carbon (PIC), coccolith enumeration and biogenic silica concentration (BSi). The purpose of these samples was to provide an assessment of the inorganic and organic particles in surface water, along with indices of community composition).
6. Operation of an along-track flow-through system from the ship's non-toxic seawater system to characterise the hydrographic and bio-optical nature of the water.
7. Water-leaving radiance measurements in the visible and near infra red taken from the bow of the ship, for characterizing the particulate content of the seawater, and comparison to NASA's SeaWiFS and MODIS ocean colour satellites.

Methods

Chlorophyll, pigments, Lugols / Formalin and POC/N: From the five main light depths, samples were collected for chlorophyll determination (acetone extraction), pigment composition (High-Perfomance-Liquid-Chromotography after Barlow *et al*., 1997a,b), particulate organic carbon and nitrogen concentration and duplicate water samples preserved with 2% acidic Lugol's solution and 4% buffered formalin for species identification. Chlorophyll measurements were made onboard with a TD-700 Turner Designs fluorometer, calibrated with fresh chlorophyll a standard (Sigma, UK) in 90% acetone and set up to measure chlorophyll *a* in the presence of chlorophyll *b* following Welschmeyer (1994) [TA, WB, LH, AP].

Dissolved Organic Carbon, Nitrogen and Phosphorus: Water samples were collected from the five main light depths during the pre-dawn CTD cast. Duplicate samples for DOC were collected in glass ampoules, preserved with 5 x l 2M hydrochloric acid and flame-sealed using a handheld butane-gas torch. Samples for DON and DOP were collected in 50-ml plastic screw-top containers and frozen at -20°C. Analysis will follow the methodology of Knap *et al*., (1996) [TA, AP].

Particle Absorbance (PABS): Water samples (1 - 3 l) were collected from the five main light depths during the pre-dawn CTD cast and filtered through 25 mm diameter Whatman GF/F filters, placed in small petri-dishes and stored at -80°C. Analysis will follow the methodology of Tassan *et al.*, (1995) in association with Dave Suggett (University of Essex) [LH, AP].

Carbon fixation (PP): Water samples (3 light, 3 dark) from 5/6 light depths in the water column were collected, spiked with 20 µCi ^{14}C-labelled sodium hydroxide ($NaH^{14}CO_3$) and incubated over a daylight period (dawn to dusk, typically 10 - 12 hrs) in simulated *in-situ* incubators cooled with either sea-surface water or chilled freshwater to in-situ temperatures +/-3°C. Samples were filtered onto 0.2 mm 47 mm diameter polycarbonate filters under gentle vacuum (<200 mbar) and fumed for 30 minutes over concentrated hydrochloric acid in a desiccator. After fuming samples were placed in 6-ml pony vials with 5-ml of Optiphase HiSafe 3 or Ultima Gold and activity counted in a TriCarb 3100TR low activity liquid scintillation counter (LSC) onboard. At two depths (55% and 1% of E_0) samples were first gravity filtered through 2 mm 47 mm diameter polycarbonate filters and then sequentially filtered through 0.2 mm filters with both filters fumed and counted separately. In addition, 15 samples (plus three dark) from the surface (55% E_0) and fluorescence maximum (typically 1% E_0) were collected, spiked with 20 µCi ^{14}C labelled sodium hydroxide ($NaH^{14}CO3$) and incubated along a light gradient to produce photosynthesis v irradiance (PvsE) curves for analysis of photosynthetic parameters. After 2 hours samples were removed, filtered through 0.2µm 47-mm polycarbonate filters, fumed and counted in the TriCarb LSC onboard. Absolute light levels within the incubator were measured within the sample chamber using a Biospherical Instruments QSL-2000 4π PAR sensor. Stock solutions were prepared daily with fresh filtered seawater and checked by addition of 100 µl of stock solution to 9.9 ml Carbosorb and LS counting of ten 100 µl replicates from this mixture in 5 ml PermaFluor E+: coefficient of variance for replicate standards was <2% [TA, AH]. Stock solutions were prepared daily with fresh filtered seawater and checked by addition of 100 µl of stock solution to 9.9 ml Carbosorb and LS counting of five 100 µl replicates from this mixture in 5 ml PermaFluor E+: coefficient of variance for replicate standards was <2% [TA, AH].

Calcification ($Ca^{14}CO_3$): (after Balch *et al.*, 2000): Water samples (3 light, 1 dark) from 3 light depths were collected, spiked with 80 µCi ^{14}C-labelled sodium hydroxide ($NaH^{14}CO_3$) and incubated identically to samples for PP (see above) for a duration of 24 hours. Samples were filtered onto 0.2 µm (later 0.4 µm) 47 mm diameter polycarbonate filters under gentle vacuum and placed in pony vials. Filter cups, frits and forceps were thoroughly rinsed with fresh filtered seawater after filtration of a sample and between samples to remove any contamination from labelled dissolved inorganic carbon ($DI^{14}C$) Following filtration a septum and bucket were attached to each vial. Inside the bucket, a GFA filter soaked with 200 µl of a polyethylamine (PEA) was placed to collect ^{14}C-labelled CO_2. Using a small gauge syringe, 1 ml of a 1% phosphoric acid was injected past the bucket into the bottom of the vial and the samples were left for a minimum of 24 hours: acidification of the polycarbonate filter causes the conversion of ^{14}C labelled inorganic carbon ($PI^{14}C$) to be released as $^{14}CO_2$ which is trapped by the PEA onto the GFA filter. After the samples have equilibrated, the septums were removed, the bucket (with GFA) placed in a fresh pony vial and 4 ml of Optiphase Hisafe or Ultima Gold was added to both the polycarbonate containing vial and the GFA containing vial. Samples were counted in the TriCarb 3100TR low activity liquid scintillation counter (LSC) onboard [TA, AH].

Particulate Inorganic Carbon: A 1 litre sample of seawater was taken from between 6-8 depths and was vacuum filtered onto 0.45µm polycarbonate filters. The filters were rinsed with potassium tetraborate buffer and stored in centrifuge tubes at room temperature. Upon returning to Southampton Oceanography Centre the samples will be analysed using ICPAES [TA, WB].

Coccolithophore composition (SEM): Between 500ml and 2 litres of seawater was filtered onto 0.4µm polycarbonate filters for each of the five light depths. These filters will be analysed upon return to SOC using a LEO scanning electron microscope [TA, AP].

Coccolithophore composition (Light microscopy): Microscope enumeration of coccolithophores and coccoliths was done by filtering a 50 -150 ml water sample through a Millipore HA filter, rinsed with borate buffer, and frozen in a petri dish until counted (Haidar and Thierstein 2001; Haidar *et al*., 2000). Back in the laboratory, the filter will be placed on a glass microscope slide, and 60ºC Canada Balsam placed on top of the filter, followed by a cover slip. The clarified filter will be examined with an Olympus BH2 microscope equipped with polarization optics. Birefringent coccoliths and plated coccolithophores will then be counted. For statistical reasons, 200 coccoliths or cells will be counted from each sample, when available.

Biogenic Silica (BSi): A 500ml-1250ml sub-sample of seawater was taken for the analysis of BSi from 6-8 sampling depths. These depths always included the six light regime depths and for dawn casts two additional sub-euphotic depths were added, particularly if the water column was clear. The sample was vacuum-filtered onto 45mm 0.4 μm polycarbonate filters. These were then stored in small petri dishes at –20°C for analysis back at Southampton Oceanography Centre (SOC). At the SOC, the BSi will be dissolved with 2.5ml sodium hydroxide. This solution will be neutralised with 0.1mol l^{-1} hydrochloric acid, and concentrations will be determined using a flow autoanalyser [WB].

Photosynthetic parameters via FRRF: Discrete samples were collected from six light depths for laboratory Fast Repetition Rate Fluorometer (FRRF) measurements. Such complementary measurements were likely to be very important given the ambiguity in interpretation inherent with *in situ* FRRF data, and for analysis in conjunction with physiological parameters derive from the ^{14}C PvsE method. Samples were collected in every pre-dawn cast from the CTD rosette and quickly transferred to a controlled temperature laboratory on the ship. Samples were allowed to dark acclimate for >30 minutes before being placed in the dark chamber attached to the optical head of an FRRF in the Controlled Environment laboratory, cooled to *in situ* temperature. Blanks for these experiments were generated by filtering the sample through a 47mm GF/F followed by a 0.2 μm polycarbonate filter. The filtrate was then analysed using the FRRF set at the same gain as the sample run [AH].

Flow-through bio-optical system

This system operates semi-continuously, every 4 minutes it measures temperature, salinity, chlorophyll fluorescence, total backscattering at 543nm (bbtot), acidified backscattering (bbacid; backscattering of the seawater suspension after the pH has been lowered to dissolve calcium carbonate), acid labile backscattering (bb'; the difference between the bbtot and bbacid), absorption and attenuation at 9 visible wavelengths (made every 2 minutes), absorption and attenuation at 9 visible wavelengths after water was routed through 0.2μm filters (during intervening 2 minute segments). [WB]

Above-Water Radiance Measurements

In order to check the PIC algorithm performance, free of atmospheric error, water-leaving radiance, sky radiance and downwelling irradiance were measured from the bow of the *RRS Discovery* using a Satlantic SeaWiFS Aircraft Simulator (MicroSAS). The same wavelengths used in the 2-band and 3-band calcite algorithms were measured with the MicroSAS. The system consists of a down-looking radiance sensor and a sky-viewing radiance sensor, both mounted on the bow. A downwelling irradiance sensor was mounted far from any potentially shading structures, on the tallest mast of the RRS Discovery. These data were then used to estimate normalized water-leaving radiance as a function of wavelength. The radiance detector was set to view the water at 40° from nadir as recommended by Mueller *et al*. (2003b). Sensors were rinsed daily with MilliQ water in order to remove salt deposits and any dust. The water radiance sensor was able to view over an azimuth range of ~270^{o} across the ship's heading with no contamination from the ship's wake. The direction of the sensor was adjusted constantly to view the water 120^{o} from the sun's azimuth, to minimize sun glint. This was done using a computer-based system that calculated the sun's azimuth angle relative to the

ship's heading and elevation constantly. The system used a GPS to estimate the direction of the ship when underway. When on station, a compass on the bow was used to estimate ships direction, correcting for magnetic declination and variance. Pitch and roll sensors provided a means to filter out any measurements made from sub-optimal viewing geometries due to ship's roll. Depending on the ships course, the computer controlled a stepping motor that turned the sensors to the proper viewing angle. Protocols for operation and calibration were performed according to Mueller (Mueller *et al.*, 2003a,b,c). Before 1000h and after 1400h local time, data quality was poorer as the solar elevation decreased. Post-cruise, the 16Hz data will be filtered to remove as much residual white cap and glint as possible (we accept the lowest 5% of the data). When the ship was stopped on station, measurements will also be made. A plaque calibration was performed daily (using a 10% spectralon plaque) to check for instrument drift. [WB]

Description of measurements made

During AMT15 underway samples were collected about every 3-6 hours for particulate inorganic carbon and biogenic silica, particulate organic carbon and nitrogen, chlorophyll *a* and (occasionally) pigments. Water-column sampling during AMT15 concentrated around collection of the main core measurements from 6 light depths from the predawn CTD cast (~0200 – 0400h local time). BSi, PIC and cell count measurements were made on 8 depths from the 0200 cast, typically to 300m depth. The same measurements were made from a reduced set of depths from the late morning 'optics' cast (1100h local time).

(a) Underway

Table 1. Ships time, measurement(s) collected and personnel responsible each day of the cruise.

Time (local)	Measurement(s)	Person(s) responsible
0200	Morning CTD	
0700	PIC, BSi, POC, PON, cell counts, Chl (HPLC)	AP, WB
1100	PIC Optics cast	
1400	PIC, BSi, POC, PON, cell counts, Chl (HPLC)	AP, WB
2000	PIC, BSi, POC, PON, cell counts, Chl (HPLC)	AP, WB

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N
19-Sep	08:18	8	8	8	0.53	0818190904	0818190904
19-Sep	15:01	9	9	9	0.46	1501190904	1501190904
19-Sep	18:05	10	10	10	0.66	1805190904	1805190904
19-Sep	21:06	11	11	11	0.36	2106190904	2106190904
19-Sep	23:59	12	12	12	0.35	2359190904	2359190904
20-Sep	03:07	13	13	13	0.27	0307200904	0307200904
20-Sep	06:00	14	14	14	0.55	0600200904	0600200904
20-Sep	09:01	15	15	15	0.49	0901200904	0901200904
20-Sep	13.05	16	16	16	0.40	1305200904	1305200904
20-Sep	15.07	17	17	17	0.20	1507200904	1507200904
20-Sep	18.00	18	18	18	0.29	1800200904	1800200904
20-Sep	21.00	19	19	19	0.32	2100200904	2100200904
21-Sep	0:04	20	20	20	0.35	0004210904	0004210904
21-Sep	9:00	29	29	27		0900210904	0900210904
21-Sep	15:03	34	34	34		1503210904	1503210904
21-Sep	21:00	35	35	35		2100210904	2100210904
22-Sep	15.16	48	48	48	0.19	1516220904	1516220904

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N
22-Sep	21.20	49	49	49	0.29	2120220904	2120220904
23-Sep	8.55	58	58	58	0.12	0900230904	0900230904
23-Sep	15.02	65	65	65	0.16	1515230904	1515230904
23-Sep	20.40	66	66	66	0.09		
24-Sep	9.05	75	75	75	0.12	0905240904	0905240904
24-Sep	15.18	82	82	82	0.07	1518240904	1518240904
24-Sep	21.15	83	83	83	0.08	2115240904	2115240904
25-Sep	9.06	92	92	92	0.09	0900250904	0900250904
25-Sep	15.00	100	100	100		1500250904	1500250904
26-Sep	8.50	109	109	109	0.07	0850260904	0850260904
26-Sep	15.00	118	118	118	0.06	1500260904	1500260904
26-Sep	21.05	119	119	119	0.13	2105260904	2105260904
28-Sep	15.01	134	134	134	0.13	1501280904	1501280904
28-Sep	21.00	135	135	135			
29-Sep	9.00	144	144	144	0.14	0900290904	0900290904
29-Sep	15.02	151	151	151	0.15	1502290904	1502290904
29-Sep	21.15	152	152	152	0.23	2115290904	2115290904
30-Sep	9.05	159	159	159	0.73	0905300904	0905300904
30-Sep	15.43	166	166	166	12.68	1543300904	1543300904
1-Oct	9.01	179	179	179	0.38	0901011004	0901011004
1-Oct	15.15	186	186	186	0.39	1515011004	1515011004
2-Oct	9.09	199	199	199	1.91	0909021004	0909021004
2-Oct	15.00	212	212	212	1.06	1500021004	1500021004
3-Oct	8.59	219	219	219	0.49	0859031004	0859031004
4-Oct	8.43	229	229	229		0843041004	0843041004
4-Oct	15.06	236	236	236	0.16	1506041004	1506041004
4-Oct	21.00	245	245	245			
5-Oct	9.00	246	246	246	0.03	0900051004	0900051004
5-Oct	15.01	253	253	253	0.14	1501051004	1501051004
5-Oct	20.58	254	254	254			
6-Oct	9.02	263	263	263	0.14	0902061004	0902061004
6-Oct	15.00	270	270	270	0.19	1500061004	1500061004
7-Oct	9.03	279	279	279	0.22	0903071004	0903071004
7-Oct	14.58	286	286	286	0.15	1458071004	1458071004
8-Oct	15.04	295	295	295	0.10	1504081004	1504081004
8-Oct	19.47	296	296	296	0.08	1947081004	1947081004
9-Oct	8.34	305	305	305			
9-Oct	15.03	312	312	312	0.11	1503091004	1503091004
9-Oct	20.06	313	313	313	0.11	2006091004	2006091004
10-Oct	8.33	322	322	322			
10-Oct	15.00	329	329	329	0.13	1500101004	1500101004
10-Oct	20.58	330	330	330	0.13	2058101004	2058101004
11-Oct	7.58	331	331	331	0.13	0758111004	0758111004
11-Oct	14.58	338	338	338	0.09	1458111004	1458111004
11-Oct	20.53	339	339	339	0.10	2053111004	2053111004
12-Oct	8.59	349	349	349	0.11	0859121004	0859121004
12-Oct	14.48	356	356	356	0.14	1448121004	1448121004
12-Oct	20.06	357	357	357	0.12	2006121004	2006121004
13-Oct	9.10	365	365	365	0.08	0910131004	0910131004

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N
13-Oct	14.47	372	372	372	0.07	1447131004	1447131004
13-Oct	19.45	373	373	373	0.07	1945131004	1945131004
14-Oct	9.05	381	381	381	0.05	0905141004	0905141004
14-Oct	14.44	388	388	388	0.03	1444141004	1444141004
14-Oct	19.50	389	389	389	0.04	1950141004	1950141004
15-Oct	8.32	397	397	397	0.04	0832151004	0832151004
15-Oct	14.49	404	404	404	0.03	1449151004	1449151004
15-Oct	20.10	405	405	405	0.03	2010151004	2010151004
16-Oct	9.17	413	413	413	0.04	0917161004	0917161004
16-Oct	19.31	429	429	429	0.03	1931161004	1931161004
17-Oct	9.00	430	430	430	0.04	0900171004	0900171004
17-Oct	14.29	437	437	437	0.05	1429171004	1429171004
17-Oct	19.31	438	438	438	0.05	1931171004	1931171004
18-Oct	8.24	445	445	445		0824181004	0824181004
18-Oct	15.07	452	452	452	0.05	1507181004	1507181004
18-Oct	19.48	453	453	453	0.05	1948181004	1948181004
19-Oct	9.38	461	461	461	0.04	0938191004	0938191004
19-Oct	15.00	468	468	468	0.05	1500191004	1500191004
19-Oct	21.00	469	469	469	0.04	2100191004	2100191004
20-Oct	7.03	477	477	477	0.05	0703201004	0703201004
20-Oct	14.59	484	484	484	0.05	1459201004	1459201004
20-Oct	19.56	485	485	485	0.04	1956201004	1956201004
21-Oct	7.52	493	493	493	0.07	0752211004	0752211004
21-Oct	15.19	500	500	500	0.07	1519211004	1519211004
21-Oct	18.33	501	501	501	0.08	1833211004	1833211004
22-Oct	6.01	509	509	509	0.05	0601221004	0601221004
22-Oct	14.03	516	516	516	0.08	1403221004	1403221004
22-Oct	18.34	517	517	517	0.08	1834221004	1834221004
23-Oct	6.01	525	525	525	0.12	0601231004	0601231004
23-Oct	14.00	532	532	532	0.29	1400231004	1400231004
23-Oct	18.37	533	533	533	0.35	24-10-4 1	24-10-4 2
24-Oct	6.16	542	542	542	0.44	24-10-4 3	24-10-4 4
24-Oct	13.46				0.51	24-10-4 5	24-10-4 6
24-Oct	14.43	549	549	549	0.58	1443241004	1443241004
24-Oct	18.34	550	550	550	0.49	1834241004	1834241004
25-Oct	5.39	559	559	559	0.49	0539251004	0539251004
25-Oct	15.34	566	566	566		1534251004	1534251004
25-Oct	18.47	567	567	567	0.44	1847251004	1847251004

(b) CTD stations

Table 2. Stations (CTD cast number) sampled and measurement(s) made. Abbreviations used are PP (primary production or carbon-fixation), $Ca^{14}CO_3$ (calcification or inorganic carbon fixation), SIS (simulated in situ ^{14}C uptake incubations), BSi (particulate biogenic silica), PIC (particulate inorganic carbon), SEM (samples for scanning electron microscopy), PvsE (^{14}C light response curves) and FRRF (discrete FRRF measurements). Note: * core measurements are chlorophyll (total), pigments, HPLC, PABS and POC/N.

