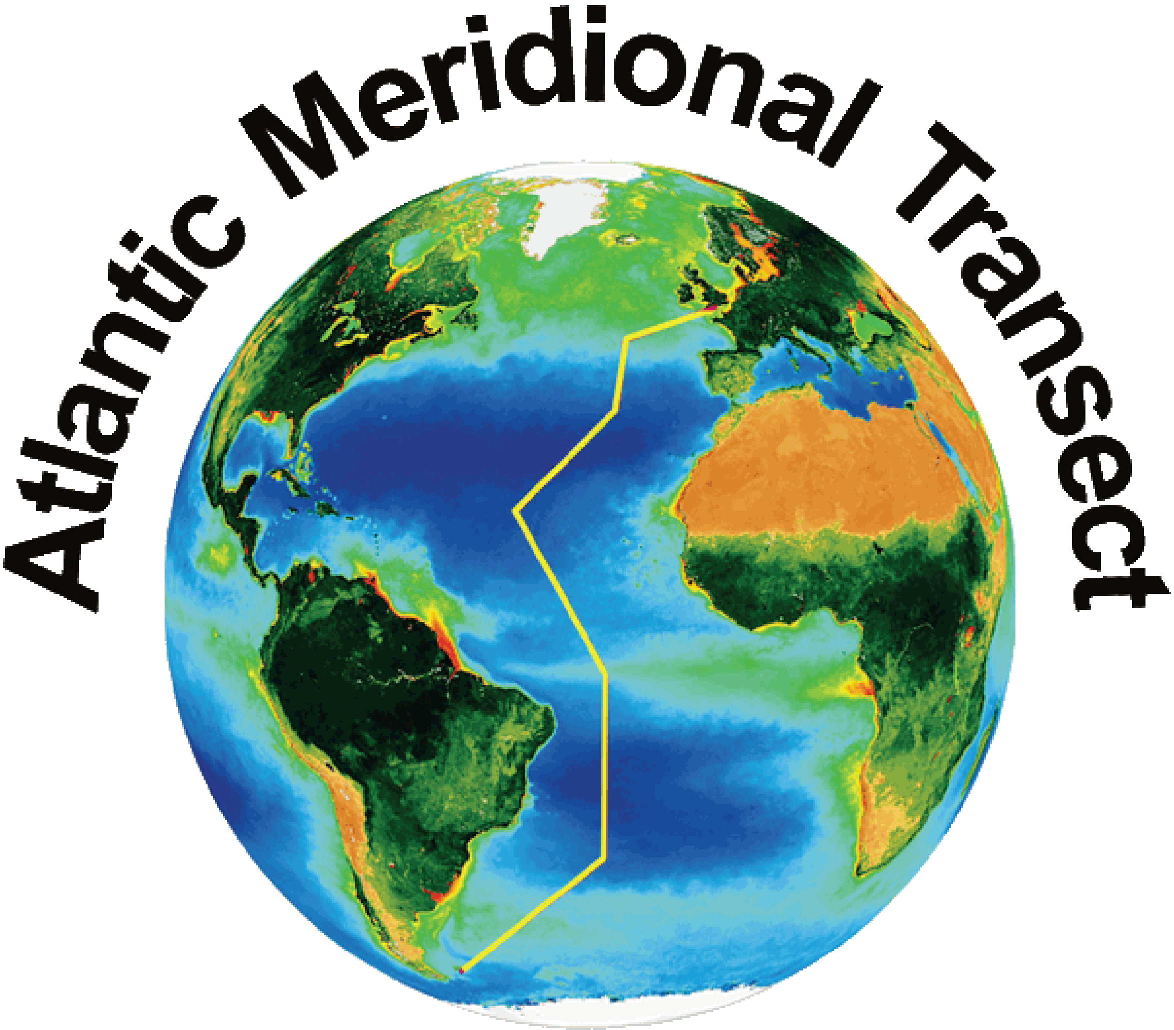
AMT23 Cruise Report



PML Plymouth Marine Laboratory

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

RRS James Clark Ross JR300

(1 October – 11 November 2013)

Principal Scientist: Mikhail Zubkov

National Oceanography Centre

CONTENTS

The Atlantic Meridional Transect (AMT) – the NERC programme of national capabilities

The aim of the AMT programme is to quantify key biogeochemical and ecosystem processes and their inherent variability over extended spatial and time scales in the Atlantic Ocean. This is achieved by executing an annually repeated meridional transect through contrasting oceanic provinces from oligotrophic subtropical gyres to highly productive temperate regionas and shelf seas. The JR300 cruise on board the RRS James Clark Ross is the 23rd transect of the AMT.

The AMT specific objectives are:

- To examine the nature and causes of ecological co-existence and biogeochemical variability in planktonic ecosystems;
- To quantify the effects of this variability on nutrient cycling, on biogenic export and on air-sea exchange of climate active gases;
- To construct multi-decadal, multidisciplinary basin-scale time-series which are integrated within a wider “Pole-to-pole” observatory concept;
- To provide essential sea-truth validation for current and next generation satellite missions;
- To provide essential data for global ecosystem model development and validation;
- To provide a valuable, highly sought after and unique training arena for the next generation of UK and International oceanographers.

Acknowledgements

First and foremost I am much obliged to the Logistic team of the British Antarctic Survey for their help with organizing the AMT23 cruise on the RRS James Clark Ross at such a short notice. My gratitude extends to the National Marine Facilities-Sea Systems people for their professional work both at sea and ashore. I am very grateful to Graham Chapman – the master and the officers and crew for providing an excellent service, for expert help with designing an optimal cruise track in such time-constrained circumstances and for looking after the scientists on board. I thank the remote sensing team at NEODAAS, including Silvana Mallor Hoya and Ben Taylor, for regular updates on oceanographic conditions during the cruise. I would also like to thank Rob Thomas at BODC for providing Argo float forecast information, which together with satellite data helped with putting the onboard sampling activities into a broader context of changing water masses. I thank