CTD No.	Date	Core	HPLC B	SF CHL	SEM	Lugols & Formalin	$Ca^{14}CO_3$	DOC/N/P	BSi, PIC	SiS	P vs E	FRRF
2	19-Sep	X	X	X	X			X	X			X
6	21-Sep	X	X		X			X	X			X
7	21-Sep	X							X			
9	22-Sep	X	X	X	X	X		X	X	X		X
10	22-Sep	X	X						X			
12	23-Sep	X	X		X			X	X		X	X
13	23-Sep	X							X			
15	24-Sep	X	X		X	X		X	X	X	X	X
16	24-Sep	X							X			
18	25-Sep	X	X		X	X		X	X		X	X
19	25-Sep	X							X			
21	26-Sep	X	X	X	X			X	X	X	X	X
22	26-Sep	X							X			
24	27-Sep	X	X		X	X		X	X			X
25	28-Sep	X							X			
27	29-Sep	X		X	X	X	X	X	X	X	X	X
28	29-Sep	X							X			
30	30-Sep	X	X	X	X	X		X	X	X		X
31	30-Sep	X							X			
32	30-Sep	X	X						X			
34	1-Oct	X	X		X	X	X	X	X	X		X
35	1-Oct	X							X			
36	1-Oct	X	X			X			X			
38	2-Oct	X	X		X	X		X	X			X
39	2-Oct	X							X			
40	2-Oct	X	X			X			X			
41	3-Oct	X	X		X	X			X			X
44	4-Oct	X	X		X			X	X			
45	4-Oct	X							X			
47	5-Oct	X	X		X			X	X			X
48	5-Oct	X							X			
50	6-Oct	X	X		X			X	X			X
51	6-Oct	X							X			
53	7-Oct	X	X		X	X		X	X			X
54	7-Oct	X							X			
56	8-Oct	X	X	X	X	X			X		X	X
58	9-Oct	X	X	X	X		X	X	X	X	X	X
59	9-Oct	X							X			
61	10-Oct	X	X	X	X	X		X	X	X	X	X
62	10-Oct	X							X			
63	11-Oct	X							X			
65	12-Oct	X	X	X	X	X		X	X	X	X	X

CTD No.	Date	Core	HPLC B	SF CHL	SEM	Lugols & Formalin	$Ca^{14}CO_3$	DOC/N/P	BSi, PIC	SiS	P vs E	FRRF
66	12-Oct	X							X			
68	13-Oct	X	X	X	X			X	X		X	X
69	13-Oct	X							X			
71	14-Oct	X	X	X	X			X	X	X	X	X
72	14-Oct	X							X			
74	15-Oct	X		X	X	X	X		X		X	X
76	16-Oct	X	X									
77	16-Oct			X	X	X		X	X	X		X
78	16-Oct	X							X			
79	17-Oct	X			X			X	X		X	X
80	17-Oct	X							X			
81	18-Oct	X	X									
82	18-Oct			X	X	X		X	X	X	X	X
83	18-Oct	X							X			
84	19-Oct	X	X									
85	19-Oct			X	X	X	X	X	X		X	X
86	19-Oct	X							X			
87	20-Oct	X	X	X	X	X		X	X			X
89	20-Oct	X							X			
90	21-Oct	X	X					X				
91	21-Oct			X	X	X			X	X	X	X
92	21-Oct	X						X	X			
94	22-Oct	X		X	X				X		X	X
95	22-Oct	X							X			
96	23-Oct	X	X	X	X	X		X	X		X	X
98	23-Oct	X							X			
100	24-Oct	X	X	X	X	X	X	X	X	X	X	X
101	24-Oct	X							X			
103	25-Oct	X	X	X	X	X		X	X		X	X
104	25-Oct	X							X			
105	26-Oct	X	X	X	X	X			X			

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Micro- and mesozooplankton grazing

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Background

Current knowledge would predict that in oligotrophic systems most energy flow circulates within the microbial loop, whereas in more productive areas, characterised by larger primary producers, mesozooplankton and sedimentation play the major role in carbon export. However, there might be serious flaws in these arguments. Mesozooplankton is being defined here as the fraction of zooplankton retained by a net with a mesh-width of 200µm and is the far most studied zooplankton fraction. Contemporary studies evidence that small zooplankton (not retained by the 200µm net), including nauplii and small copepods, are major contributors to oceanic zooplankton biomass.

However, they have been omitted in most studies and predictive models, giving an uncertainty in the actual grazing control that "total" zooplankton is having upon the primary production (PP). Furthermore and contrarily to conventional wisdom, recently developed empirical models and cross-ecosystem studies (Calbet, 2001) predict that the impact of mesozooplankton grazing is proportionally higher in oligotrophic systems (~40% of PP) than in highly productive areas (~10% of PP). This unexpected result suggests that mesozooplankton play a more important role in oligotrophic systems than thought before, with up to 40% of primary production bypassing the microbial loop. In such systems the energy transfer may become more efficient, making picoplanktonic carbon prone to potential export through faecal pellet sinking.

One of the main objectives of the AMT programme is to determine how the structure, functional properties and trophic status of the major planktonic ecosystems vary in space and time. Our study will contribute to this task by resolving the tight relationships between structural and functional properties of the planktonic system under different oceanic regimes. This knowledge will help to understand the fate of primary production, which is the role of size spectra and mineralization capacity of planktonic organisms as major determinants of CO_2 and organic matter export to the atmosphere and deep water.

Objectives

- Determine the structure of the zooplankton community by 200m vertical hauls with 63µm and 200µm plankton nets.
- Estimate the zooplankton grazing impact on different components of the microbial community by incubation experiments.
- Obtain depth integrated abundances of picoplankton (*Prochlorococcus*, *Synecococcus* and heterotrophic bacteria), nanoplankton (autotrophic and heterotrophic flagellates), and microplankton community (large flagellates, diatoms, dinoflagellates, ciliates and small protozoans).

Methods

1) Nets

Every night between 02:00 and 03:00 approximately, two consecutive vertical hauls were done with 63µm and 200µm double WP-2 plankton-nets. Every second day when the grazing experiment was conducted an additional vertical net was done to obtain live animals for the incubations. For the living sample a 5 to 10 l plastic bag was used as a non-filtering cod end to minimise organism damage and reduce sampling stress (Table 1).

The nets were towed up at 10 m min^{-1} (live sample) and 30m min^{-1} (fixated sample, 4% buffered formaldehyde) respectively.

The live animals were placed into 5 l plastic beakers and used for the grazing experiments.

2) Grazing experiments

Experimental incubations with pre-screened seawater were used to determine, by cell disappearance, the grazing rates of two zooplankton size fractions on the different components of the microbial community (Table 2).

The experimental water was collected from the deep chlorophyll maximum (DCM) from the monster dawn cast at 02:00. It was poured into a 50 l bucket and reverse-flow screened with a 100 µm mesh sieve to remove major grazers. To override nutrient enrichment effects due to zooplankton excretion in the experimental bottles, the water had been previously amended with a nutrient mixture of 15 µM NH_4Cl and 1 µM Na_2HPO_4.

Plastic bottles of 4l were filled with the natural suspension and incubated for *ca.* 24 hours in an on-deck incubator covered with a screen simulating 1% surface irradiance. A continuous flow of surface water through the incubator kept the temperature constant. Three aliquots of zooplankton were prepared with each of the two live samples. For the microzooplankton fraction, animals between 63µm - 200µm were obtained by reverse-flow screen with a 200 µm mesh. Each experiment consisted of 3 experimental bottles (for both the micro- and mesozooplankton fraction), 3 control bottles (without grazers) and 2 initial bottles.

To estimate the biomass of zooplankton added in each treatment, 3 aliquots (30 ml) of the micro and mesozooplankton sample were fixed in formaldehyde 4%. Other three aliquots were filtered onto Whatmann GF/A to estimate the carbon and nitrogen content of the sample.

Initial and final subsamples were taken to determine the different components of the microbial communities. Phytoplankton pigments (Chl *a*) were measured by filter aliquots onto GF/F Whatmann and 5µm pore-size polycarbonate membrane filters under a low vacuum pressure. The filters were analysed fluorometrically after an acetone extraction which was done on board.

Bacteria and picoplankton subsamples of 2 ml were preserved in paraformaldehyde + gluteraldehyde (1% + 0.05% final concentration, respectively) and stored at -80ºC for flow cytometry analysis. For nanoflagellate abundance 250 ml samples were preserved in gluteraldehyde (1% final concentration) for 3 to 6 hours (4ºC dark) and filtered (< 100 mm Hg) onto 0.8 µm and 2.0 µm pore-size black polycarbonate membrane filters. When 5 ml remain to filter, the solution was stained with DAPI (5 µg ml^{-1} final concentration) for 5 min. The filters were mounted on glass slides with low fluorescence immersion oil and examined by epifluorescence microscopy. Subsamples of 200 ml were preserved with 1% acid Lugol's solution for dinoflagellates and ciliates analyses.

To estimate the "real" initial chlorophyll concentration in the experimental bottles after adding the zooplankton, aliquots were also taken at the beginning of the experiment and filtered onto Whatmann GF/F and 5µm pore-size polycarbonate membrane filters.

To assess the possible effect of the nutrient addition on the phytoplankton community, parallel experiments were done. 3 bottles of 625 ml were filled with the non-nutrient enriched pre-screened water and other 3 bottles were filled with the enriched water. Samples were filtered to determine the chlorophyll concentration.

3) Vertical profile

The same day of the experiment, approximately 2 l water samples were taken from the pre-dawn cast at 7 different depths to obtain a depth integrated microplankton composition. Samples were taken for picoplankton (1% paraformaldehyde), nanoplankton (10% gluteraldehyde) and microzooplankton enumeration (acidic Lugol's solution, 2% final concentration) (Table 3).

Samples for microzooplankton community were taken for Paul Hampton from the pre-dawn cast at 7 depths in all stations (Table 4).

Preliminary results

There was significant difference in the amount of plankton found in the nets in the different oceanic regions. There were fewer and generally smaller animals in the oligotrophic regions compared to a more abundant and apparent diverse sample in the upwelling waters.

In the grazing experiments we saw different trends. In general, there was a decrease in the total chlorophyll between the control and both fractions of zooplankton suggesting that both sizes of zooplankton can graze upon prey smaller than 100 µm. For the size fractionated chlorophyll there was no clear trend. Sometimes it was possible to detect grazing by both fractions, or just by the small one, and occasionally we could not detect any change. Is important to mention that on 3 experiments we could not get any difference between the controls and the experimental bottles suggesting that the heterotrophic fraction is more important on these oceanic regions than the autotrophic (measured by chlorophyll).

Table 1. Microzooplankton (63 µm) vertical hauls. The mesozooplankton vertical tows were included as part of A. Peralba-Marco report.

Date	Sample Code	A/D	Depth (m)
19-Sep-04	Zoop-01	D	55
21-Sep-04	Zoop-02	A/D	125
22-Sep-04	Zoop-03	D	200
23-Sep-04	Zoop-04	A/D	200
24-Sep-04	Zoop-05	D	200
25-Sep-04	Zoop-06	A/D	200
26-Sep-04	Zoop-07	D	200
27-Sep-04	Zoop-08	D	200
29-Sep-04	Zoop-11	A/D	200
30-Sep-04	Zoop-12	D	200
1-Oct-04	Zoop-13	A/D	150
2-Oct-04	Zoop-14	D	50
3-Oct-04	Zoop-15	A/D	200
4-Oct-04	Zoop-16	D	200
5-Oct-04	Zoop-17	A/D	200
6-Oct-04	Zoop-18	D	200
7-Oct-04	Zoop-19	D	200

Date	Sample Code	A/D	Depth (m)
8-Oct-04	Zoop-20	A/D	200
9-Oct-04	Zoop-21	D	200
10-Oct-04	Zoop-22	D	200
12-Oct-04	Zoop-24	A/D	200
13-Oct-04	Zoop-25	D	200
14-Oct-04	Zoop-26	A/D	200
15-Oct-04	Zoop-27	D	200
16-Oct-04	Zoop-28	A/D	200
17-Oct-04	Zoop-29	D	200
18-Oct-04	Zoop-30	A/D	200
19-Oct-04	Zoop-31	D	200
20-Oct-04	Zoop-32	A/D	200
21-Oct-04	Zoop-33	D	200
22-Oct-04	Zoop-34	A/D	200
23-Oct-04	Zoop-35	D	200
24-Oct-04	Zoop-36	A/D	200

D: fixed sample; A: alive sample

Table 2. Grazing experiments.

Date	Sample Code	Grazing Experiment	DCM (metres)	CTD
21-Sep-04	Zoop-03	Exp-01	50	05
23-Sep-04	Zoop-05	Exp-02	69	11
25-Sep-04	Zoop-07	Exp-03	98	17
29-Sep-04	Zoop-11	Exp-04	53	26
1-Oct-04	Zoop-13	Exp-05	50	33
3-Oct-04	Zoop-15	Exp-06	45	41
5-Oct-04	Zoop-17	Exp-07	50	46
8-Oct-04	Zoop-20	Exp-08	50	55
12-Oct-04	Zoop-24	Exp-09	100	64
14-Oct-04	Zoop-26	Exp-10	140	70
16-Oct-04	Zoop-28	Exp-11	170	76
18-Oct-04	Zoop-30	Exp-12	180	81
20-Oct-04	Zoop-32	Exp-13	145	87
22-Oct-04	Zoop-34	Exp-14	75	93
24-Oct-04	Zoop-36	Exp-15	40	99

Table 3. Vertical profile.

Date	Sample Code	CTD	Depth (m)						
29-Sep-04	Zoop-11	27	50	40	25	20	15	10	Surface
1-Oct-04	Zoop-13	34	50	40	25	20	15	10	Surface
3-Oct-04	Zoop-15	42	45	30	20	15	10	5	Surface
5-Oct-04	Zoop-17	47	50	30	20	15	10	5	Surface
8-Oct-04	Zoop-20	56	150	110	75	50	20	10	Surface
12-Oct-04	Zoop-24	65	150	100	70	45	35	15	Surface
14-Oct-04	Zoop-26	70	140	125	60	50	35	20	Surface
16-Oct-04	Zopp-28	77	250	170	80	45	30	25	Surface
18-Oct-04	Zoop-30	82	275	180	140	85	50	30	Surface
20-Oct-04	Zoop-32	88	180	150	125	60	35	20	Surface
22-Oct-04	Zoop-34	94	125	100	45	35	25	15	Surface
24-Oct-04	Zoop-36	99	50	40	30	20	10	5	Surface

Table 4. Vertical profile for P. Hampton.

Date	Sample Code	CTD	Depth (m)						
19-Sep-04	01	02	Surface	10	25	35	50	100	140
21-Sep-04	03	06	Surface	10	35	50	100	200	300
22-Sep-04	04	09	Surface	5	15	25	60	75	300
23-Sep-04	05	12	Surface	10	15	30	75	110	150
24-Sep-04	06	15	Surface	10	15	50	75	110	300
25-Sep-04	07	18	Surface	15	25	50	120	150	300
26-Sep-04	08	21	Surface	15	30	55	115	180	300
27-Sep-04	09	24	Surface	15	30	55	115	180	300
29-Sep-04	11	27	Surface	10	15	25	50	75	300
30-Sep-04	12	30	Surface	5	10	15	30	50	300
1-Oct-04	13	34	Surface	10	15	20	25	50	300
2-Oct-04	14	38	Surface	5	10	15	25	35	60
3-Oct-04	15	42	Surface	5	10	20	30	45	300
4-Oct-04	16	44	Surface	10	15	30	70	100	300
5-Oct-04	17	47	Surface	5	10	30	50	300	
6-Oct-04	18	50	Surface	10	15	25	60	200	
7-Oct-04	19	53	Surface	10	15	25	60	300	
8-Oct-04	20	56	Surface	10	20	30	75	300	
9-Oct-04	21	58	Surface	10	20	30	75	110	300
10-Oct-04	22	61	Surface	10	15	30	65	100	300
12-Oct-04	24	65	Surface	15	25	45	100	300	
13-Oct-04	25	68	Surface	15	30	55	125	180	300
14-Oct-04	26	71	Surface	20	35	60	140	300	
15-Oct-04	27	74	Surface	25	45	80	170	250	300
16-Oct-04	28	77	Surface	25	30	45	170	300	
18-Oct-04	30	82	Surface	30	50	85	180	300	
19-Oct-04	31	85	Surface	20	40	70	100	150	300
20-Oct-04	32	88	Surface	20	35	60	150	300	
22-Oct-04	34	94	Surface	15	25	45	150	300	
23-Oct-04	35	97	Surface	10	20	35	85	120	300
24-Oct-04	36	100	Surface	5	10	20	40	300	
25-Oct-04	37	103	Surface	5	10	20	45	100	300
26-Oct-04	38	105	Surface	10	20	30	75	110	300

Samples were concentrated to 1 l

Reference

Calbet A. 2001. Mesozooplankton grazing effect on primary production: a global comparative analysis in marine ecosystems. Limnology and Oceanography 46, 1824-1830.

Micro- and nano-molar nutrients

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Objective

To study the spatial and temporal variations in the concentrations of inorganic nutrients (nitrate plus nitrite, nitrite, silicate, phosphate and ammonium), which will contribute to AMT Objective 2, Hypotheses 5 and 6.

Two analytical systems were used: the Bran and Luebbe Autoanalyser III (AAIII), this is a classic colorimetric nutrient autoanalyser that measures micromolar nutrient concentrations; and Waveguide Capillary Cells used for nanomolar measurements of nitrate plus nitrite, nitrite, nitrite and phosphate.

Generally, Plymouth Marine Laboratory measures nano molar ammonium. However, due to unforeseen circumstances the person responsible for this work was unable to join the ship, and thus no nano-molar ammonium measurements have been made. Also, two people are required to measure nutrients and despite being a person down this work was achieved with various help from reliable colleagues, a special thanks to them at the end of this report.

Technical difficulties were experienced with the waveguides during the first week of the cruise. These were fully resolved.

Methodology

The Bran and Luebbe AAIII consists of five channels that measure micromolar nitrite, nitrate plus nitrite, ammonium, silicate and phosphate. This machine is now into its fourth consecutive AMT cruise. Provisional data analysis was made during the cruise, for contour plots of nitrate and silicate.

Nanomolar nitrate plus nitrite, nitrite and phosphate were determined using Waveguide Capillary cells made by World Precision Instruments, USA. A waveguide is composed of a 2m capillary cell with a small inner diameter. A light source is directed through fibre optics into the waveguide and a fibre optic out of the waveguide is connected to a detector box. The absorbency signal is then amplified and recorded onto chart paper.

CTD samples were taken from the predawn and mid-morning casts. CTD water samples were taken from a 24 x 20 litre CTD/Rosette system during the predawn cast and from the titanium 24 x 10 litre CTD/Rosette system during the mid-morning cast. Prior to sampling, sample bottles and the sample tube were MilliQ washed. Gloves were worn at all times during sampling. Waveguide samples were collected first into 120 ml Nalgene bottles. Waveguide samples were analysed within three hours. The micro-molar samples were collected into 60 ml Nalgene bottles and analysed within two hours.

Stock solutions were made before leaving Southampton. Fresh sub and working stocks were made for each machine for each cast. No samples have been frozen.

Underway sampling

Nutrient underway samples were only taken from 15 hours ship time and only when the waveguide was operational. This underway-sampling time was coordinated with other measurements, i.e. chlorophyll.

Results

The Bay of Biscay is a region of frontal zones that exhibit high nutrient concentrations where micromolar ammonium is detectable. As we progressed southward into the Northern gyre and more oligotrophic waters, the concentrations became significantly reduced in conjunction with the deepening of the chlorophyll maxima. During the traverse of coastal upwelling off Morocco, surface nitrate plus nitrite was 1–2 μm and 30 μm at 30 m. When we left the coastal waters and resumed a southward track, the waters became briefly oligotrophic, surface nitrate plus nitrite less than 1 μm. We were fortunate to sample through the Guinea Dome, prior the Equatorial Upwelling. This combined zone lasted from 17°N to 5°S and exhibited low surface nutrient concentrations with progressively higher nitrate plus nitrite, silicate and phosphate with increasing depth. As we moved into the Southern Gyre, and more oligotrophic waters, nitrate plus nitrite, and nitrite would remain a few nanomoles until the deep chlorophyll maxima, then nitrite would show its peak and nitrate plus nitrite would become micromolar. South of 35°S the prominent thermocline had vanished and the chlorophyll maxima was shallower, the nitrite maxima also became shallower. The last part of the journey took us into the roaring 40's. The Sub Antarctic waters were well mixed and the surface nitrite had values of 1 μm and nitrate plus nitrite of around 4 μm.

On return to Plymouth Marine Laboratory Katie Chamberlain and Malcolm Woodward will jointly quality assure the data before submitting to British Oceanographic Data Centre.

CTDs sampled and analysed

Table 1 All water samples were analysed for nano and micromolar nitrate plus nitrite, nitrite, silicate and phosphate, unless otherwise stated. Micro molar ammonium was only analysed for CTDs 2 – 5.

Date	CTD number	CTD bottle	Comments
19/09/04	2	24, 19, 15, 13, 8, 6, 4, 1	Micromolar only
19/09/04	3	Cancelled	
20/09/04	4	5, 3, 1	
21/09/04	6	24, 20, 16, 13, 9, 7, 5, 4, 3, 2, 1	
21/09/04	7	23, 21, 18, 16, 12, 10, 3, 2, 1	
22/09/04	9	24, 20, 16, 13, 11, 8, 6, 5, 3, 2, 1	
22/09/04	10	23, 22, 21, 17, 16,14, 10, 8, 5, 3, 2, 1	
23/09/04	12	24, 20, 15, 12, 11, 7, 6, 4, 3, 2, 1	
23/09/04	13	23, 22, 21, 17, 16, 15, 10, 9, 8, 5, 3, 1	
24/09/04	15	24, 20, 16, 14, 11, 7, 6, 4, 3, 2, 1	
25/09/04	18	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
25/09/04	19	23, 22, 19, 17, 16, 10, 8, 6, 5, 3, 2, 1	Micromolar only
26/09/04	21	24, 20, 16, 12, 11, 7, 8, 6, 4, 3, 2, 1	
26/09/04	22	23, 22, 19, 17, 16, 10, 9, 6, 5, 3, 2, 1	
27/09/04	24	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
28/09/04	25	23, 22, 19, 17, 16, 13, 10, 9, 5, 3, 2, 1	
29/09/04	27	24, 20, 16, 12, 11, 7, 5, 4, 3, 2, 1	
29/09/04	28	24, 22, 19, 17, 16, 13, 11, 5, 4, 3, 2, 1	
30/09/04	30	24, 20, 16, 13, 12, 8, 7, 5, 4, 3, 2, 10	
30/09/04	32	22, 18, 14, 10, 6, 2	Micromolar only
01/10/04	34	24, 20, 16, 15, 12, 11, 7, 6, 4, 3, 2, 1	Micromolar only
01/10/04	35	24, 22, 19, 15, 13, 10, 9, 8, 6, 5, 3, 2, 1	Micromolar only
01/10/04	36	21, 17, 13, 9, 5, 1	Micromolar only
02/10/04	38	24, 20, 16, 13, 11, 7, 5, 3, 1	Micromolar only
02/10/04	39	23, 21, 19, 17, 16, 15, 13, 11, 9, 8, 6, 5, 3, 2, 1	Micromolar only
02/10/04	40	23, 21, 17, 13, 9, 5, 1	Micromolar only
03/10/04	42	24, 20, 16, 15, 11, 10, 6, 5, 3, 2, 1	Micromolar only
04/10/04	44	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	Micromolar only

Date	CTD number	CTD bottle	Comments
04/10/04	44	23, 21, 19, 17, 14, 13, 10, 9, 8, 6, 5, 3, 2, 1	
05/10/04	47	24, 20, 16, 12, 11, 7, 5, 4, 3, 2, 1	
05/10/04	48	23, 22, 19, 17, 15, 13, 10, 9, 8, 6, 5, 3, 2, 1	
06/10/04	50	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
06/10/04	51	23, 22, 19, 17, 15, 13, 10, 9, 8, 6, 5, 3, 2, 1	
07/10/04	53	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
07/10/04	54	23, 22, 19, 17, 15, 13, 10, 9, 8, 6, 5, 3, 2, 1	
08/10/04	56	24, 20, 15, 11, 10, 6, 4, 3, 2, 1	
9/10/04	58	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
09/10/04	59	23, 22, 19, 17, 16, 15, 13, 10, 8, 6, 5, 3, 2, 1	
10/10/04	61	24, 20, 16, 12, 11, 7, 6, 4, 3, 2, 1	
10/10/04	62	23, 22, 19, 17, 15, 13, 10, 9, 8, 6, 5, 3, 2, 1	
11/10/04	63	23, 22, 19, 17, 15, 13, 10, 9, 8, 7, 5, 3, 2, 1	
12/10/04	65	24, 20, 16, 13, 12, 11, 7, 6, 4, 3, 2, 1	
12/10/04	66	23, 22, 19, 17, 16, 14, 13, 12, 10, 8, 5, 3, 2, 1	
13/10/04	68	24, 20, 16, 15, 12, 11, 10, 9, 6, 5, 3, 2, 1	
13/10/04	69	23, 22, 19, 17, 14, 13, 12, 10, 9, 6, 5, 3, 2, 1	
14/10/04	71	24, 21, 19, 15, 14, 11, 10, 9, 5, 4, 2, 1	
14/10/04	72	23, 21, 19, 17, 16, 14, 13, 12, 9, 8, 5, 3, 2, 1	
15/10/04	74	24, 21, 19, 15, 14, 11, 10, 5, 4, 2, 1	
15/10/04	75	24, 22, 19, 17, 16, 14, 12, 9, 8, 7, 4, 2, 11, 1	
16/10/04	77	24, 22, 20, 18, 15, 14, 11, 10, 5, 4, 2, 1	
16/10/04	78	23, 21, 18, 15, 13, 11, 10, 8, 6, 5, 3, 16, 12, 7, 4	
17/10/04	80	23, 21, 20, 17, 16, 13, 12, 10, 9, 8, 5, 3, 2, 1	
18/10/04	82	24, 21, 19, 15, 14, 11, 10, 9, 5, 4, 2, 1	
18/10/04	83	23, 21, 19, 17, 16, 14, 10, 9, 8, 7, 5, 3, 2, 1	
19/10/04	85	24, 21, 18, 15, 14, 11, 10, 9, 4, 3, 2, 1	
19/10/04	86	23, 21, 20, 17, 16, 14, 12, 10, 9, 8, 5, 3, 2, 1	
20/10/04	88	24, 21, 19, 15, 12, 11, 10, 6, 5, 4, 2, 1	
20/10/04	89	23, 21, 20, 17, 16, 13, 12, 10, 8, 7, 5, 3, 2, 25	
21/10/04	91	24, 21, 19, 15, 12, 11, 10, 6, 5, 3, 2, 1	
21/10/04	92	24, 21, 19, 15, 12, 11, 10, 6, 5, 3, 2, 1	
22/10/04	94	1, 22, 20, 16, 12, 11, 7, 6, 4, 3, 2	
22/10/04	95	2, 21, 20, 17, 16, 14, 12, 23, 11, 7, 9, 8, 6, 5	
23/10/04	97	24, 20, 16, 13, 12, 8, 7, 5, 4, 3, 2, 1	
23/10/04	98	23, 21, 20, 17, 14, 13, 12, 10, 8, 7, 5, 3, 2, 1	
24/10/04	100	24, 20, 16, 13, 12, 8, 7, 5, 4, 3, 2, 1	Micromolar only
24/10/04	101	23, 21, 20, 17, 16, 13, 10, 9, 8, 7, 5, 3, 2, 1	Micromolar only
25/10/04	103	24, 20, 16, 13, 12, 8, 6, 4, 3, 2, 1	Micromolar only
25/10/04	104	23, 21, 20, 17, 16, 14, 13, 12, 8, 7, 5, 3, 2, 1	Micromolar only

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Prochlorococcus communities and their co-occurring viruses

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Objectives:

1. To collect DNA samples for analysing the genetic relatedness between populations of the cyanobacteria, *Prochlorococcus*, over geographic distance and down the light gradient in the Atlantic Ocean.
2. Determine genetic variation (and possible infectivity) of bacteriophages over geographic distance and down the light gradient in the Atlantic Ocean by:
   i. Collecting viable *Prochlorococcus* bacteriophages.
   ii. Investigating whether the *in situ Prochlorococcus* bacteriophage population is capable of infecting and lysing established *Prochlorococcus* cultures.
3. To determine bacterioplankton composition in different provinces and seasons using ACF and molecular identification.

Methodology:

1. 7 litres of seawater from the pre-dawn CTDs from four depths (55%, 33%, 14% and 1% light depths) were filtered through 2.2 µm sterivex filters. Additional samples were also taken in the gyres (Table 1). The water was forced through the filters with a peristaltic pump at 400 rpm and 2½ litres of the filtrate were retained from each depth. Once 7 litres had been processed, as much water as possible was extracted from the filter cartridges, the ends closed with blue tack and the filters frozen immediately in liquid nitrogen. The filters were then stored in the –80˚C freezer.
2. 5ml of each of the four light depths, 55%, 33%, 14% and 1%, from the pre-dawn CTD was pipetted into a cryovial and stored at 4˚C. The cryovials should contain a natural concentration of viable viruses for use back at PML.

   The sterivex filtrate contains no cells, due to the size of the filter pores, whilst still containing the majority of viruses. 0.5 litres of the sterivex filtrate was used to clean and condition the 50,000 MWCO (50 kD) tangential flow unit. After conditioning the remaining 2 litres was filtered and concentrated down to 8-12 ml. Water was concentrated from each of the 4 light depths. The tangential flow concentrate was then placed into a length of pre-conditioned dialysis membrane and both ends secured. A tray with was covered with absorbent paper and 4 piles of 10 ml Polyethylene Glycol (PEG) placed on it. A dialysis membrane was placed onto each pile of PEG and then covered with a further 5 ml of PEG. The membranes were left in the PEG for 3-5 hours at 4˚C. The PEG draws out water from the membranes and any particles with a molecular weight greater than 14,000 (including viruses) are retained in the membrane. When the volume in the membrane was reduced to less than 2 ml it was removed from the PEG. The outside of the membrane was rinsed and then the contents transferred to 2 ml eppendorf tubes. The eppendorfs were then stored at 4˚C.

   Established cultures of high light and low light *Prochlorococcus* strains and three *Synechococcus* strains were brought on board and kept in an incubator with blue light at 24˚C. These were then subcultured every four days into two sets of fresh media. Whilst the strains were healthy two test tubes of each culture were prepared. Seawater (5 ml of 33% and 1% light depth water from the pre-dawn CTD) was filtered through a 1 µm filter to remove large grazers. One test tube of each culture was retained as a control and 0.5 ml of the filtered seawater added to the other. For the high light strain of *Prochlorococcus*, water from the 33% light depth was used and 1% light depth water for the low light strains. For *Synechococcus* one tube with water from 33% light and one from 1% light were prepared. Inoculated test tubes were placed in racks in the incubator and left for 2-6 days. Lysis of the inoculated culture would indicate possible viral activity. 5ml of any inoculated cultures that lysed (bleached) was retained and stored at 4˚C.

Samples

Table 1. Additional samples taken in the gyres

Date	CTD number	Additional depth
25/09/04	18	120m
26/09/04	21	80m, 150m
27/09/04	24	150m
13/10/04	68	150m
14/10/04	71	160m
15/10/04	74	200m
16/10/04	77	200m

Results

1. 14 1 frozen sterivex filters were produced on the cruise with some additional samples processed in the gyres. The DNA from these samples will be analysed at PML.
2. There are 14 1 eppendorfs each containing water concentrated 1000 fold and 143 cryovials containing unfiltered seawater stored at 4˚C. Any viable viruses from these samples will be used to carry out lysis experiments on *Prochlorococcus*. *Prochlorococcus* viruses will be genetically sequenced by Ellie Harrison during her PhD at PML
3. During the first night on-board a problem with the incubator meant that the temperature rose from the ideal 23˚C up to 40˚C thus killing the *Prochlorococcus* cultures. A back-up culture was brought from PML but unfortunately because these were less vigorous than the original cultures they began to bleach and were too pale for use by 26/09/04. Thus it was not possible to perform the lysis experiment.

Bio-optics

LORRAINE HAY
University of Strathclyde/Plymouth Marine Laboratory

Cruise Objectives

The main objectives of this AMT cruise were to continue the bio optical work carried out on AMT12, 13 and 14. To this end the main goals are to:

- Determine the apparent and inherent optical properties, pigment composition and photosynthetic parameters from *in-situ* measurements.
- Interrelate *in-situ* parameters and determine algorithms for phytoplankton pigments, species composition and CDOM.
- Interrelate *in-situ* parameters and determine algorithms for photosynthetic growth rate parameters.
- Apply algorithms to remotely sensed data (ocean colour and SST) and validate for the Atlantic Ocean.

Instrumentation

The following equipment was deployed during AMT15.

Satlantic HyperPro. The Satlantic HyperPro was deployed as a surface floating radiometric system during the course of AMT15. The optical properties measured during the cruise consisted of above surface downwelling irradiance, $E_d(0^+)$, and upwelling radiance just below the surface, $L_u(0^-)$. The HyperPro is a hyperspectral radiometer and records optical data in the wavelength region between 350 and 800 nm. Calibration of the optical sensors was carried out a Strathclyde University prior to the cruise and will also be carried out upon return to the laboratory.

Wetlabs AC9 Plus. This instrument is used to measure the inherent optical properties of absorption and attenuation over nine wavelengths (412, 440, 488, 510, 532, 555, 650, 676, 750 nm). The AC9Plus is a profiling instrument that allows the absorption and attenuation coefficients to be measured at different depths in the water column.

Wetlabs VSF. This instrument is a backscattering meter and measures scattering at three discrete angles (100, 125 and 150 degrees). The measurement of the change in angular scattering is key to relating water reflectance at the different sun and view angles that are found in ocean colour observations.

SeaBird SBE 19Plus CTD. Employed to measure the hydrographical features of the water column, the data from the CTD is also used to correct the AC9 Plus data for the effects due to changes in salinity and temperature.

Satlantic Optics. These optical sensors were used to make profiling measurements of E_d and L_u throughout the water column. This optical data was recorded at the following wavelengths 412, 443, 490, 510, 555, 670 and 765 nm. These wavelengths correspond to the SeaWiFS satellite channels.

Fast repetition rate fluorometer (FRRF). The FRRF can measure the absorption cross section of photosystem 2, the quantum yield and the rate of photosynthetic electron transport.

Instrument Deployment and Performance

The optics instruments were deployed daily at 11am, local time, during the course of the cruise. The optics cast consisted, when sea state permitted, of the HyperPro being deployed as we came on station where the speed of the *RRS Discovery* decreased. This was done in order to carry the HyperPro out of the ships' shadow. Once the HyperPro was retrieved, the optics rig which contained the AC9 Plus, SeaBird CTD, VSF, FRRF, E_d and L_u sensors, was then was deployed. Table 1 lists the dates, positions, and instrument data obtained during the course of the cruise.

The HyperPro worked well during the course of the cruise but we were limited to deploying at stations with a calm sea state otherwise the instrument was prone to tilting through unacceptable angles.

The Wetlabs AC9 in general worked well for the majority of casts. However, at points during the cruise the AC9 failed to log data to its memory even though the instrument initiated successfully. As the AC9 also logs the VSF and CTD data this resulted in the loss of this data for these stations in addition to the AC9 data. This problem was sporadic during the cruise. A similar problem with the AC9 Plus was also reported on AMT cruises 13 and 14.

The AC9 Plus was calibrated on three occasions during the cruise using water from the ships pure water system.

The Satlantic optical sensors deployed on board the optics rig worked well during the entire cruise.

Due to damage suffered by one of the SeaBird CTD connector pins, thought to be due to seawater corrosion, we were unable to download the data recorded by this instrument from the 6th of October onwards. For the casts conducted after this date the data was logged to the internal memory of the instrument and upon to return the UK the faulty connector will be replaced and the data will be downloaded.

At the beginning of the cruise the FRRF being used onboard the optics rig continually failed to switch on. A faulty battery was thought to be the source of the problem but upon replacing the battery it was found that the FRRF only worked for casts between the 23rd and 26th of September. It was then discovered that the FRRF was having problems communicating with the flashcard. This resulted in the FRRF being used on the optics frame being replaced. FRRF data then becomes available from the 30th of September onwards.

Seawater Samples.

Water samples from the main CTD rosette cast conducted at 11am were also collected in order to tie in with the optics cast. In the majority of casts 6 depths were collected and sampled. Chlorophyll *a* (acetone extraction) was carried out on board. Water was also filtered from each of the six depths for pigment composition (High Pressure Liquid Chromatography, HPLC) and particulate organic carbon (POC). Particulate absorption (PABS) from three depths (usually corresponding to the surface, chlorophyll maximum and from a depth in between) were also carried out. The HPLC and POC filters will be analysed at Southampton Oceanography Centre and the PABS filters will be analysed at the University of Strathclyde.

Data Availability

The HyperPro optical data has been processed on board ship using the software package ProSoft 7.6 and should be submitted to BODC shortly upon return to the UK.

The FRRF data has also been processed on board and should also be submitted upon return to the UK.

The AC9 data requires all post processing to be carried out as does the Satlantic optics data and will be made available once this work has been carried out.

Acknowledgements

Special thanks go to the crew of the *RRS Discovery* especially to Steve, Greg, Andy, Dave and Iain for their help with the deployment of the optics rig. Also thanks to Darren Young for driving the winch during the optics deployment. To Jon Short for his help in solving the FRRF problem and Abigail Pattenden for processing the chlorophyll *a* acetone extracts. Remote sensing images were provided by Sam Lavender during the course of the cruise. Lastly thanks to Chris Lowe for being very patient with me!

Table 1: Optics cast for AMT 15 station positions, CTD cast number and instruments deployed.

Date	CTD	Station	Lat	Long	Hyperpro	AC9+	CTD	Optics	FRRF
19/09/04	3	2	48°30.10'N	08°55.09'W	Yes	No	Yes	Yes	No
20/09/04	No optics deployment, rough seas and problem battery for AC9+ and FRRF.								
21/09/04	7	5	47°42.03'N	15°59.51'W	No	Yes	Yes	Yes	No
22/09/04	10	7	44°55.87'N	19°13.90'W	Yes	Yes	Yes	Yes	No
23/09/04	13	9	41°22.23'N	20°00.23'W	No	Yes	Yes	Yes	Yes
24/09/04	16	11	37°38.46'N	20°30.53'W	Yes	Yes	Yes	Yes	Yes
25/09/04	19	13	33°52.49'N	21°00.25'W	Yes	No	Yes	No	Yes
26/09/04	22	15	30°27.46'N	19°28.07'W	No	Yes	Yes	Yes	Yes
27/09/04	No optics deployment, docked at Tenerife.								
28/09/04	25	17	25°48.07'N	18°42.15'W	Yes	Yes	Yes	Yes	No
29/09/04	27	19	22°27.32'N	20°37.00'W	Yes	Yes	Yes	Yes	No
30/09/04	31	21	20°51.88'N	17°27.56'W	Yes	Yes	Yes	Yes	Yes
01/10/04	35	24	20°45.33'N	18°15.55'W	Yes	Yes	Yes	Yes	Yes
02/10/04	39	27	22°09.30'N	18°22.31'W	Yes	Yes	Yes	Yes	Yes
03/10/04	No optics deployment, do not have permission to work in Mauritania's waters.								
04/10/04	45	31	16°33.94'N	21°13.25'W	No	No	Yes	Yes	Yes
05/10/04	48	33	13°06.06'N	22°01.01'W	Yes	No	Yes	Yes	Yes
06/10/04	51	35	09°55.08'N	22°46.21'W	Yes	Yes		Yes	Yes
07/10/04	54	37	06°51.91'N	23°26.67'W	No	Yes		Yes	Yes
08/10/04	No optics deployment, engine failure of RRS Discovery.								
09/10/04	59	40	01°51.15'N	24°35.15'W	No	Yes		Yes	Yes
10/10/04	62	42	00°58.75'S	24°59.90'W	Yes	Yes		Yes	Yes
11/10/04	63	43	04°38.35'S	24°59.58'W	No	Yes		Yes	No
12/10/04	No optics deployment due to illness.								
13/10/04	69	47	11°41.76'S	24°59.80'W	Yes	Yes		No	Yes
14/10/04	72	49	15°29.85'S	24°59.42'W	Yes	Yes		Yes	Yes
15/10/04	75	51	19°14.23'S	24°59.85'W	Yes	Yes		Yes	Yes
16/10/04	78	53	21°02.28'S	22°50.20'W	No	No		Yes	Yes
17/10/04	80	55	22°28.26'S	19°49.55'W	No	No		Yes	Yes
18/10/04	83	57	24°07.84'S	16°17.13'W	Yes	Yes		Yes	Yes
19/10/04	86	59	25°47.27'S	12°43.84'W	Yes	Yes		Yes	Yes
20/10/04	89	61	27°26.31'S	09°07.26'W	Yes	Yes		Yes	Yes
21/10/04	92	63	29°04.65'S	05°28.07'W	Yes	Yes		Yes	Yes
22/10/04	95	65	32°16.42'S	03°04.60'W	Yes	Yes		Yes	Yes
23/10/04	98	67	35°39.90'S	00°27.76'W	Yes	Yes		Yes	Yes
24/10/04	101	69	39°01.03'S	02°11.67'E	Yes	No		Yes	Yes
25/10/04	104	71	39°59.39'S	06°53.82'E	No	Yes		Yes	Yes

Dynamics of microbial communities

JANE HEYWOOD
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Aim

To compare abundance and metabolic activities of planktonic microorganisms along the trophic gradient in the Atlantic Ocean.

Objectives

- To collect samples for the analysis of picoplankton abundance along the AMT15 transect.
- To compare the rate of grazing of bacterioplankton in surface waters from different oceanic regions.
- To compare the turnover rates of amino acids along the transect.
- To assess the variability of heterotrophic bacterial production rates.
- To collect samples for analyses of bacterioplankton community composition using fluorescence *in situ* hybridisation and other molecular techniques.

Methods

Seawater samples were collected in HCl washed 50 ml polypropylene tubes from each depth on both the 3am and 11am casts. Subsamples were fixed with paraformaldehyde (1% final concentration) and frozen for flow cytometric analysis of autotrophic and heterotrophic picoplankton abundance post-cruise. Samples were also collected for molecular identification of microbial community composition. These samples were either fixed with paraformaldehyde and frozen or frozen in liquid nitrogen.

Bacterial production and organic nutrient turnover rates were estimated by measuring the uptake of radiolabelled amino acids during incubation with water samples at saturating concentrations. Seawater was collected in HCl washed 1 l vacuum flasks from several depths at 29 stations along the transect. Samples were incubated in 2 ml polypropylene vials with ^{35}S-labelled methionine and ^{3}H-labelled leucine at ambient sea temperature.

Seawater samples incubated with ^{35}S-methionine were fixed and frozen for flow cytometric sorting to quantify the proportional uptake rates by different microbial groups. Additional samples were incubated with ^{3}H-leucine, fixed and frozen for microradiography combined with fluorescence *in situ* hybridisation (MAR-FISH) also to link substrate uptake with specific microbial groups.

Bacterivory was estimated in surface water at 12 stations by incubating seawater samples with pulse-chase labelled bacteria, dual labelled with ^{35}S-methionine and ^{3}H-leucine followed by size fractionation using 1 µm and 0.2 µm polycarbonate filters.

Detailed analysis of the data collected will be carried out back in the UK.

Carbon parameters; alkalinity, total carbon dioxide and partial pressure of carbon dioxide, and oxygen

ANDREW HIND
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Objectives

To quantify components of the marine CO_2-carbonate system in order to determine the flux of CO_2 between the atmosphere and the ocean, through the analysis of:

- discrete total inorganic carbon (TCO_2)
- discrete total alkalinity (TA)
- continuous partial pressure of CO_2 (continuous pCO_2) and oxygen

Methods

The three instruments were set up in the chemistry laboratory, with alkalinity being relocated to the constant temperature laboratory, for the analysis of the above parameters. The discrete instrumentation was used to analyse seawater samples collected from the Niskin bottles of the CTD, the continuous pCO_2 was analysing sea surface pCO_2 and oxygen continuously in the non-toxic seawater supply of RRS Discovery.

Discrete seawater samples were taken according to Standard Operating Procedure (SOP) 1 outlined in DOE (1994). Reagent bottles of 250 ml or 500ml volume were used for TCO_2 and TA samples. They were drawn from the Niskin bottles immediately after the oxygen samples were taken. All seawater samples were taken with Tygon tubing into pre-cleaned bottles. They were rinsed once, filled from the bottom, and overflown once. Bottles and flasks were stoppered without any gas bubbles entrapped. The samples were fixed by creating a headspace and adding saturated mercuric (II) chloride ($HgCl_2$) solution according to DOE (1994). All samples were analysed on board with no samples stored for later analysis.

Discrete total inorganic carbon (TCO_2)

Total inorganic carbon was analysed by coulometry. The instrument consisted of a coulometer (model 5100, UIC Inc, USA), a CO_2 extraction unit based on the Single Operator Multiparameter Metabolic Analyzer (SOMMA), developed by Kenneth Johnson (Johnson *et al*., 1985; 1987; 1993; Johnson 1992), and modified at UEA, and a PC with electronic interfaces.

Seawater samples for TCO_2 were taken in 250 ml reagent bottles, kept at ambient temperature within the laboratory container prior to analysis. During analysis, a known volume was taken from the sample bottle, and all inorganic carbonate is converted to CO_2 (gas) by addition of excess phosphoric acid (1 M, 8.5%). Oxygen free Nitrogen (passed through soda lime to remove any traces of CO_2), is used to carry the evolving CO_2 to the coulometer cell. In the coulometer cell, all CO_2 is quantitatively absorbed forming an acid, which is coulometrically titrated. The coulometer is set to integrate the titration as counts (CTS), and titration endpoint is set to within 25 CTS per 60 seconds. Three replicate analyses were carried out for each sample.

The accuracy of the analysis on board was determined regularly by measuring certified reference material (CRM), supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO).

Table 1. Stations and Niskins sampled for tCO_2

Date	CTD	Niskin
25/09/2004	19	1
25/09/2004	19	2
25/09/2004	19	3
25/09/2004	19	6
25/09/2004	19	8
25/09/2004	19	13
25/09/2004	19	17
25/09/2004	19	23
26/09/2004	22	1
26/09/2004	22	2
26/09/2004	22	3
26/09/2004	22	6
26/09/2004	22	7
26/09/2004	22	10
26/09/2004	22	11
26/09/2004	22	13
26/09/2004	22	15
26/09/2004	22	19
26/09/2004	22	22
26/09/2004	22	23
29/09/2004	28	1
29/09/2004	28	2
29/09/2004	28	3
29/09/2004	28	5
29/09/2004	28	9
29/09/2004	28	10
29/09/2004	28	11
29/09/2004	28	13

Date	CTD	Niskin
29/09/2004	28	15
29/09/2004	28	19
29/09/2004	28	17
29/09/2004	28	22
29/09/2004	28	23
30/09/2004	32	3
30/09/2004	32	8
30/09/2004	32	11
30/09/2004	32	15
30/09/2004	32	19
30/09/2004	32	23
02/10/2004	39	1
02/10/2004	39	2
02/10/2004	39	5
02/10/2004	39	11
02/10/2004	39	15
02/10/2004	39	17
02/10/2004	39	19
02/10/2004	39	23
04/10/2004	45	3
04/10/2004	45	8
05/10/2004	48	1
05/10/2004	48	16
05/10/2004	48	19
05/10/2004	48	23
05/10/2004	48	9
07/10/2004	54	1
07/10/2004	54	5

Date	CTD	Niskin
07/10/2004	54	8
09/10/2004	54	17
09/10/2004	59	13
09/10/2004	59	17
09/10/2004	59	22
09/10/2004	59	24
10/10/2004	61	24
10/10/2004	61	20
10/10/2004	61	12
10/10/2004	61	11
10/10/2004	61	9
10/10/2004	61	5
12/10/2004	66	3
12/10/2004	66	8
12/10/2004	66	17
12/10/2004	66	23
14/10/2004	72	3
14/10/2004	72	5
14/10/2004	72	10
14/10/2004	72	19
15/10/2004	74	15
15/10/2004	74	24
15/10/2004	74	11
15/10/2004	74	10
15/10/2004	74	7
15/10/2004	74	4

Table 2. Underway samples taken form the ship's non toxic supply in the constant temperature laboratory for discrete tCO_2

28/09/2004	1500
08/10/2004	1900

Discrete total alkalinity (TA):

Total alkalinity was determined by the titration of a calibrated volume of seawater, equilibrated to 25ºC, with a strong acid (HCl). The s-shaped titration curve produced by potential of a proton sensitive electrode shows two inflection points, characterising the protonation of carbonate and bicarbonate, respectively. The acid consumption up to the second point is equal to the titration alkalinity. From this value, the carbonate alkalinity is calculated by subtracting the contributions of other ions present in the seawater. These concentrations can be derived from the pH and salinity of the sample.

For this analysis, the VINDTA (Versatile INstrument for the Determination of Titration Alkalinity, Marianda, Kiel, Germany) was used. It is an open cell titration system, with sample delivery via a thermostated calibrated pipette. Sample handling and titration is program controlled. The titration is carried out using a Titrino (Model 719 S, Metrohm, Switzerland). The results are calculated using a non-linear curve fitting approach, comparing a calculated curve to the data points and making use of the best-fit coefficients for alkalinity calculation. Alkalinity data were calibrated with CRMs.

Table 3. Stations and Niskins sampled for discrete alkalinity

Date	CTD	Niskin
22/9/04	10	2
22/9/04	10	3
22/9/04	10	9
22/9/04	10	13
22/9/04	10	17
22/9/04	10	22
22/9/04	10	23
22/9/04	10	24
23/9/04	13	2
23/9/04	13	3
23/9/04	13	9
23/9/04	13	13
23/9/04	13	17
23/9/04	13	22
23/9/04	13	23
23/9/04	13	24
24/9/04	16	1
24/9/04	16	2
24/9/04	16	3
24/9/04	16	8
24/9/04	16	13
24/9/04	16	17
24/9/04	16	23
25/9/04	19	1
25/9/04	19	2
25/9/04	19	3
25/9/04	19	6
25/9/04	19	8
25/9/04	19	13
25/9/04	19	17

Date	CTD	Niskin
25/9/04	19	23
26/9/04	22	1
26/9/04	22	2
26/9/04	22	3
26/9/04	22	5
26/9/04	22	9
26/9/04	22	10
26/9/04	22	11
26/9/04	22	13
26/9/04	22	15
26/9/04	22	17
26/9/04	22	19
26/9/04	22	22
26/9/04	22	23
28/9/04	28	1
28/9/04	28	2
28/9/04	28	3
28/9/04	28	5
28/9/04	28	9
28/9/04	28	10
28/9/04	28	11
28/9/04	28	13
28/9/04	28	15
28/9/04	28	17
28/9/04	28	19
28/9/04	28	22
28/9/04	28	23
30/9/04	29	3
30/9/04	29	4
30/9/04	29	9

Date	CTD	Niskin
30/9/04	29	12
30/9/04	29	20
30/9/04	29	21
30/9/04	31	3
30/9/04	31	8
30/9/04	31	11
30/9/04	31	15
30/9/04	31	19
30/9/04	31	23
30/9/04	32	3
30/9/04	32	8
30/9/04	32	11
30/9/04	32	15
30/9/04	32	19
30/9/04	32	23
1/10/04	33	1
1/10/04	33	2
1/10/04	33	3
1/10/04	33	12
1/10/04	33	17
1/10/04	33	21
1/10/04	35	1
1/10/04	35	4
1/10/04	35	8
1/10/04	35	13
1/10/04	35	19
1/10/04	35	23
2/10/04	38	1
2/10/04	38	9
2/10/04	38	13

Date	CTD	Niskin
2/10/04	38	16
2/10/04	38	20
2/10/04	38	24
2/10/04	39	1
2/10/04	39	2
2/10/04	39	5
2/10/04	39	11
2/10/04	39	15
2/10/04	39	17
2/10/04	39	19
2/10/04	39	23
4/10/04	45	1
4/10/04	45	3
4/10/04	45	8
4/10/04	45	14
4/10/04	45	23
5/10/04	48	1
5/10/04	48	3
5/10/04	48	6
5/10/04	48	9
5/10/04	48	13
5/10/04	48	16
5/10/04	48	19
5/10/04	48	23
6/10/04	51	1
6/10/04	51	5
6/10/04	51	8
6/10/04	51	10
6/10/04	51	15
6/10/04	51	23
7/10/04	54	1
7/10/04	54	2
7/10/04	54	5
7/10/04	54	8
7/10/04	54	13
7/10/04	54	15
7/10/04	54	17
7/10/04	54	19
7/10/04	54	23
9/10/04	59	1
9/10/04	59	3
9/10/04	59	6
9/10/04	59	10
9/10/04	59	13
9/10/04	59	17
9/10/04	59	22
9/10/04	59	24
10/10/04	61	1
10/10/04	61	5
10/10/04	61	9
10/10/04	61	11
10/10/04	61	12
10/10/04	61	16
10/10/04	61	20
10/10/04	61	24
12/10/04	66	1
12/10/04	66	3
12/10/04	66	8
12/10/04	66	10
12/10/04	66	14
12/10/04	66	17
12/10/04	66	22
12/10/04	66	23
14/10/04	72	2
14/10/04	72	3
14/10/04	72	1
14/10/04	72	5
14/10/04	72	8
14/10/04	72	10
14/10/04	72	14
14/10/04	72	19
15/10/04	74	1
15/10/04	74	3
15/10/04	74	4
15/10/04	74	7
15/10/04	74	10
15/10/04	74	11
15/10/04	74	15
15/10/04	74	19
15/10/04	74	21
15/10/04	74	24
17/10/04	80	23
17/10/04	80	1
17/10/04	80	2
17/10/04	80	2
17/10/04	80	3
17/10/04	80	5
17/10/04	80	8
17/10/04	80	11
17/10/04	80	14
17/10/04	80	17
17/10/04	80	21
20/10/04	89	1
20/10/04	89	2
20/10/04	89	2
20/10/04	89	4
20/10/04	89	8
20/10/04	89	23
20/10/04	89	24
21/10/04	92	1
21/10/04	92	3
21/10/04	92	8
21/10/04	92	11
21/10/04	92	17
21/10/04	92	23
22/10/04	94	1
22/10/04	94	2
22/10/04	94	5
22/10/04	94	9
22/10/04	94	11
22/10/04	94	12
22/10/04	94	16
23/10/04	98	1
23/10/04	98	3
23/10/04	98	8
23/10/04	98	13
23/10/04	98	14
23/10/04	98	24
24/10/04	101	1
24/10/04	101	2
24/10/04	101	5
24/10/04	101	8
24/10/04	101	13
24/10/04	101	14
24/10/04	101	17
24/10/04	101	23
26/10/04	105	1
26/10/04	105	6
26/10/04	105	9
26/10/04	105	16
26/10/04	105	22

Table 4. Underway samples taken form the ship's non toxic supply in the constant temperature laboratory for discrete alkalinity

Date	Time GMT
19/09/2004	1500
18/10/2004	1705
18/10/2004	1925
18/10/2004	2205
18/10/2004	2205
18/10/2004	1925
19/10/2004	0016
19/10/2004	1810
20/10/2004	1700
19/10/2004	2210
20/10/2004	1923
20/10/2004	2146
21/10/2004	0029
21/10/2004	1339
17/10/2004	1646
17/10/2004	1835
21/10/2004	2054
21/10/2004	2208
22/10/2004	0008

Continuous partial pressure of CO_2 (continuous pCO_2):

The partial pressure of CO_2 in surface seawater was determined by infrared absorption of CO_2 in a gas stream being continuously equilibrated with the CO_2 of surface seawater. The system used was built at UEA, its design based on the one described by Cooper *et al* (1998).

Seawater from the continuous non toxic supply of RRS Discovery was passed through a housing containing an oxygen/temperature sensor (Aanderaa model 3930, Aanderaa Instruments AS, Norway), and into a peculator type equilibrator at 5 litres/min. Air was continuously circulated through the equilibrator and the detector (LiCor model 6262, LiCor, Inc., USA). At least once per hour, the system analysed CO_2 in air, pumped in from the foremast.

Gas standards of approximately 250 ppm and 450 ppm CO_2 in air were measured throughout the cruise, in order to calibrate the LiCor detector.

Measurements were made without complete drying of the gas prior to the LiCor, and the LiCor's measurements of water vapour were used to correct to xCO_2 in dry air. Equilibrator pCO_2 was then calculated assuming 100% humidity. Two platinum resistant thermometers inside the equilibrator monitored its temperature, and pCO_2 in seawater was corrected to seawater temperature assuming and a 4.23% increase in pCO_2 per one degree centigrade.

Under controlled conditions in the laboratory, and during a pool side international intercomparison in Japan in 2003, the type of instrument used for this cruise gave a precision of ± 0.7 ppm CO_2.

Acknowledgements

In addition to the Crew and Officers of the RRS Discovery, the PS and the cruise participants I would particularly like to thank Dorothee Bakker, Gareth Lee and Andy MacDonald for their help with setting up the laboratory and Ute Schuster for technical advice via email throughout the cruise.

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Dinitrogen fixation in the Atlantic Ocean

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Objectives

- Develop an acetylene reduction gas chromatographic method for use with marine oligotrophic water samples as an indirect measure of dinitrogen fixation
- Further develop the ^{15}N stable isotope method for atmospheric dinitrogen fixation.
- To make measurements of dinitrogen fixation, by means of the acetylene reduction technique.
- To make measurements of dinitrogen fixation, by means of the ^{15}N stable isotope incorporation technique.
- Further develop protocols for both the ^{15}N and acetylene reduction techniques in a research vessel environment.
- Test and establish the validity of the large volume direct acetylene reduction technique as a direct measure of oceanic dinitrogen fixation

Methods

Acetylene reduction: Dinitrogen fixation is based upon the biodegradation of acetylene to ethylene, by means of the triple bond in the acetylene being broken by the nitrogenase enzyme. This enzyme is only present in organisms that possess the ability to fix atmospheric dinitrogen, and it is therefore a reliable measure of the dinitrogen fixation from the natural biota. Water was collected each morning from the "monster" (2am) CTD from 4 depths equivalent to 97% and 55% of surface irradiance. The samples were spiked with saturated sample water and incubated in 250 ml gas tight bottles for 12 hours in on-deck incubators, with the appropriate light filters.

The required light depths were calculated from PAR data from the previous day's data. The samples were removed after incubation and stored in a dark box, a 30 ml was added headspace (oxygen free nitrogen) was added to the bottles, which were then equilibrated and analysed by gas chromatography (flame ionisation detection).

^{15}N stable isotope technique: This technique is a direct measure of the uptake of ^{15}N by the dinitrogen fixing organisms. ^{15}N was introduced as a gas into 2.4 l polycarbonate bottles, through a PTFE faced septa, any uptake of ^{15}N labelled nitrogen, therefore must be as a result of atmospheric dinitrogen fixation. Water was collected each morning from the monster CTD from 2 light depths equivalent to 97% and 55% of surface irradiance. This was then transferred into polycarbonate bottles. Time series experiments were carried out every day (T0, T6, T12 and T24), with the depth of the sample water alternating from surface to 55%, and samples were done in triplicate

Pigment and ^{15}N natural abundance samples were also taken to back up the primary acetylene reduction and ^{15}N addition experiment

Table 1. ^{15}N sampling – nitrogen addition experiments

Day 1

Light levels	Additions (N)	TO	T6	T12	T25
Surface	14	1	----------	----------	1
	15	3	3	3	3
55%	14	1	----------	----------	1
	15	3	----------	----------	3

Day 2

Light levels	Additions (N)	TO (Reps)	T6 (Reps)	T12 (Reps)	T25 (Reps)
Surface	14	1	----------	----------	1
	15	3	----------	----------	3
55%	14	1	----------	----------	1
	15	3	3	3	3

These were incubated for the appropriate time in on deck incubators with the appropriate light filters, removed and filtered on to glass fibre filters (GFFs), placed in small Petri dishes, dried and stores in silica gel.

Table 2. Acetylene sampling

Light levels	TO (Reps)	T12 (Reps)
Surface	3	3
55%	3	3

These were incubated for the appropriate time in on deck incubators with the appropriate light filters, removed, a head space added and analysed for the activity of nitrogenase enzyme.

Table 3. CTD samples analysed and additional samples taken to back up the primary nitrogen fixation data

Date	CTD number	Acetylene reduction rate	^{15}N filter	Pigment sample	^{15}N natural abundance
23/09/04	11		✓		
24/09/04	14		✓		
25/09/04	17		✓		
26/09/04	20		✓		
29/09/04	26	✓	✓	✓	✓
30/09/04	29	✓	✓	✓	✓
01/10/04	33	✓	✓	✓	✓
02/10/04	37	✓	✓	✓	✓
03/10/04	41	✓	✓	✓	✓
04/10/04	43	✓	✓	✓	✓
05/10/04	46	✓	✓	✓	✓
06/10/04	49	✓	✓	✓	✓
07/10/04	52	✓	✓	✓	✓

Date	CTD number	Acetylene reduction rate	^{15}N filter	Pigment sample	^{15}N natural abundance
08/10/04	55	✓	✓	✓	✓
09/10/04	57	✓	✓	✓	✓
10/10/04	60		✓	✓	✓
12/10/04	64	✓	✓	✓	✓
13/10/04	67	✓	✓	✓	✓
14/10/04	70	✓	✓	✓	✓
15/10/04	73	✓	✓	✓	✓
16/10/04	76	✓		✓	✓
17/10/04	79	✓	✓	✓	✓
18/10/04	81	✓	✓	✓	✓
19/10/04	84	✓	✓	✓	✓
20/10/04	87	✓	✓	✓	✓
21/10/04	90	✓	✓	✓	✓
22/10/04	93	✓		✓	✓
23/10/04	96	✓	✓	✓	✓
	99	✓	✓	✓	✓

Preliminary Results

^{15}N gaseous uptake: ^{15}N results will not be available until mass spectrometry analysis can be done later in the year.

Acetylene reduction: Due to time constraint and many technical problems this data is currently in a format which can not be full analysis at this point. This data will be available later this year

Conclusion

During the first week of the cruise the acetylene was found to contain high levels of ethylene contaminate (10 ppm approx). This level of contamination significantly higher than previously measured. A calibration data set was produced and the level of contamination was determined to be linear. A standard level of contamination was identified for the addition of 40 ml of the acetylene. This level of contamination was observed (+/- 1%) throughout the cruise. This did not appear to mask fluctuation in the ethylene levels.

The acetylene reduction technique after great deal of development has proven be a useful and relatively accurate tool for measuring diazotrophic-nitrogen fixation *in situ*. This technique provides real time, relatively rapid data collection and can be effectively operated by a single person. It provides a indirect rate measurement, which if combined with ^{15}N isotopic gaseous uptake will provide a very powerful tool for the assessment of diazotrophic-nitrogen fixation within oceanic environment.

There has been a great deal of ^{15}N samples collected on this cruise. With the assistance of Dr A Rees I have been able to carry out replication and time series tests every day.

Acknowledgements

I would like thank Dr Andy Rees, whose assistance and advice at 2am every morning meant I was able to collect a lot more samples than on previous cruises.

UKORS computing Report

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Summary

RRS Discovery is fitted with a central data logging system known as the ABC system. All available data streams from the ABC were collected. Most data streams have a one second sample interval with the exception of surfmet (30s) and ea500d1 (ping interval). ASCII listings were produced for all ABC system data streams. Data from the Chelsea FRFF and RDI LADCP that were deployed on the stainless steel CTD frame were included in the final data archive. Also included in the archive was Autosal salinometer data and associated spreadsheets for calibration of the Surfmet Thermosalinograph and Seabird CTDs. A separate document describing the CTD data processing done onboard is included on the cruise DVD. Other systems that were run were the 150 kHz and 75 kHz Vessel Mounted ADCP's (VMADCP's). The 150 kHz VMADCP was logged via the level C, whereas the newer 75 kHz unit logged locally, with the data being copied across the network at the end of the cruise. The data archive was distributed to the PSO and BODC on DVD with compression of some datasets, notably processed CTD data and all the ABC data. A backup copy of the DVD was left onboard the ship, also one backup was taken back to UKORS. Approximately eight Gigabytes of data was acquired including processed data. All in all a successful and productive cruise.

Comments on Data Quality

On the whole, the cruise was a success in terms of data management and quality, however there were some instrumentation and data loss issues. The Chernikeef EM log has poor calibration particularly velocity port to starboard, however with multiple GPS systems, this is not an issue for station positioning. The transmissometer on the Surfmet system was faulty or intermittent for most of the cruise. The starboard TIR sensor on the Surfmet package gave a consistent positive offset and a higher value than the port sensor, this is suspect. Data from the Surfmet fluorometer was good, though it is due for a calibration, this is not much of an issue as fluorometer calibration is highly dependant on plankton species and size. There was a loss of a few hours of ABC data during the power blackout that occurred mid cruise. There is a gap in the winch data caused by a configuration error during the port-call to Tenerife.

ABC Raw Data Details

The following raw data streams were logged:

Navigation

- gps_4000 – Trimble 4000DS GPS
- gps_g12 – Ashtec G12 GPS
- gps_ash – Ashtec ADU-2 multi antenna GPS with ships' attitude
- gps_glos – Glonass GPS
- gyronmea – Ships Gyro
- log_chf – Chernikeef EM log (ships' speed through the water)

Bathymetry

- ea500d1 – Simrad EA500 Precision Echo Sounder

Surface Sampling & Meteorology

- surfmet – Surface Sampling and Meterology Package

Acoustic Doppler Current Profiler

- adcp – 150kHz RDI VMADCP

Cable Monitoring

- winch – Scientific Winch Cable Load and Metering System (CLAM).

ABC Processed Data Details

Minimal data processing was done on the ABC data, however the following useful streams were produced:

- rawdep – A copy of EA500d1 for marking echo sounder data as suspect during bad pings, despikes depth data.
- prodep – PES data with a regional correction for velocity of sound using Carter's Tables.
- relmov – Ships' relative motion.
- bestnav – Best navigation using rollover of redundant GPS's with interpolation using dead-reckoning from log and gyro during GPS down time.
- pro_wind – True windspeed and direction calculated from the Surfmet package and the best navigation to correct for ships movement.
- protsg – Processed thermosalinograph data from the Surfmet package, includes salinity, and density.

CTD Data Processing

CTD data for all casts was processed using the same method. Different instrument configuration files were used depending on whether the stainless steel or titanium frames were deployed. Also the UPWIRR PAR sensor on the Ti-frame was replaced during the cruise due to damage, resulting in a second .con file. Corrections were applied for DO cell time constant and conductivity cell thermal mass. All data was low pass filtered. Oxygen values were derived after correction and filtering had been applied. Salinity values were derived after bin averaging into two db bins against pressure (nominally two metres depth). A bottle summary of raw data was produced for each cast, as was an ASCII listing of key values in 2 db bins. Surface bins down to 10-12 m are heavily weighted by poor data prior to pumps starting and other aberrations during deployment. Surface bins at the end of the upcast are unaffected by these artefacts.

Egg production rates of *Clausocalanus* species (Copepoda: Calanoida)

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Introduction

Clausocalanus is one of the quantitatively most important planktonic copepod genus in the world oceans. In a transect conducted in the Atlantic Ocean, Calbet and Agustí (Calbet and Agustí, 1999) reported that *Clausocalanus* genus was the most abundant copepod genus accounting for 55% of the zooplankton community (in terms of abundance) at most of the stations surveyed. During previous AMT cruises (AMT4, 5 and 6) *Clausocalanus* was included together with *Paracalanus* and *Pseudocalanus* in the 'small calanoid' group due to identification problems (Woodd-Walker, 2001).

According to the *Clausocalanus* species distribution reported by Frost and Fleminger (1968), nine species of this genus occur in the Atlantic Ocean: *Clausocalanus paululus* (Farran, 1926); *C. pergens* (Farran, 1926); *C. furcatus* (Brady, 1883); *C. arcuicornis* (Dana, 1849); *C. parapergens* (Frost and Fleminger, 1968); *C. jobei* (Frost and Fleminger, 1968); *C. lividus* (Frost and Fleminger, 1968); *C. mastigophorus* (Claus, 1863); *C. ingens* (Frost and Fleminger, 1968).

Clausocalanus presents both the reproductive strategies described in copepods. At least six species are egg-carrying copepods (*Clausocalanus paululus, C. pergens, C. furcatus, C. arcuicornis, C. parapergens,* and *C. jobei*) and two are broadcast spawning copepods (*C. lividus* and *C. mastigophorus*). There is no information about *C. ingens* reproduction.

Principal Aims

Secondary production evaluation from data collected on egg production and egg viability of *Clausocalanus* species along the AMT and its influence on carbon flux in the different biogeochemical provinces.

Taxonomical analysis of zooplankton samples will increase knowledge on zooplankton communities along the Atlantic Ocean and on *Clausocalanus* species distribution, their abundance and relative importance in epiplanktonic communities, and the degree of its species populations overlap in relation with the environmental factors. It will be also a new contribution on sex ratio of this important copepod genus.

Parameters Studied (at species level)

Clutch size: Number of eggs extruded as a clutch.

Egg production rate (EPR): Number of eggs laid per adult female and per day.

Egg viability: Percentage of eggs of one clutch that reach to hatch.

Inter-clutch period: Time between two clutch events.

Carbon content: Females and eggs carbon content to obtain weight-specific fecundity.

Secondary production (SP): Estimated with data on egg production, egg viability, female biomass and female abundance.

Methodology

Quantitative mesozooplankton samples were collected at the same time as the Monster and Pre-dawn CTD casts (from 02:00 to 03:00 GMT) using a double WP-2 net (57 cm mouth diameter and 200 µm mesh aperture) equipped with a filtering cod-end. Vertical hauls from 200 m up to the surface were performed at 0.2-0.3 $m.s^{-1}$ speed. Zooplankton samples were then fixed with 4% buffered formaldehyde-seawater solution and stored to be analysed later in the laboratory.

At the same sampling station, every two days (see Table 1 for more information), live mesozooplankton samples were collected using also a double WP-2 net but this time equipped with a non-filtering cod-end (a plastic bag of about 8 l) in order to collect the animals gently. Vertical hauls were performed from the DCM up to surface (see Table 1) at 0.1 $m.s^{-1}$ speed. Once on deck, the cod-end content was poured in a plastic cooler previously filled with surface seawater. In the laboratory, live specimens of *Clausocalanus* species were sorted by eye and picked with a large-mouth glass pipette and then checked under the stereomicroscope. Only mature and actively swimming adult females with intact appendages were used for incubation. Seawater used for incubations was collected with a Niskin bottle from the DCM.

Other times, live zooplankton samples were collected using a double microzooplankton net (34 cm mouth diameter and 63 µm mesh aperture) equipped with a large cod-end with small filtering window. Once on deck, the content of the cod-end was poured in a plastic jar previously filled with surface seawater. These samples were used to pick live individuals to be incubated or were stored in the fridge for about six hours and then more than 50 individuals of the most abundant *Clausocalanus* species were sorted under the stereomicroscope, rinsed with distilled water, placed onto pre-combusted Whatman glass fibre GF/C filter of known weight and dried in the oven at 80ºC for 24 hours for further specific dry weight measurement and CHN analysis.

The females that during the sorting process would be carrying their egg-sac/mass were incubated individually in 300 ml flask for measuring their inter-clutch period. These egg-carrying species that did not present their sacs during the sorting process were incubated in 1 l Duran glass bottles (max. 20 individuals per bottle) filled with natural particle assemblage waiting for their egg-mass/sac deposition. Broadcast spawning *Clausocalanus* species were only incubated individually in 300 ml flasks.

Egg-mass/sac deposition was checked several times a day by eye and the ovigerous females were removed. Ovigerous females were placed individually in WillCo-dishes®, stained with the vital dye FDA and observed under the inverted fluorescent microscope (Zeiss IM-35) to assess egg viability (for information on embryo viability detection protocol see Buttino *et al.* 2004).

Flasks and bottles were incubated on deck on a Ferris wheel (to avoid food particle deposition) submersed in an incubator with surface seawater supply. The temperature of the incubator was monitored and when it was higher than 26ºC the bottles and flasks were incubated in a cooler environment and turned by hand (from 4 to 10 October).

Preliminary Results

Around 800 adult females of *Clausocalanus* species were incubated along the transect. One quarter of them produced eggs. *C. paululus* and *C. pergens* were present at the North Atlantic Drift, presenting large interclutch period, small clutch size (in relation to the other species of the genus), and so low EPR, but high viability. From North Atlantic Subtropical Gyre to the South Atlantic Gyre, *C. fucatus* (characteristic from warm stratified waters) was the dominant *Clausocalanus* species. It presented high EPR and low viability at the upwelling area and the opposite to the oligotrophic waters of the South Atlantic Gyre, with an increase of the interclutch period. When the thermocline started to disappear, the composition of the genus changed and was more diverse, appearing other egg-carrying *Clausocalanus* species and also some free-spawner species.

To characterise the functional reproductive responses of the studied species to environmental factors, EPR, egg viability and inter-clutch period at the different regions (already identified as provinces by Longhurst *et al*., 1995) should be analyzed in more detail.

Future Calculations and Analysis

- Analysis of dry weight and CHN of *Clausocalanus* species studied along the transect.
- Quantification of the zooplankton samples.
- Estimation of the secondary production with the "egg production" approach, according to the equation reported on Poulet *et al*., 1995. This equation considers fecundity as a component of secondary production, does not give an estimate of the total production and represents rather, for a given species, only a fraction of the total population secondary production, corresponding strictly to the contribution of adult females.
- Measurement of nauplii recruitment by multiplying the previous estimation of secondary production by egg viability or hatching success (Poulet *et al.*, 1995).

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Table 1. Zooplankton samples collected for this study during the AMT15 (at Type of sample, DSW means sample used to sort individuals for dry specific weight).

Date	Station	Sample Code	Net	Type of sample	Haul (m)	Velocity ($m.s^{-1}$)
19/09/2004	1	SZN-1	Meso	FIXED	50	0.17
20/09/2004	-	-	-	-	-	-
21/09/2004	4	SZN-2	Meso	FIXED	125	0.21
			Meso	ALIVE	50	0.06
22/09/2004	6	SZN-3	Meso	FIXED	200	0.30
			Micro	ALIVE	200	0.20
23/09/2004	8	SZN-4	Meso	FIXED	200	0.24
24/09/2004	10	SZN-5	Meso	FIXED	200	0.15
			Micro	ALIVE	200	0.12
25/09/2004	12	SZN-6	Meso	FIXED	200	0.22
			Meso	ALIVE	100	0.11
26/09/2004	14	SZN-7	Meso	FIXED	200	0.20
27/09/2004	16	SZN-8	Meso	FIXED	200	0.20
			Meso	ALIVE	100	0.12
28/09/2004	-	-	-	-	-	-
29/09/2004	18	SZN-9	Meso	FIXED	200	0.28
			Meso	ALIVE	100	0.07
30/09/2004	20	SZN-10	Meso	FIXED	200	0.20
			Micro	DSW	200	0.14
01/10/2004	23	SZN-11	Meso	FIXED	200	0.20
			Meso	ALIVE	50	0.07
02/10/2004	26	SZN-12	Meso	FIXED	50	0.12
			Micro	ALIVE	50	0.08
03/10/2004	29	SZN-13	Meso	FIXED	200	0.30
			Meso	ALIVE	100	0.14
04/10/2004	30	SZN-14	Meso	FIXED	200	0.30
05/10/2004	32	SZN-15	Meso	FIXED	200	0.30
			Meso	ALIVE	100	0.14
06/10/2004	34	SZN-16	Meso	FIXED	200	0.26
			Micro	DSW	200	0.20
07/10/2004	36	SZN-17	Meso	FIXED	200	0.20
08/10/2004	38	SZN-18	Meso	FIXED	200	0.24
			Meso	ALIVE	100	0.17
09/10/2004	39	SZN-19	Meso	FIXED	200	0.20
			Micro	ALIVE	200	0.20
10/10/2004	41	SZN-20	Meso	FIXED	200	0.20
			Meso	ALIVE (x2)	100	0.17
11/10/2004	-	-	-	-	-	-
12/10/2004	44	SZN-21	Meso	FIXED	200	0.22
			Meso	ALIVE	125	0.17
13/10/2004	46	SZN-22	Meso	FIXED	200	0.13
			Micro	DSW	200	0.18

Date	Station	Sample Code	Net	Type of sample	Haul (m)	Velocity ($m.s^{-1}$)
14/10/2004	48	SZN-23	Meso	FIXED	200	0.21
			Meso	ALIVE	150	0.21
15/10/2004	50	SZN-24	Meso	FIXED	200	0.26
			Micro	ALIVE	200	0.28
16/10/2004	52	SZN-25	Meso	FIXED	200	0.21
			Meso	ALIVE	200	0.12
17/10/2004	54	SZN-26	Meso	FIXED	200	0.20
			Micro	ALIVE	200	0.16
18/10/2004	56	SZN-27	Meso	FIXED	200	0.33
			Meso	ALIVE	200	0.12
19/10/2004	58	SZN-28	Meso	FIXED	200	0.24
			Micro	ALIVE	200	0.19
20/10/2004	60	SZN-29	Meso	FIXED	200	0.33
			Meso	ALIVE	150	0.10
21/10/2004	62	SZN-30	Meso	FIXED	200	0.26
			Micro	ALIVE	200	0.24
22/10/2004	64	SZN-31	Meso	FIXED	200	0.33
			Meso	ALIVE	100	0.24
23/10/2004	66	SZN-32	Meso	FIXED	200	0.22
			Micro	ALIVE	200	0.17
24/10/2004	68	SZN-33	Meso	FIXED	200	0.28
			Meso	ALIVE	50	0.10
25/10/2004	70	SZN-34	Meso	FIXED	200	0.22
26/10/2004	72	SZN-35	Meso	FIXED	200	0.20

Underway nitrous oxide and methane

ANDY REES
Plymouth Marine Laboratory

Aim

To monitor changes in the surface concentrations/saturations of dissolved nitrous oxide and methane relative to the atmosphere along the latitudinal range of the cruise.

This was the first deployment of this instrument which is designed to run in an autonomous manner for the duration of the cruise. Unfortunately a large number of problems were experienced, these were largely centred around the software, so that at best a semi-automated analysis was possible. Sporadic analyses were made between the 20th September and the 19th October with particular emphasis placed on the upwelling survey (30/09/04 – 03/10/04), the quality of this data is at present dubious.

Stable isotopic signature of Dissolved Inorganic Carbon

COLLECTED BY ANDY REES/ANDY HIND FOR PAUL QUAY
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Objectives:

To measure the decadal changes of the surface $^{13}C/^{12}C$-DIC and the air-sea $^{13}C/^{12}C$ disequilibrium since the 1990s. Measurements of the $^{13}C/^{12}C$ of DIC made on WOCE and NOAA cruises during the 1990s, by workers at the university of Washington and at Woods Hole, demonstrated that the surface change in $^{13}C/^{12}C$ is proportional to the amount of anthropogenic CO_2 taken up by the ocean. Additionally, surface ocean $^{13}C/^{12}C$ measurements yield an estimate of the air-sea $^{13}C/^{12}C$ disequilibrium which, in turn, is needed to estimate the amount of CO_2 taken up by terrestrial versus ocean sinks based on inversions of atmospheric CO_2 and $^{13}C/^{12}C$ time series data.

Seawater samples were collected from the ships non-toxic supply into glass collection bottles and preserved with mercuric chloride. The full sample list is found in Appendix 4.

Gross Primary Production (GPP), Dark Community Respiration (DCR) and Net Community Production (NCP) dissolved oxygen concentration in seawater

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Objectives

- To determine the depth and spatial distribution of net community production (NCP), i.e., the balance of gross primary production (GPP) and community respiration (CR), and to relate it to community structure and nutrient supply.
- To determine the plankton NCP in the upwelling region of the eastern edge of the Northern Atlantic subtropical gyre, within the context of a possible organic carbon source for the centre of the gyre.
- To compare the GPP:CR ratio in the Northern and Southern Atlantic subtropical gyres and to relate this to atmospheric and hydrographic derived nutrient supply and to community structure.
- To test and refine system-specific empirical models to predict the GPP:CR balance in each province from remote estimations of primary production.
- To measure dissolved oxygen concentration in order to calibrate the oxygen sensors of the two CTDs used during the cruise.

Methods

Measurements of dissolved oxygen were made using an automated Winkler titration system with photometric endpoint detection (Williams and Jenkinson 1982). Oxygen saturation was calculated from the equations for solubility in seawater of Benson and Krause (1984).

GPP, NCP and dark CR were determined from *in vitro* changes in dissolved oxygen concentration after 24 hours light and dark incubations. Water was collected directly from the Niskin bottles into polypropylene aspirators from depths equivalent to ca. 97%, 55%, 33%, 14% and 1% of surface irradiance. The water was siphoned into 125 ml borosilicate glass bottles, and four zero time replicates were fixed immediately. Two further sets of replicates were incubated for 24 hours in surface water cooled deck incubators or in temperature controlled water baths at *in situ* temperatures. One set was incubated in the dark, the other set in light of equivalent irradiance to that found at the *in situ* depth. This was controlled using polycarbonate screens incorporating neutral density acrylic of differing transmission (Joint *et al*., 1993; Donald *et al*., 2001). During hours of darkness, the incubators were covered with opaque screens

Samples Collected

30 vertical profiles of five depths were sampled daily from the pre-dawn cast (ca. 03:00, ship time) for GPP/DCR rates.

303 samples for *in situ* oxygen concentration were collected from the pre-dawn and mid morning casts (ca. 03:00 and 11:00, respectively) for the calibration of the CTD oxygen sensors.

Results

The complete calibration procedure of CTD sensors will be undertaken at BODC, but preliminary calibrations carried out onboard suggest that the no relevant "drift" of the SBE sensor occurred on this cruise. The calibration is well constrained with standard residuals well within the limits advised by BODC (Fig. 1).

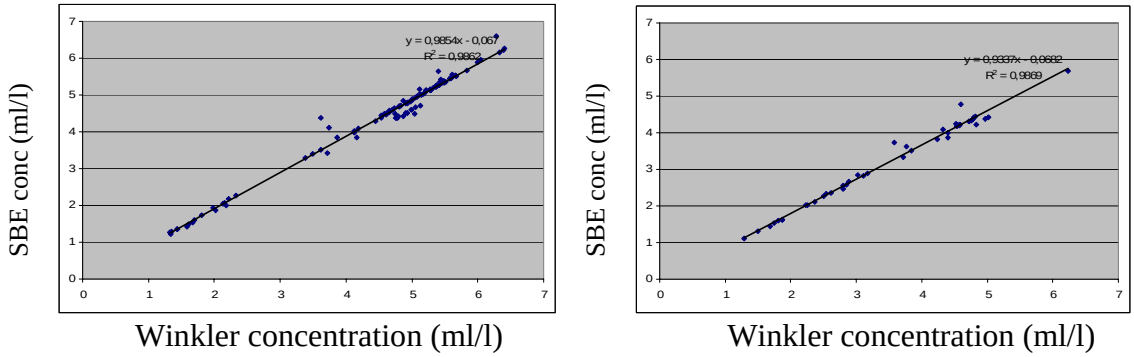

Figure 1. Dissolved oxygen calibration curves for the Seabird CTD sensor versus onboard determined Winkler titrations

Productivity and respiration analyses were all performed on board, but data will be processed on return to Spain. It is expected that all O_2, GPP, NCP and DCR data will be deposited at BODC by June 2005.

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Acknowledgements

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UKORS instrumentation

J. SHORT
Southampton Oceanography Centre

CTD Operations

1. A total of 105 CTD casts were undertaken on the cruise, 68 of which used the stainless steel frame and 37 used the Titanium frame. The stainless steel frame configuration was as follows;

   - Sea-Bird 9/11 *plus* CTD system
   - 24 by 20L Ocean Test Equipment External Spring water samplers
   - Sea-Bird 43 Oxygen sensor
   - Chelsea MKIII Aquatracka Fluorometer
   - Chelsea MKII Alphatracka 25cm path Transmissometer
   - OED LADCP pressure case battery pack
   - Chelsea PAR Sensor (downwelling)
   - Turner Designs Cyclops-7 Fluorometer
   - RD Instruments Workhorse 300 KHz Lowered ADCP (downward-looking configuration)
   - Chelsea FRRF/battery pack/pressure sensor

The pressure sensor is located 15cm from the bottom of the water samplers, and 132 cm from the top of the water samplers. This frame was used for the early morning monster and pre-dawn casts and was not deployed any deeper than 300m

The Sea-Bird CTD configuration was as follows:

- SBE 9 *plus* Underwater unit s/n 09P-19817-0636
- Frequency 0—SBE 3P Temperature sensor s/n 03P-4105 (primary)
- Frequency 1—SBE 4C Conductivity sensor s/n 04C-2571 (primary)
- Frequency 2—Digiquartz temperature compensated pressure sensor s/n 83008
- Frequency 3—SBE 3P Temperature sensor s/n 03P-4151 (secondary)
- Frequency 4—SBE 4C Conductivity sensor s/n 04C-2580 (secondary)
- SBE 5T submersible pump s/n 05T-3086
- SBE 5T submersible pump s/n 05T-3088
- SBE 32 Carousel 24 position pylon s/n 32-31240-0423
- SBE 11 *plus* deck unit

The auxiliary A/D output channels were configured as below:

- V2 --- SBE 43 Oxygen s/n 43B-0621
- V3 --- Chelsea MKIII Aquatracka Fluorometer s/n 088160
- V4 --- Chelsea PAR Sensor (UWIRR) s/n 01
- V5 --- Turner Designs Cyclops 7 fluorometer
- V6 --- WetLabs Light Scatter Sensor 339
- V7 --- Chelsea MKII Alphatracka 25cm path Transmissometer s/n 161048

The additional self-logging instruments were configured as follows:

- Chelsea FRRF s/n 182042
- RDI Workhorse 300 KHz Lowered ADCP (downward-looking configuration) s/n 4275

Notes

The LSS was removed from the stainless frame prior to casts on Jday 271.

There were many occasions of the 20l water bottles not sealing properly. There were never more than two per cast and the scientists sampling from these casts were informed and so did not take water from these bottles. This is an unfortunate design flaw of these particular bottles and no amount of fiddling with lanyard length or cocking method has produced a method of getting 100% closures.

The titanium frame configuration was as follows;

- Sea-Bird 9/11 plus CTD system
- 24 by 10L Ocean Test Equipment External Spring trace metal water samplers
- Sea-Bird 43 Oxygen sensor
- Chelsea MKIII Aquatracka Fluorometer
- Chelsea MKII Alphatracka 25cm path Transmissometer
- Chelsea PAR Sensor (upwelling)
- Chelsea PAR Sensor (downwelling)

The Titanium Sea-Bird CTD configuration was as follows:

- SBE 9 plus Underwater unit s/n 09P-34173-0758
- Frequency 0—SBE 3P Temperature sensor s/n 03P-4381 (primary)
- Frequency 1—SBE 4C Conductivity sensor s/n 04C-2851 (primary)
- Frequency 2—Digiquartz temperature compensated pressure sensor s/n 90074
- Frequency 3—SBE 3P Temperature sensor s/n 03P-4380 (secondary)
- Frequency 4—SBE 4C Conductivity sensor s/n 04C-2858 (secondary)
- SBE 5T submersible pump s/n 05T-3002
- SBE 5T submersible pump s/n 05T-3085
- SBE 32 Carousel 24 position pylon s/n 32-34173-0493
- SBE 11 plus deck unit

The auxiliary A/D output channels were configured as below:

- V2 --- SBE 43 Oxygen s/n 43B-0363
- V3 --- Chelsea MKIII Aquatracka Fluorometer s/n 88/2960/163
- V4 --- Chelsea PAR Sensor (UWIRR) s/n 03
- V5 --- Chelsea PAR Sensor (DWIRR) s/n 04
- V6 --- WetLabs Light Scatter Sensor s/n 338
- V7 --- Chelsea MKII Alphatracka 25cm path Transmissometer s/n 161047

Notes

Downward looking (UWIRR) PAR replaced prior to cast CTD019. Replaced with serial number 004. Configuration file changed and saved with suffix “2”

LSS from SS frame (s/n – 339) added to Ti frame prior to cast CTD022

Bottle 6 replaced prior to cast CTD019

Moving Vessel Profiler

A total number of 24 profiles were conducted during the cruise. The sensor configuration was as below:

- MVP300-1700 s/n 10014, with MSFFF:
- AML Micro Sensor CTD s/n 7109
- WETLabs Flash Lamp Fluorometer s/n FLF-370D
- AML Dissolved Oxygen sensor s/n 4815
- Satlantic OCR 507-ICSW Irradiance sensor s/n 0104
- Satlantic OCR 507-R10W Radiance sensor s/n 0055
- PML Tilt and Roll sensor
- SATLANTIC nutrients sensor s/n 345

The instrument was deployed at ~1800 20/9/04 and was profiling well. At ~0500 21/9/04 the control PC for the instrument was showing an emergency stop and it was necessary to recover the instrument manually. On checking the winch assembly it was discovered that the wire had parted and the fish had been lost. This loss will be investigated but it was thought to be prudent not to deploy the spare fish until the exact causes of the loss had been discovered.

Miscellaneous

Salinometer - An Autosal 8400B salinometer was used on this cruise to process 144 samples either from the CTD casts or the underway water. The salinometer was located in the Stable Laboratory and operated at 24°C bath temperature and 21°C to 24°C ambient lab temperature. All samples were processed according to WOCE standards and protocols.

SurfMet – The UKORS “Surf”ace water “Met”eorological suite of instrumentation was run for the duration of the cruise the system comprises;

- Transmissometer
- Fluorimeter
- Conductivity sensor
- Temperature sensor
- Port and Starboard PAR sensors
- Port and Starboard TIR sensors
- Wind direction
- Wind speed

Controlled via a “LabView” program running on a desktop PC

The transmissometer was replaced with a spare on day 285 0925UTC

Both the 75kHz and 150 kHz UKORS vessel mounted ADCP’s were run for the duration of the cruise.

Determination of the concentration and photoreactivity of coloured dissolved organic matter

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Coloured dissolved organic matter (CDOM) is the principle chromophore in most natural waters and the absorbance of sunlight by CDOM is the primary initiator of photochemical reactions in marine and freshwater environments. Photochemical reactions involving CDOM result, among other things, in the mineralisation of a dissolved organic carbon (DOC) to CO_2 and CO, the consumption of dissolved oxygen and oxidation of residual DOC, a shift in the molecular weight and bioavailability of residual DOC, and the photobleaching of CDOM absorbance.

Aims and Objectives

1. To determine how CDOMs spectral properties vary in the different oceanic regions studied.
2. To examine how CDOM photobleaching and the consumption of O_2 during the photodegradation of DOC varies with CDOM levels and character.

Experimental

Determination of CDOM absorbance spectra

Absorbance spectra (220-700 nm) of filtered (0.2 μm) and unfiltered seawater samples were obtained for underway, CTD and irradiation experiment samples using a Tidas ultra violet – visible diode array spectrophotometer with a variable pathlength between 2 and 200 cm (Ultra-Path). Underway samples were collected between 22°N and 40°S, CTD samples and irradiation experiments with CTD water are summarised in Table 1. The exceptionally long maximum pathlength of this setup allowed a level sensitivity far greater than that which is possible with traditional spectrophotometers which typically have a maximum pathlength of 10 cm. This extra sensitivity allowed the accurate measurement of CDOM, particulate absorbance and CDOM photobleaching rates in all waters encountered during the cruise.

Photobleaching Experiments

Irradiation experiments were carried out in gas tight, quartz BOD bottles. These were filled with filtered samples from the CTD. Quartz BOD bottles were then placed in an irradiation tank in direct sunlight. CDOM absorbance levels in the initial, dark and irradiated samples were measured.

CDOM photobleaching followed expected trends. Photobleaching rates were greatest around 300-350 nm and resulted in a steepening of CDOM spectral between 290 and 330 nm. The photobleaching rates will be compared to the original spectral and source characteristics of the samples and used as proxy for other photoreactions based on previous and up coming laboratory studies aimed at using the simple measurement of CDOM photobleaching as a proxy for other photoreaction rates.

Photo-consumption of O_2

An attempt to determine O_2 losses during photochemical degradation of DOC was made in similar experiments. In each experiment 8 borosilicate (glass) BOD bottles and 4 quartz BOD bottles were filled with 0.2 μm filtered samples. 4 glass bottles were fixed immediately for t0's, the other 4 glass bottles were placed in a dark non-toxic supplied water bath and the quartz bottles were placed in the sun in a non-toxic water bath. O_2 levels were determined using a Winkler titration with a titration

photometric endpoint. This method along with sample handling is discussed fully by Pablo Serrett elsewhere in the cruise report.

At present it is impossible to say whether photo-oxidation occurred due to a possible difference in the calibrations of the quartz and glass BOD bottles. This matter will be addressed and the data reassessed in due course.

Table 1. Summary of CDOM spectra determined and photobleaching experiments conducted during AMT15.

Date	CTD No.	CDOM	Photobleaching experiment
21/09/2004	7	12 depths	
22/09/2004	10	12 depths	
23/09/2004	13	12 depths	
24/09/2004	16	12 depths	
25/09/2004	19	12 depths	
26/09/2004	22	12 depths	
28/09/2004	25	12 depths	
29/09/2004	28	12 depths	
30/09/2004	31	12 depths	Y
01/10/2004	34	12 depths	Y
01/10/2004	35	12 depths	
01/10/2004	36	12 depths	
02/10/2004	38	12 depths	
02/10/2004	39	12 depths	
04/10/2004	45	12 depths	Y
05/10/2004	48	12 depths	Y
06/10/2004	51	12 depths	Y
07/10/2004	54	12 depths	Y
09/10/2004	59	12 depths	Y
10/10/2004	62	12 depths	
11/10/2004	63	12 depths	
12/10/2004	66	12 depths	Y
13/10/2004	69	12 depths	Y
14/10/2004	72	12 depths	
15/10/2004	75	12 depths	Y
16/10/2004	78	12 depths	
17/10/2004	80	12 depths	
18/10/2004	83	12 depths	
19/10/2004	86	12 depths	Y
20/10/2004	89	12 depths	Y
21/10/2004	92	12 depths	
22/10/2004	95	12 depths	
23/10/2004	98	12 depths	
24/10/2004	101	12 depths	
25/10/2004	104	12 depths	

Redox, size speciation and distribution of dissolved iron in the Atlantic Ocean

SIMON USSHER
University of Plymouth

Aims

1. To quantify dissolved Fe(II) and dissolved iron (dFe) in <0.2 µm and <0.02 µm fractions using Flow Injection Chemiluminescence (FI-CL).
2. To compare the data set to physical properties of the different water masses (e.g. temperature, dissolved gases) as well as CDOM (in collaboration with Aron Stubbins), in the AMT transect to gain insight into the physico chemical control of iron speciation in the Atlantic Ocean.
3. To compare other nutrient (Katie Chamberlain, PML), chlorophyll and primary production data with iron distributions and assess the significance of iron as a limiting nutrient in different regions covered during the transect.
4. Observe the regional effects of atmospheric flux on dFe concentrations in the surface waters of the transect (in collaboration with Matthieu Waeles, UEA).

Experimental

1. Fe determination

The FI-CL method used an automated flow injection analyser for Fe(II) determination, which provided control of 3 peristaltic pumps (Minipuls 3, Gilson), a 3-way, two-position solenoid valve (EW-01367-72, Cole-Parmer Instrument Co., Hanwell, UK) and a six port injection valve (C22, Valco Instruments Co., Houston, USA) whilst simultaneously powering and acquiring measurement data from a photon counting head (H6240-01, Hamamatsu Photonics, Welwyn Garden City, UK). Instrument control and data acquisition were performed using a notebook computer via an RS-232 connection and all software was written in LabVIEW version 7 (National Instruments Corp.). The flow injection manifold was similar to that reported by Bowie *et al*. (1998; 2002) for the determination of total dissolved iron. It incorporated an 8-HQ preconcentration column and an HCl (0.05 M) carrier was used to elute Fe(II) from the column. An optional buffer line (used only for pH 2 solutions and seawater experiments) mixed ammonium acetate solution with the sample to give a final pH of ~5.5. The 8-HQ column was rinsed before each elution (25 s) to remove any unassociated species using a UHP water wash line controlled via the three-way valve. The flow cell was made from coiled transparent PVC tubing (Altec, Hants, UK) and mounted on the window of the photon counting head.

All measurements reported for both methods are the mean peak heights of 3 or 4 replicates and error bars represent two standard deviations (2s) unless stated otherwise.

Calibration. Experiments conducted with acidified (pH 2) or buffered (pH 5.5) seawater were calibrated by spiking 20 ml aliquots of solution with varying volumes of Fe(II) standard.

Blank measurements. For these experiments the blank was defined as the signal caused by the elution of the 8-HQ column without sample introduction (i.e. by passing only the buffer solution over the column followed by a UHP water wash and elution). Separate reagent blanks will be made for additions made to sample before analysis.

2. Sampling

Watercolumn – Titanium CTD frame and assigned trace metal bottles (10 l Ocean Test) stored in the clean container when not in use. Filtration was performed using PTFE membrane (0.2 µm pore size, 25 mm) and Anotop (0.02 µm pore size syringe, 25 mm). Both filters were connected in-line to an eight channel peristaltic pump (Gilson) allowing simultaneous processing of 6 samples.

Surface – Pumped from a towfish (3-6 m depth) using a diaphragm pump (Sandpiper II), this was connected to the clean container by ½" i.d. polyethylene tubing. The tubing and pump system were initially washed with 5% HCl (ARISTAR, BDH) solution. The seawater flow was split via a Y-piece in the clean container allowing unfiltered seawater and filtered water to be collected underway. The underway filter used was a Sartobran 300 cartridge (Sartorius, 0.2 µm pore size).

3. Results and data presentation

Fe(II) samples were analysed in-situ at each 11:00 a.m. station south of 10°N and show increasing concentrations with depth. Further data analysis will be carried out to determine whether this was a temperature controlled phenomenon.

All dFe analyses will be made at the shore based lab in Plymouth in January and data will be available in early spring 2005

References

Bowie A.R., Achterberg E.P., Mantoura R.F.C., Worsfold P.J. 1998. Determination of sub-nanomolar levels of iron in seawater using flow injection with chemiluminescence detection. Anaytica Chimica Acta 361, 189-200.

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Atmospheric sampling

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Objectives

The atmospheric sampling campaign aims to determine deposition fluxes of key nutrients (N, P and Fe) along the AMT track and to use this information to assess the importance of atmospheric nutrients supply and its contribution to the nutrient limitation of primary productivity. In addition to determining fluxes, our work aims to identify the sources of these nutrients using isotopic composition and air-parcel back trajectories. An additional aim for AMT15 is to determine the isotopic composition of Fe in the soluble fraction (after leaching of the particles with a NH_3/CH_3COOH buffer) and the total fraction. Furthermore the origin of the soluble fraction can be compared to that of the total fraction.

Methods

Sampling was conducted on the Discovery's monkey island when wind conditions permitted, i.e. apparent wind direction was forward of the monkey island ensuring no contamination from the ship's stack. Three high volume aerosol samplers were deployed (see picture). Two of them (for major ions and trace metals sampling) used a 1 m^3 min^{-1} flow and cascade impactors to separate aerosol particles at a diameter of 1 µm. A third system was used for isotopes collection with a higher flow rate (approximately 1.7 m^3 min^{-1}) and without size segregation in order to collect enough material for isotopic measurements.

Two rain samplers (for major ions and trace metals sampling) were deployed when the opportunity presented itself. The funnels were deployed at the end of a boom extended approx 1.5 m forward of the monkey island in order to minimise contamination of the samples by "bounce-off" from the ship's superstructure. The samples collected were processed in a laminar flow hood and subsequently frozen.

A low air sampling system (approx 4 m^3 h^{-1}) connected to a filter pack system was also used for the collection of ammonia gas concentrations. Filters were changed in a glove box under positive pressure of ammonia free air and frozen at -20°C.

Results

All analysis will take place at UEA. However, visual inspections of the aerosol filters indicated that Saharan dust was sampled over a broad latitude range (42°N to 7°N) with very high concentration encountered just off the coast of Morocco/Mauritania. Aerosols from the ITCZ and southern tropical atmosphere appeared to contain significant quantities of black material, which may indicate the presence of biomass burning products. Air in the South Atlantic gyre was very clean.

A log of atmospheric sampling is presented below.

Start date	End date	Start latitude		Trace metals	Major ion	Fe isotopes	NH_3	Rain samples
19-Sep	20-Sep	48.29	N	✓	✓	✓		1
20-Sep	21-Sep	48.03	N	✓	✓	✓	✓	1
21-Sep	22-Sep	47.41	N	✓	✓	✓	✓	
22-Sep	23-Sep	44.52	N	✓	✓	✓	✓	
23-Sep	24-Sep	41.22	N	✓	✓	✓	✓	
24-Sep	25-Sep	37.36	N	blank	blank	✓	✓	
25-Sep	26-Sep	33.55	N	✓	✓	✓	✓	
26-Sep	27-Sep	30.31	N	✓	✓	✓		
27-Sep	28-Sep			collection paused due to wind condition				
28-Sep	29-Sep							
29-Sep	30-Sep	22.27	N	✓	✓	✓	✓	
30-Sep	01-Oct	20.53	N	✓	✓	✓	✓	
01-Oct	02-Oct	20.45	N	✓	✓	✓	✓	
02-Oct	03-Oct	22.09	N	✓	✓	✓		
03-Oct	04-Oct							
04-Oct	05-Oct			collection paused due to wind condition				
05-Oct	06-Oct							
06-Oct	07-Oct	9.52	N	✓	✓	✓	✓	3
07-Oct	08-Oct	6.52	N	✓	✓	✓	✓	3
08-Oct	09-Oct	3.58	N	✓	✓	✓	✓	
09-Oct	10-Oct	1.51	N	✓	✓	✓	✓	
10-Oct	11-Oct	0.59	S	✓	✓	✓	✓	
11-Oct	12-Oct	4.39	S	✓	✓	✓	✓	
12-Oct	13-Oct	8.04	S	✓	✓	✓	✓	
13-Oct	14-Oct	11.42	S	✓	✓	✓	✓	
14-Oct	15-Oct	15.30	S	✓	✓	✓	✓	
15-Oct	17-Oct	19.14	S	✓	✓	✓	✓	2
17-Oct	19-Oct	22.28	S	✓	✓	✓	✓	
19-Oct	21-Oct	25.47	S	✓	✓	✓	✓	
21-Oct	23-Oct	29.05	S	✓	✓	✓	✓	
23-Oct	25-Oct	36.09	S	✓	✓	✓	✓	
25-Oct	27-Oct	40.00	S	✓	✓	✓	✓	

Acknowledgements

Many thanks to the officers Richard, Phil and Darcy who called me whenever rain appeared. Also thanks to the *Discovery* crews.

Synechococcus

KATRIN ZWIRGLMAIER
University of Warwick

Objectives

The objective is to analyse the community biodiversity in ecosystems of different trophic status, i.e. oceanographic provinces. The work will focus on representatives of the genus *Synechococcus* as one of the most abundant groups of picophytoplankton in oceanic waters, which is responsible for up to a quarter of the primary production in some oceanic regions.

Phylogenetic and physiological analysis in combination with the findings from hypotheses 1, 5 and 6 should lead to a better understanding of the specific environmental niches occupied by *Synechococcus*.

Aims

1. Analyse the vertical and longitudinal distribution of *Synechococcus* along the cruise track using two different approaches – DNA based dot blot hybridisation and whole cell based fluorescence in situ hybridisation (FISH).
2. Concentrate cells with a tangential flow system for later cell sorting and fosmid library construction. Libraries derived from a shallow and a deep sample will be compared with regard to physiologically important genes.
3. Isolate new *Synechococcus* strains.

Sampling

Pre-Dawn cast, 3.00 am

Daily samples were taken from the pre dawn cast, 10 litres from 8-11 depths.

Total number of samples taken: 307 samples from 35 stations.

The samples were processed as follows:

- 1.5 ml of each depth were fixed with paraformaldehyde/glutaraldehyde (1%/ 0.5% f.c.) and frozen in liquid N_2. These samples will be used for flow cytometric analysis.
- 10 ml of four selected depths were used for cultures.
- 200 ml of each depth were filtered onto 0.2 µm filters (50 ml on a 25 mm diameter filter, 150 ml on a 47 mm filter). The filters were fixed with paraformaldehyde (1%) and stored at -80°C. The samples will be used for fluorescence in situ hybridisation (FISH).
- 10 litres of each depth were used for size fractionation (3 µm and 0.45 µm filters). The filters were submerged in DNA lysis buffer and stored at -80 C. The samples will be used for DNA isolation and subsequent dot blot analysis.

Monster Cast, 2.00 am

At several points of the cruise track (centre and edge of the gyres and upwelling) 100 litres were sampled from two depths (55% and 0.1% light intensity).

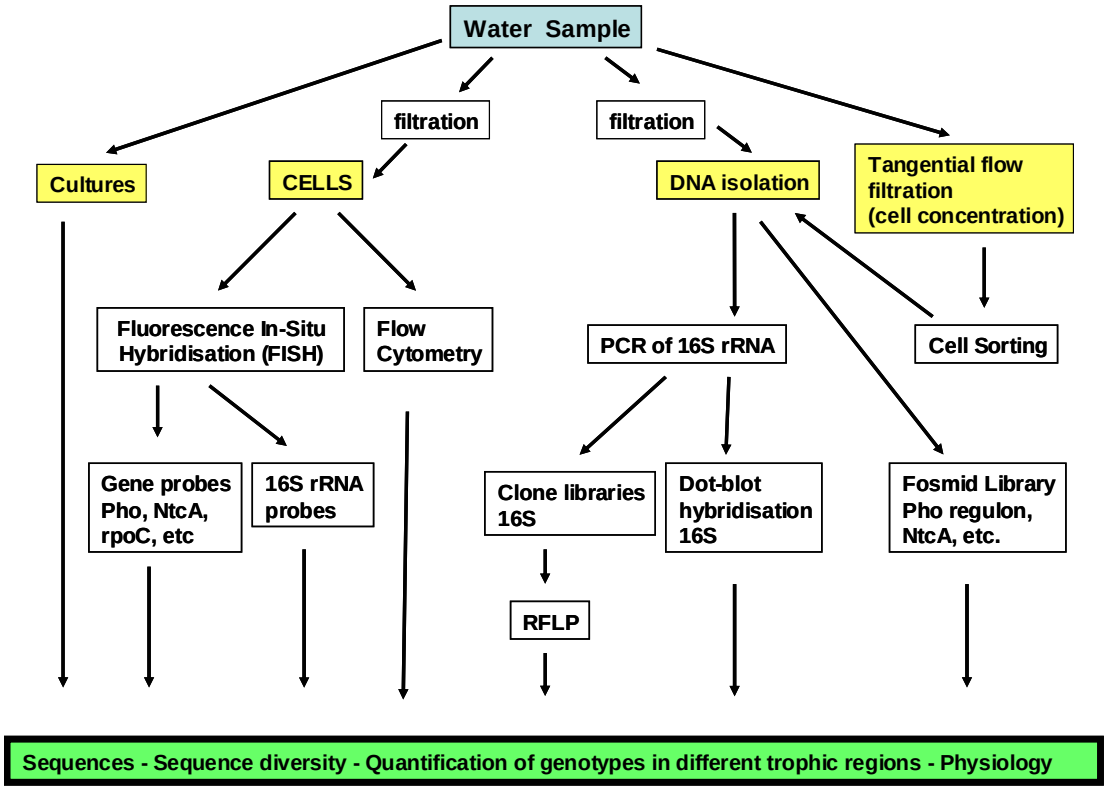
The 100 l were concentrated to about 0.5 ml by tangential flow filtration using a 0.3 µm membrane. The concentrated cells were fixed with paraformaldehyde/glutaraldehyde (1% / 0.5% f.c.), frozen in N_2 and stored at -80°C. The samples will be used for cell sorting and library construction for physiological analysis.

Total number of samples taken : 16 samples from 8 stations

Analysis

All analysis of the samples will be done back in Warwick.

Figure 1. Flow chart summarising the various methods that will be used for phylogenetic and physiological analysis of the samples



Appendix 1 – Station log

AMT 15 – Discovery 284
September – October 2004

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
19.09.04	48°44.06'N	7°50.25'W	0100			0106	0206	01#01	CTD01	150m depth pycnocline 45-50m
								01#02	NET	
						0222	0322	01#03	CTD02	
				0415	**3.25**			01#04	NET	
	48°30.09'N	8°55.09'W	1000			1000	1100	02#01	HyperP	
						1023	1123	02#02	CTD03	175m depth Titanium CTD to 1000m Bottle firing failed
				~1230	**1.5**	1100	1200	02#03	OPTICS	
			1330	1400					CTD	Test cast
20.09.04	48°02.36'N	12°32.21'W	1000	1135	**1.5**	1025	1125	03#01	CTD04	Titan to 100m Cast Bottle firing failed
21.09.04	47°54.92'N	14°36.90'W	0100			0110		04#01	CTD05	Ship to GMT Good cast -> 150m
						0150		04#02	net	Ok
				0415	**3.25**	0227		04#03	CTD#06	Ok -> 300m Bottle 23 didn't close
						0326		04#04	Net	
						0355		04#05	Net	
										~0540 lost mvp fish
	47°42.08'N	15°59.87'W	1100			1116		05#01	CTD#07	Problems with bottle firing Titan. To 500m
				1306	**2.08**	1237		05#02	Optics Rig	
22.09.04	45°59.08'N	18°23.73'W	0200			0206		06#01	CTD#08	Monster. (4069m)
						0240		06#02	Net	
						0305		06#03	CTD#09	Pre-dawn. Bottle 17 didn't fire

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local	STATION No.	EVENT	COMMENTS
				0417	**2.25**	0357	06#04	Net	
	44°55.78'N	19°13.89'W	1100			1100	07#01	HyperP.	Back on deck 1110
						1113	07#02	CTD10	Titan. To 500m
				1224	**1.5**	1117	07#03	OPTICS	Same time as CTD!
23.09.04	42°32.93'N	19°50.28'W	0200	0200		0204	08#01	CTD11	Monster to 150m. (5258 m)
						0211	08#02	NET	Same time as CTD
						0254	08#03	NET	
						0322	08#04	CTD12	Pre-Dawn to 300m
				0415	**2.25**	0340	08#05	NET	
	41°22.43'N	20°00.38'W	1100			1105	09#01	CTD13	No HyperPro Cast to 1000 m (2183m)
				1236	**1.5**	1112	09#02	OPTICS	
24.09.04	38°53.85'N	20°21.07'W	0200			0203	10#01	CTD14	Monster to 150m (4509 m)
						0210	10#02	NET	
						0237	10#03	NET	
				0400		0308	10#04	CTD15	Pre-dawn to 300m
	37°38.83'N	20°30.60'W	1100			1100	11#01	HyperP	
						1115	11#02	CTD16	Cast to 1000m (4064m)
				1250	**1.8**	1116	11#03	Optics	
25.09.04	35°05.98'N	20°51.1'W	0200			0203	12#01	CTD17	Monster to 150m (5199m)
						0208	12#02	Net	
						0247	12#03	Net	
						0314	12#04	Net	
				0415	**2.25**	0326	12#05	CTD18	Pre-dawn to 300m
	33°52.78'N	21°00.31'W	1100			1100	13#01	HyperP	
						1114	13#02	CTD19	
				1212	**1.16**	1115	13#03	Optics	
26.09.04	31°15.59'N	20°42.96'W	0200			0203	14#01	CTD20	Monster to 150m (4838m)
						0210	14#02	Nets	
						0238	14#03	Nets	
				0400	**2**	0306	14#04	CTD21	Pre-dawn to 300m

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
	30°27.79'N	19°28.13'W	1100			1110		15#01	CTD22	mid-day to 1000m
				1236	**1.6**	1113		15#02	Optics	
27.09.04	29°07.67'N	16°57.97'W	0200			0207		16#01	Net	
						0219		16#02	CTD23	Monster to 150m (3850.5m)
						0235		16#03	Net	
						0258		16#04	CTD24	Pre-dawn to 300m
				0348	**1.83**	0301		16#05	Net	
INTO SANTA CRUZ DE TENERIFE TO PICK UP WATER AND SPARES FOR AIR CONDITIONING UNITS										
28.09.04	25°48.16'N	18°42.30'W	1100			1100		17#01	HyperP	
						1105		17#02	CTD25	mid-day to 500m (3194m)
				1212	**1.25**	1110		17#03	Optics	
29.09.04	23°33.18'N	19°59.54'W	0200			0201		18#01	CTD26	Monster to 300m (3849m)
						0206		18#02	Net	
						0238		18#03	Net	
						0308		18#04	Net	
				0406	**2.08**	0315		18#05	CTD26	Pre-dawn to 300m
	22°27.53'N	20°36.99'W	1100			1109		19#01	HyperP	(4177m)
						1110		19#02	CTD27	mid-day to 1000m
				1230	**1.5**	1115		19#03	Optics	
30.09.04	21°22.27'N	18°49.54'W	0200			0203		20#01	Net	(3061m)
						0208		20#02	CTD29	Monster to 150m
						0234		20#03	Net	
				0412	**2.25**	0330		20#04	CTD30	Pre-dawn to 300m
	Begin Upwelling Survey									
	20°51.88'N	17°27.56'W	1200			1200		21#01	HyperP	UP01
						1217		21#02	Optics	
				1242	**0.75**	1220		21#03	CTD31	mid-day to 50m (66m)
	22 14.44'N	17 14.01'W	2100	2133	**0.5**	2106		22#01	CTD32	To 65m (75m) UP02
01.10.04	21°41.13'N	17°50.39'W	0200			0204		23#01	Net	Dolphins UP03
						0212		23#02	CTD33	Monster to 150m (1004m)
						0240		23#03	Net	

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local	STATION No.	EVENT	COMMENTS
						0311	23#04	Net	
				0406	**2.08**	0327	23#05	CTD34	Pre-dawn to 300m
	20°45.48'N	18°51.91'W	1130			1130	24#01	HyperP	UP04
						1145	24#02	CTD35	mid-day to 1000m3025m)
				1300	**1.5**	1150	24#03	Optics	
	20°47.32'N	18° 00.29'W	1755	1845	**0.8**	1757	25#01	CTD36	To 100m (1270m) UP05
02.10.04	21°20.39'N	17°20.34'W	0224			0225	26#01	Net	UP06
						0229	26#02	CTD37	Monster to 50m (75m)
						0241	26#03	Net	
				0354	**1.5**	0325	26#04	CTD38	Pre-dawn to 60m
	21°54.9'N	18°05.5'W	0950	1000					Collect bucket sample from mucus slick
	22°09.51'N	18°22.54'W	1200			1200	27#01	HyperP	UP07
						1210	27#02	CTD39	mid-day to 500m (2716m)
				1318	**1.33**	1212	27#03	Optics	
	22°16.78'N	17°29.94'W	1800	1840	**0.67**	1803	28#01	CTD40	To 200m (1200m) UP08
03.10.04	21°18.18'N	18°34.77'W	0200			0207	29#01	CTD41	Monster to 150m (2737m) UP09
						0207	29#02	Net	
						0253	29#03	Net	
						0308	29#04	CTD42	Pre-dawn to 200m
				0348	**1.8**	0309	29#05	Net	
04.10.04	17°49.84'N	20°52.60'W	0200			0200	30#01	Net	
						0205	30#02	CTD43	Monster to 150m (3117m)
						0229	30#03	Net	
				0342	**1.75**	0301	30#04	CTD44	Pre-dawn to 300m
	16°33.96'N	21°13.27'W	1100			1102	31#01	Optics	
				1224	**1.5**	1108	31#02	CTD45	mid-day to 1000m (3734m)

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
05.10.04	14°18.01'N	21°45.13'W	0200			0200		32#01	CTD46	Monster to 150m (4303m)
						0205		32#02	Net	
						0257		32#03	Net	
						0305		32#04	CTD47	Pre-dawn to 300m Bottle 11 misfire Bottle 1 not seal correct
				0348	**1.8**	0323		32#05	Net	
	13°06.04'N	22°01.12'W	1100			1100		33#01	HyperP	
						1103		33#02	CTD48	mid-day to 500m
				1219	**1.3**	1115		33#03	Optics	
06.10.04	10°59.91'N	22°30.50'W	0200			0202		34#01	CTD49	Monster to 150m (5089m)
						0205		34#02	Net	
						0232		34#03	Net	
				0354	**1.9**	0308		34#04	CTD50	Pre-dawn to 300m
	09°55.09'N	22°46.15'W	1100			1100		35#01	HyperP	
						1104		35#02	CTD51	mid-day to 1000m (4843m)
				1230	**1.5**	1113		35#03	Optics	
07.10.04	07°50.55'N	23°13.73'W	0200			0201		36#01	CTD52	Monster to 150m (4541m)
						0206		36#02	Net	Problems with strong current. Small net damaged
						0224		36#03	Net	
						0252		36#04	Net	
				0406	**2.1**	0317		36#05	CTD53	Pre-dawn to 300m
	06°51.91'N	23°26.66'W	1100			1100		37#01	CTD54	mid-day to 500m (3387m)
				1200	**1.0**	1105		37#02	Optics	
08.10.04	04°45.35'N	23°55.46'W	0200			0201		38#01	CTD55	Monster to 150m (4363m)
						0205		38#02	Net	
08.10.04	04°45.35'N	23°55.46'W	0200			0230		38#03	Net	

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local	STATION No.	EVENT	COMMENTS
						0257	38#04	Net	
				0348	**1.8**	0300	38#05	CTD56	Pre-dawn to 300m
			0800	Ship blacks out					
			0815	Power back on line					
			0840	Bridge control and instruments back on line					
09.10.04	02°30.48'N	24°26.07'W	0200			0207	39#01	CTD57	Monster to 150m (4066m). Single wire deployments
						0237	39#02	Net	
						0308	39#03	Net	
				0430	**2.5**	0346	39#04	CTD58	Pre-dawn to 300m Bottle 11 misfire
	01°51.23'N	24°35.31'W	1100			1100	40#01	Optics	
				1218	**1.3**	1111	40#02	CTD59	mid-day to 500m (3115m)
10.10.04	00°03.91'N	24°58.96'W	0200			0203	41#01	CTD60	Monster to 150m (3579m)
						0215	41#02	Net	
						0244	41#03	Net	
10.10.04	00°03.91'N	24°58.96'W	0200			0303	41#04	CTD61	Pre-dawn to 300m
				0342	**1.75**	0305	41#05	Net	
	00°58.76'S	24°59.90'W	1100			1100	42#01	HyperP	
						1108	42#02	CTD62	mid-day to 500m (3016m)
				1224	**1.4**	1115	42#03	Optics	
			1700 onwards – crossing line party						
11.10.04	04°39.07'S	24°59.78'W	1100			1100	43#01	Optics	
				1224	**1.4**	1105	43#02	CTD63	mid-day to 1000m (5296m)
12.10.04	06°50.81'S	25°00.34'W	0200			0202	44#01	CTD64	Monster to 150m (5601m)
						0207	44#02	Net	
						0242	44#03	Net	
						0307	44#04	CTD65	Pre-dawn to 300m
				0354	**1.9**	0310	44#05	Net	
	08°04.01'S	24°59.83'W	1100	1212	**1.25**	1105	45#01	CTD66	mid-day to 500m (5684m)

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
13.10.04	10°25.09'S	24°59.79'W	0200			0205		46#01	CTD67	Monster to 150m (5243m)
						0209		46#02	Net	
						0237		46#03	Net	
				0342	**1.75**	0258		46#04	CTD68	Pre-dawn to 300m
	11°41.77'S	24°59.80'W	1100			1100		47#01	HyperP	
						1107		47#02	CTD69	mid-day to 1000m (6316m)
				1236	**1.6**	1116		47#03	Optics	
14.10.04	14°10.62'S	24°59.71'W	0200			0203		48#01	CTD70	Monster to 150m (4763m)
						0209		48#02	Net	
						0253		48#03	Net	
						0259		48#04	CTD71	Pre-dawn to 300m
				0342	**1.75**	0321		48#05	Net	
	15°29.86'S	24°59.39'W	1100			1100		49#01	HyperP	
						1104		49#02	CTD72	mid-day to 500m (4997m)
				1218	**1.3**	1110		49#03	Optics	
15.10.04	17°57.17'S	24°59.99'W	0200			0205		50#01	CTD73	Monster to 200m (5364m)
						0207		50#02	Net	
						0238		50#03	Net	
				0354	**1.9**	0312		50#04	CTD74	Pre-dawn to 300m Bott. 8 misfire Botts.17&13 not closed
	19°14.20'S	24°59.87'W	1100			1100		51#01	HyperP	
						1105		51#02	CTD75	mid-day to 1000m (5179m)
				1236	**1.6**	1112		51#03	Optics	
16.10.04	20°38.30'S	23°40.32'W	0200			0200		52#01	CTD76	Monster to 250m (5429m) Bott. 8 misfire
						0206		52#02	Net	
						0240		52#03	Net	
						0307		52#04	Net	
				0354	**1.9**	0312		52#05	CTD77	Pre-dawn to 300m Bott. 23 leaking?

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
	21°02.24'S	22°50.20'W	1000			1008		53#01	CTD78	mid-day to 5000m (5094m)
				1348	**3.8**	1055		53#02	Optics	
17.10.04	21°55.39'S	20°58.93'W	0200			0203		54#01	CTD79	Monster to 250m (5201m) CTD wire out of sheave
						0205		54#02	Net	
				0330	**1.5**	0239		54#03	Net	
			No pre-dawn cast due to damage to CTD cable							
	22°28.26'S	19°49.55'W	1100			1100		55#01	CTD80	mid-day to 500m (4794m)
				1212	**1.25**	1104		55#02	Optics	
18.10.04	23°33.88'S	17°30.26'W	0200			0202		56#01	CTD81	Monster to 275m (4052m)
						0204		56#02	Net	
						0244		56#03	Net	
						0311		56#04	CTD82	Pre-dawn to 300m
				0400	**2**	0313		56#05	Net	
	24°07.85'S	16°17.15'W	1100			1100		57#01	HyperP	
						1105		57#02	CTD83	mid-day to 1000m (3749m)
				1230	**1.5**	1113		57#03	Optics	
19.10.04	25°14.04'S	13°55.42'W	0200			0207		58#01	CTD84	Monster to 250m (3124m)
						0210		58#02	Net	
						0236		58#03	Net	
				0400	**2**	0320		58#04	CTD85	Pre-dawn to 300m Botts. 23&24 no-fire
	25°47.28'S	12°43.89'W	1100			1100		59#01	HyperP	(3528m)
						1104		59#02	CTD86	mid-day to 500
				1218	**1.3**	1117		59#03	Optics	
20.10.04	26°53.11'S	10°20.19'W	0200			0203		60#01	CTD87	Monster to 350m (3799m)
						0204		60#02	Net	
						0233		60#03	Net	

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
						0255		60#04	Net	
				0400	**2**	0316		60#05	CTD88	Pre-dawn to 300m
	27°26.33'S	09°07.29'S	1100			1100		61#01	HyperP	(4150m)
						1105		61#02	CTD89	mid-day to 1000m
				1224	**1.4**	1120		61#03	Optics	
21.10.04	28°35.04'S	06°34.36'W	0100			0200	0300	62#01	CTD90	Monster to 250m (4124m) Clocks forward 1hour
						0208	0308	62#02	Net	
						0231	0331	62#03	Net	
				0350	**1.8**	0306	0406	62#04	CTD91	Pre-dawn to 300m
	29°04.64'S	05°28.07'W	1000			1000	1100	63#01	HyperP	
						1007	1107	63#02	CTD92	mid-day to 500m (4441m)
				1118	**1.3**	1014	1114	63#03	Optics	
22.10.04	31°08.47'S	03°55.29'W	0100			0103	0203	64#01	CTD93	Monster to 200m (4528m)
						0108	0208	64#02	Net	
						0151	0251	64#03	Net	
						0210	0310	64#04	CTD94	Pre-dawn to 300m Botts. 13&23 no seal Bott. 6 misfire at surf?
				0248	**1.8**	0213	0313	64#05	Net	
	29°04.64'S	05°28.07'W	1000			1000	1100	65#01	HyperP	(4452m)
						1002	1102	65#02	CTD95	mid-day to 1000m
22.10.04	29°04.64'S	05°28.07'W	1000	1118	**1.3**	1011	1111	65#03	Optics	
23.10.04	34°30.87'S	01°22.75'W	0100			0109	0209	66#01	CTD96	Monster to 150m (4386m)
						0112	0212	66#02	Net	
						0140	0240	66#03	Net	
				0254	**1.9**	0215	0315	66#04	CTD97	Pre-dawn to 300m
	35°39.91'S	00°27.80'W	1000			1000	1100	67#01	HyperP	(4060m)
						1005	1105	67#02	CTD98	mid-day to 500m
				1112	**1.25**	1015	1115	67#03	Optics	
24.10.04	37°49.66'S	01°13.55'E	0100			0102	0202	68#01	CTD99	Monster to 150m

DATE	LAT	LONG	ARRIVAL STATION (GMT)	LEAVE STATION	TIME ON STATION (hours)	TIME GMT - local		STATION No.	EVENT	COMMENTS
										(4983m)
						0105	0205	68#02	Net	
						0133	0233	68#03	Net	
						0155	0255	68#04	Net	
				0242	**1.75**	0202	0302	68#05	CTD100	Pre-dawn to 300m
	39°01.06'S	02°11.59'E	1000			1000	1100	69#01	HyperP	(5130m)
						1002	1102	69#02	CTD101	mid-day to 1000m
				1118	**1.3**	1010	1110	69#03	Optics	
25.10.04	40°00.07'S	05°00.80'E	0100			0101	0201	70#01	CTD102	Monster to 99m (5012m)
						0106	0206	70#02	Net	
				0218	**1.3**	0133	0233	70#03	CTD103	Pre-dawn to 300m
	39°59.91'S	06°53.83'E	1000			1005	1105	71#01	CTD104	mid-day to 500m
				1112	**1.25**	1025	1125	71#02	Optics	
26.10.04	40°00.91'S	10°01.59'E	0054			0103	0203	72#01	CTD105	Pre-dawn to 300m (4898m)
				0148	**1.9**	0110	0210	72#02	Net	

Appendix 2 – Station variables

DATE	LAT	LONG	Time (GMT)	Station No.	Surface					Approx Depth		Atmos. press.	Water Depth (m)
					Temp (°C)	Salinity	Fluor. (mV)	NO_3+ NO_2 (µmol/l)	Chlpll. (mg/m3)	Thermo cline (m)	Fluor. Max (m)		
19.09.04	48°44.06'N	7°50.25'W	0100	01	-	-	-	0.04	0.81	45-50	-		150
	48°30.09'N	8°55.09'W	1000	02	16.98	35.734	372	misfire	Misfire	-	-		175
20.09.04	48°02.36'N	12°32°21W	1000	03	17.08	35.876	295	Firing failed	Firing failed	45	55		4324
21.09.04	47°54.92'N	14°36.90'W	0100	04	16.55	35.820	420	0.07	0.84	60	45		4599
	47°42°08'N	15°59°87'W	1100	05	16.82	35.883	276	0.03	0.29	40	30		4796
22.09.04	45°59.08'N	18°23.73'W	0200	06	18.65	36.105	195	<0.03	0.20	45	58		4069
	44°55.78'N	19°13.89'W	1100	07	18.44	35.992	203	<0.03	-	45	55		4062
23.09.04	42°32.93'N	19°50.28'W	0200	08	19.88	36.141	182	0.03	0.27	40	80		5258
	41°22.43'N	20°00.38'W	1100	09	20.13	36.270	172	0.03	0.19	55	75		2183
24.09.04	38°53.85'N	20°21.07'W	0200	10	21.77	36.571	161	0.04	0.18	50	75		4509
	37°38.83'N	20°30.60'W	1100	11	23.06	36.820	161	-	0.12	40	85		4050
25.09.04	35°05.98'N	20°51.1'W	0200	12	24.09	36.848	154	<0.03	0.10	35	86		5197
	33°52.78'N	21°00.31'W	1100	13	24.64	37.366	154	<0.03	0.07	45	100		5187
26.09.04	31°15.59'N	20°42.96'W	0200	14	24.70	37.447	153	0.04	0.08	55	115		4838
	30°27.79'N	19°28.13'W	1100	15	24.58	37.38	155	<0.03	0.08	50	110		4724
27.09.04	29°07.67'N	16°57.97'W	0200	16	24.36	37.153	157	0.07	0.14	50	116		5176
28.09.04	25°18.12'N	18°42.1'W	1100	17	26.03	37.319	174	0.04	0.14	45	85		3850
29.09.04	23°33.26'N	19°59.34'W	0200	18	25.07	37.020	146	0.03	0.17		50		3846
	22°27.53'N	20°36.99'W	1100	19	24.23	36.878	143	0.03	0.16	60	60	1014.8	4177
30.09.04	21°22.27'N	18°49.54'W	0200	20	23.39	36.377	300	0.06	1.05	30	30	1011.4	3071
	20°51.88'N	17°27.56'W	1200	21 UP01	20.07	36.072	580	6.9	6.58	10	Mixed to 10m	1012.7	66
	22°14.44'N	17°14.01'W	2100	22 UP02	21.08	36.644	410	1.18	3.44	10 & 18	Mixed to 10m	1012.3	75
01.10.04	21°41.13'N	17°50.39'W	0200	23 UP03	21.51	36.216	400	0.13	2.37	50	Mixed to 50m	1011.9	1004

DATE	LAT	LONG	Time (GMT)	Station No.	Surface					Approx Depth		Atmos. press.	Water Depth (m)
					Temp (°C)	Salinity	Fluor. (mV)	NO_3+ NO_2 (µmol/l)	Chlpll. (mg/m3)	Thermo cline (m)	Fluor. Max (m)		
01.10.04	20°45.48 N	18°51.91'W	1130	24 UP04	24.71	36.389	180	0.06	0.39	25	25	1014.0	3025
	20°47.32 N	18°00.29'W	1755	25 UP05	23.15	36.279	513	1.74	3.27	Fall from 10/20	Mixed to 30	1011.4	1270
02.10.04	21°20.39'N	17°20.34'W	0224	26 UP06	19.87	36.237	1061	4.31	12.5	25	Mixed to 25	1011.9	75
	22°09.51'N	18°22.54'W	1200	27 UP07	21.87	36.138	222	0.71	0.45	25/30	30	1013.3	2716
	22°16.78'N	17°29.94 W	1800	28 UP08	22.51	36.389	316	3.53	1.01	35	30	1011.7	1200
03.10.04	21.18.18'N	18°34.77'W	0200	29 UP09	23.72	36.297	262	0.03	0.93	50	45	1012.8	2737
04.10.04	17°49.84'N	20°52.60'W	0200	30	26.68	36.542	236	0.04	0.16	50-60	50	1011.9	3117
	16°33.96'N	21°13.27'W	1100	31	27.34	36.607	249	0.04	0.17	32	60	1012.7	3734
05.10.04	14°18.01'N	21°45.13'W	0200	32	28.24	36.061	258	0.09	0.19	17	50	1010.1	4303
	13°06.04'N	22°01.12'W	1100	33	28.63	35.885	270	0.05	0.17		45		4696
06.10.04	10°59.91'N°	22°30.50'W	0200	34	28.94	35.51	291	<0.03	0.12	25	60	1010.5	5089
	09°55.09'N	22°46.15'W	1100	35	29.01	35.701	304	<0.03	0.18	20-30	50	1012.1	4843
07.10.04	07°50.55'N	23°13.73'W	0200	36	29.00	35.64	304	<0.03	0.15	Slow fall to 40m	60	1010.1	4541
	06°51.91'N	23°26.66'W	1100	37	28.89	35.063	318	<0.03	0.14	20	45	1012	3387
08.10.04	04°45.35'N	23°55.46'W	0200	38	28.14	34.551	324	<0.03	0.10	50	75	1010.3	4375
			0800	Ship blacks out									
			0815	Power back on line									
			0840	Bridge control and instruments back on line									
09.10.04	02°30.48'N	24°26.07'W	0200	39	27.91	35.571	314	<0.03	0.13	35	80	1011.4	4066
	01°51.23'N	24°35.31'W	1100	40	27.60	35.802	305	<0.03	0.00	75-80	75	1013.6	3115

DATE	LAT	LONG	Time (GMT)	Station No.	Surface					Approx Depth		Atmos. press.	Water Depth (m)
					Temp (°C)	Salinity	Fluor. (mV)	NO_3+ NO_2 (µmol/l)	Chlpll. (mg/m3)	Thermo cline (m)	Fluor. Max (m)		
10.10.04	00°03.91'N	24°58.96'W	0200	41	26.48	36.154	348	0.08	0.15	50-100 (75?)	65	1011.0	4237
	00°58.76'S	24°59.90'W	1100	42	26.46	36.161	323	<0.03	0.18	75-80	75 (50-80)	1013.3	3016
11.10.04	04°39.07'S	24°59.78'W	1100	43	26.26	36.224	275	<0.03	0.10	70	80	1013.1	5296
12.10.04	06°50.81'S	25°00.34'W	0200	44	25.85	36.299	273	<0.03	0.11	75	100	1012.4	5601
	08°04.01'S	24°59.83'W	1100	45	25.36	36.299	268	<0.03	0.09	120	120	1013.8	5684
13.10.04	10°25.09'S	24°59.79'W	0200	46	25.38	36.483	251	<0.03	0.10	75	125	1012.6	5195
	11°41.77'S	24.59.80'W	1100	47	25.19	36.654	244	<0.03	0.07	60	133	1014.6	6316
14.10.04	14°10.62'S	24°59.71'W	0200	48	24.68	37.09	228	<0.03	0.05	25 & 125	140	1013.5	4866
	15°29.86'S	24°59.39'W	1100	49	23.89	37.254	226	<0.03	0.04	75 & 160	165	1016.5	4997
15.10.04	17°57.17'S	24°59.99'W	0200	50	23.80	37.277	215	<0.03	0.03	150	170	1015.9	5366
	19°14.20'S	24°59.87'W	1100	51	23.58	37.182	210	<0.03	0.02	150	160	1018.7	5179
16.10.04	20°38.30'S	23°40.32'W	0200	52	23.34	37.156	202	<0.03	Lost surface sample	130 - 150	170	1019.8	5429
	21°02.24'S	22°50.20'W	1000	53	23.18	37.136	198	<0.03	0.03	155	170	1020.8	5094
17.10.04	21°55.39'S	20°58.93'W	0200	54	22.52	37.017	192	<0.03	0.05	145	170	1019.5	5201
	22°28.26'S	19°49.55'W	1100	55	22.32	36.943	185	<0.03	0.04	90	150	1021.0	4794
18.10.04	23°33.88'S	17°30.26'W	0200	56	21.65	36.807	184	<0.03	0.06	170	180	1020.4	4102
	24°07.85'S	16°17.15'W	1100	57	21.26	36.646	178	<0.03	0.05	113	150	1021.5	3749
19.10.04	25°14.04'S	13°55.42'W	0200	58	20.89	36.614	174	<0.03	0.04	100/ 130	150	1022.0	3073
	25°47.28'S	12°43.89'W	1100	59	20.44	36.491	167	<0.03	0.04	100/ 120	150	1023.1	3528
20.10.04	26°53.11'S	10°20.19'W	0200	60	19.58	36.334	168	0.04	0.05	135	150	1022.1	3793
	27°26.33'S	09°07.29'S	1100	61	19.57	36.333	162	<0.03	0.06	38&85	117	1024.6	4150
21.10.04	28°35.04'S	06°34.36'W	0200	62	18.72	36.100	170	<0.03	0.09	105	110	1023.6	4172
	29°04.64'S	05°28.07'W	1000	63	18.36	35.996	166	<0.03	0.08	125	70	1025.5	4441
22.10.04	31°08.47'S	03°55.29'W	0100	64	17.87	35.888	168	<0.03	0.01	20-30 &100	100	1023.6	4452

DATE	LAT	LONG	Time (GMT)	Station No.	Surface					Approx Depth		Atmos. press.	Water Depth (m)
					Temp (°C)	Salinity	Fluor. (mV)	NO_3+ NO_2 (µmol/l)	Chlpll. (mg/m3)	Thermo cline (m)	Fluor. Max (m)		
	29°04.64'S	05°28.07'W	1000	65	17.57	35.731	148	<0.03	0.07	10 & 120	100	1023.2	4306
23.10.04	34°30.87'S	01°22.75'W	0100	66	17.05	35.535	177	<0.03	0.12	25-30	85	1021.8	4393
	35°39.91'S	00°27.80'W	1000	67	15.56	35.073	193	1.66	0.39	20	38&55	1023.2	4060
24.10.04	37°49.66'S	01°13.55'E	0100	68	13.76	34.844	355	2.57	0.38	25-30	40	1025.1	4983
	39°01.06'S	02°11.59'E	1000	69	12.51	34.738	210	4.67	0.42	30-35	45	1025.6	5130
25.10.04	40°00.07'S	05°00.80'E	0100	70	11.14	34.529	368		0.59	37	45	1020.6	5001
	39°59.91'S	06°53.83'E	1000	71	10.72	34.481	205		0.61		50	1023.8	5377
26.10.04	40°00.91'S	10°01.59'E	0054	72	12.75	34.957	293		0.44	75	Mixed to 75m	1026.8	4898

Appendix 3 – Underway sampling

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N	Nutrients
19-Sep	08:18	8	8	8	0.53	0818190904	0818190904	
19-Sep	15:01	9	9	9	0.46	1501190904	1501190904	
19-Sep	18:05	10	10	10	0.66	1805190904	1805190904	
19-Sep	21:06	11	11	11	0.36	2106190904	2106190904	
19-Sep	23:59	12	12	12	0.35	2359190904	2359190904	
20-Sep	03:07	13	13	13	0.27	0307200904	0307200904	
20-Sep	06:00	14	14	14	0.55	0600200904	0600200904	
20-Sep	09:01	15	15	15	0.49	0901200904	0901200904	
20-Sep	13.05	16	16	16	0.40	1305200904	1305200904	
20-Sep	15.07	17	17	17	0.20	1507200904	1507200904	X
20-Sep	18.00	18	18	18	0.29	1800200904	1800200904	
20-Sep	21.00	19	19	19	0.32	2100200904	2100200904	
21-Sep	0:04	20	20	20	0.35	0004210904	0004210904	
21-Sep	9:00	29	29	27		0900210904	0900210904	
21-Sep	15:03	34	34	34		1503210904	1503210904	X
21-Sep	21:00	35	35	35		2100210904	2100210904	
22-Sep	15.16	48	48	48	0.19	1516220904	1516220904	X
22-Sep	21.20	49	49	49	0.29	2120220904	2120220904	
23-Sep	8.55	58	58	58	0.12	0900230904	0900230904	
23-Sep	15.02	65	65	65	0.16	1515230904	1515230904	X
23-Sep	20.40	66	66	66	0.09			
24-Sep	9.05	75	75	75	0.12	0905240904	0905240904	
24-Sep	15.18	82	82	82	0.07	1518240904	1518240904	X
24-Sep	21.15	83	83	83	0.08	2115240904	2115240904	
25-Sep	9.06	92	92	92	0.09	0900250904	0900250904	
25-Sep	15.00	100	100	100		1500250904	1500250904	X
26-Sep	8.50	109	109	109	0.07	0850260904	0850260904	
26-Sep	15.00	118	118	118	0.06	1500260904	1500260904	X
26-Sep	21.05	119	119	119	0.13	2105260904	2105260904	
28-Sep	15.01	134	134	134	0.13	1501280904	1501280904	X
28-Sep	21.00	135	135	135				
29-Sep	9.00	144	144	144	0.14	0900290904	0900290904	
29-Sep	15.02	151	151	151	0.15	1502290904	1502290904	X
29-Sep	21.15	152	152	152	0.23	2115290904	2115290904	
30-Sep	9.05	159	159	159	0.73	0905300904	0905300904	
30-Sep	15.43	166	166	166	12.68	1543300904	1543300904	
1-Oct	9.01	179	179	179	0.38	0901011004	0901011004	
1-Oct	15.15	186	186	186	0.39	1515011004	1515011004	
2-Oct	9.09	199	199	199	1.91	0909021004	0909021004	
2-Oct	15.00	212	212	212	1.06	1500021004	1500021004	
3-Oct	8.59	219	219	219	0.49	0859031004	0859031004	
4-Oct	8.43	229	229	229		0843041004	0843041004	
4-Oct	15.06	236	236	236	0.16	1506041004	1506041004	X
4-Oct	21.00	245	245	245				
5-Oct	9.00	246	246	246	0.03	0900051004	0900051004	
5-Oct	15.01	253	253	253	0.14	1501051004	1501051004	X

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N	Nutrients
5-Oct	20.58	254	254	254				
6-Oct	9.02	263	263	263	0.14	0902061004	0902061004	
6-Oct	15.00	270	270	270	0.19	1500061004	1500061004	X
7-Oct	9.03	279	279	279	0.22	0903071004	0903071004	
7-Oct	14.58	286	286	286	0.15	1458071004	1458071004	X
8-Oct	15.04	295	295	295	0.10	1504081004	1504081004	
8-Oct	19.47	296	296	296	0.08	1947081004	1947081004	
9-Oct	8.34	305	305	305				
9-Oct	15.03	312	312	312	0.11	1503091004	1503091004	X
9-Oct	20.06	313	313	313	0.11	2006091004	2006091004	
10-Oct	8.33	322	322	322				
10-Oct	15.00	329	329	329	0.13	1500101004	1500101004	X
10-Oct	20.58	330	330	330	0.13	2058101004	2058101004	
11-Oct	7.58	331	331	331	0.13	0758111004	0758111004	
11-Oct	14.58	338	338	338	0.09	1458111004	1458111004	X
11-Oct	20.53	339	339	339	0.10	2053111004	2053111004	
12-Oct	8.59	349	349	349	0.11	0859121004	0859121004	
12-Oct	14.48	356	356	356	0.14	1448121004	1448121004	X
12-Oct	20.06	357	357	357	0.12	2006121004	2006121004	
13-Oct	9.10	365	365	365	0.08	0910131004	0910131004	
13-Oct	14.47	372	372	372	0.07	1447131004	1447131004	X
13-Oct	19.45	373	373	373	0.07	1945131004	1945131004	
14-Oct	9.05	381	381	381	0.05	0905141004	0905141004	
14-Oct	14.44	388	388	388	0.03	1444141004	1444141004	X
14-Oct	19.50	389	389	389	0.04	1950141004	1950141004	
15-Oct	8.32	397	397	397	0.04	0832151004	0832151004	
15-Oct	14.49	404	404	404	0.03	1449151004	1449151004	X
15-Oct	20.10	405	405	405	0.03	2010151004	2010151004	
16-Oct	9.17	413	413	413	0.04	0917161004	0917161004	
16-Oct	19.31	429	429	429	0.03	1931161004	1931161004	
17-Oct	9.00	430	430	430	0.04	0900171004	0900171004	
17-Oct	14.29	437	437	437	0.05	1429171004	1429171004	X
17-Oct	19.31	438	438	438	0.05	1931171004	1931171004	
18-Oct	8.24	445	445	445		0824181004	0824181004	
18-Oct	15.07	452	452	452	0.05	1507181004	1507181004	X
18-Oct	19.48	453	453	453	0.05	1948181004	1948181004	
19-Oct	9.38	461	461	461	0.04	0938191004	0938191004	
19-Oct	15.00	468	468	468	0.05	1500191004	1500191004	X
19-Oct	21.00	469	469	469	0.04	2100191004	2100191004	
20-Oct	7.03	477	477	477	0.05	0703201004	0703201004	
20-Oct	14.59	484	484	484	0.05	1459201004	1459201004	X
20-Oct	19.56	485	485	485	0.04	1956201004	1956201004	
21-Oct	7.52	493	493	493	0.07	0752211004	0752211004	
21-Oct	15.19	500	500	500	0.07	1519211004	1519211004	X
21-Oct	18.33	501	501	501	0.08	1833211004	1833211004	
22-Oct	6.01	509	509	509	0.05	0601221004	0601221004	
22-Oct	14.03	516	516	516	0.08	1403221004	1403221004	X
22-Oct	18.34	517	517	517	0.08	1834221004	1834221004	
23-Oct	6.01	525	525	525	0.12	0601231004	0601231004	

Date	GMT	PIC #	BSi #	Cell Counts	Chl (mg m-3)	HPLC	POC/N	Nutrients
23-Oct	14.00	532	532	532	0.29	1400231004	1400231004	X
23-Oct	18.37	533	533	533	0.35	24-10-4 1	24-10-4 2	
24-Oct	6.16	542	542	542	0.44	24-10-4 3	24-10-4 4	
24-Oct	13.46				0.51	24-10-4 5	24-10-4 6	
24-Oct	14.43	549	549	549	0.58	1443241004	1443241004	
24-Oct	18.34	550	550	550	0.49	1834241004	1834241004	
25-Oct	5.39	559	559	559	0.49	0539251004	0539251004	
25-Oct	15.34	566	566	566		1534251004	1534251004	
25-Oct	18.47	567	567	567	0.44	1847251004	1847251004	

Appendix 4 – Underway DIC

Date	Time	Sample ID	Latitude		Longitude		Temp.(°C)	Salinity
22-Sep	1508	uw1	44	24.25	-19	26.93	18.39	35.96
23-Sep	0312	uw2	42	33.27	-19	50.16	20.27	35.97
23-Sep	0902	uw3	41	42.31	-19	58.54	20.63	36.15
23-Sep	1550	uw4	40	44.79	-20	6.07	22.06	36.40
23-Sep	2100	uw5	39	47.2	-20	13.8	22.3	36.48
24-Sep	0438	uw6	38	45.97	-20	22.28	21.73	36.17
24-Sep	0925	uw7	37	53.62	-20	29.41	23.15	36.58
24-Sep	1515	uw8	37	10.41	-20	34.97	23.32	36.62
24-Sep	2100	uw9	36	1.88	-20	43.91	24.25	36.72
25-Sep	0915	uw10	34	10.45	-20	58.88	24.47	36.85
25-Sep	1600	uw11	33	9.13	-21	6.29	25.26	37.11
25-Sep	2145	uw12	32	2.44	-21	2.35	25.08	37.15
26-Sep	1513	uw13	30	12.06	-18	58.58	25.08	37.15
26-Sep	2110	uw14	29	36.08	-17	50.99	24.94	37.07
28-Sep	1501	uw15	25	21.18	-18	57.82	25.07	36.84
28-Sep	2103	uw16	24	19.67	-19	33.01	25.32	36.91
29-Sep	0905	uw17	22	43.49	-20	27.5	25.58	36.97
29-Sep	1710	uw18	21	56.47	-20	22.58	24.93	36.70
29-Sep	2100	uw19	21	42.3	-19	42.1	23.9	36.58
30-Sep	2140	uw20	22	13.8	-17	14.61	21.19	36.46
01-Oct	0500	uw21	21	35.25	-17	55.99	22.13	36.02
02-Oct	1505	uw22	22	12.44	-18	2.17	22.28	35.98
03-Oct	0910	uw23	20	35.75	-19	21.18	24.5	36.26
03-Oct	1600	uw24	19	37.08	-20	9.21	26.6	36.48
03-Oct	2108	uw25	18	39.92	-20	31.94	26.14	36.31
04-Oct	1504	uw39	16	9.27	-21	19.13	28.18	36.30
04-Oct	2100	uw49	15	8.09	-23	31.77	28.57	35.90
05-Oct	0424	uw40	14	12.85	-21	46.09	28.39	35.86
05-Oct	0910	uw41	13	23.05	-21	57.56	28.71	35.78
05-Oct	1550	uw42	12	32.28	-22	9.46	29.36	35.62
05-Oct	2100	uw43	11	44.5	-22	20.7	29.23	35.51
06-Oct	0905	uw44	10	12.41	-22	41.24	29.21	35.45
06-Oct	1515	uw45	9	27.27	-22	51.78	29.41	35.45
07-Oct	0455	uw48	7	46.97	-23	14.81	29.02	35.37
07-Oct	0950	uw50	7	1.71	-23	24.61	29.11	35.03
07-Oct	1505	uw301	6	25.47	-23	32.87	29.07	34.94
08-Oct	0410	uw302	4	37.34	-23	56.78	28.29	34.37
08-Oct	1400	uw303	3	43.54	-24	9.43	28.53	35.20
09-Oct	1000	uw304	1	56.09	-24	33.91	27.89	35.66
10-Oct	0155	uw305	0	3.82	-24	58.92	26.74	36.05
11-Oct	1500	uw306	-5	0.09	-24	59.9	26.68	36.16
12-Oct	0440	uw307	-6	58.51	-25	0.35	26.15	36.21
12-Oct	0905	uw308	-7	54.91	-25	0.04	25.9	36.25
12-Oct	1510	uw309	-8	32.46	-24	59.94	25.86	36.25
12-Oct	2105	uw310	-9	35.28	-24	59.76	25.73	36.27
13-Oct	0400	uw311	-10	27.46	-24	59.47	25.6	36.39
13-Oct	0925	uw312	-11	25.17	-25	0.09	25.28	36.61

Date	Time	Sample ID	Latitude		Longitude		Temp.(°C)	Salinity
13-Oct	1520	uw313	-12	11.18	-24	59.58	25.42	36.63
13-Oct	2003	uw314	-13	4.47	-25	0.18	25.48	36.56
14-Oct	0410	uw315	-14	15.1	-24	59.4	24.86	37.01
14-Oct	0900	uw316	-15	9.8	-24	59.7	24.91	36.92
14-Oct	1945	uw317	-16	48.9	-24	59.98	24	37.29
15-Oct	0920	uw318	-18	57.1	-24	59.99	23.86	37.08
16-Oct	0310	uw319	-20	38.2	-23	40.2	23.34	37.16
16-Oct	0935	uw0290	-21	0.9	-22	52.8	23.41	37.02
17-Oct	0402	uw321	-21	57.1	-20	54.7	22.83	36.91
17-Oct	1515	uw322	-22	42.7	-19	18.4	22.71	36.84
18-Oct	0450	uw323	-23	37.7	-17	21.8	21.96	36.71
18-Oct	1235	uw324	-24	8.2	-16	16.4	21.28	36.64
18-Oct	1935	uw325	-24	42.5	-15	3.1	21.67	36.60
19-Oct	1210	uw350	-25	47.3	-12	43.5	20.81	36.39
19-Oct	1915	uw352	-26	20.4	-11	30.5	20.2	36.24
20-Oct	0435	uw353	-26	54.8	-10	15.1	19.66	36.14
20-Oct	1300	232	-27	29.15	-9	0.6	19.2	35.96
20-Oct	2010	uw63	-28	5.25	-7	41.5	19.11	35.96
22-Oct	0955	uw356	-32	6.4	-3	12.3	17.68	35.61
22-Oct	1945	uw357	-33	30.9	-2	8.5	18.12	35.70
23-Oct	0405	uw358	-34	32.5	-1	21.5	17.36	35.51
23-Oct	1945	uw359	-36	51.9	0	27.7	15.53	35.16
24-Oct	0345	uw360	-37	50.6	1	14.6	14.1	34.79
24-Oct	1820	uw361	-40	0	3	2.2	12.34	34.56
25-Oct	0405	uw362	-39	59.9	5	12.3	11.81	34.51
25-Oct	1315	uw363	-39	59.6	7	7.7	11.22	34.41
26-Oct	0250	uw364	-40	0	10	2.3	12.75	34.96

The survivors! The assembled ship and scientific crews who managed to reach the foc'sle – 24 hours before arrival into Cape Town.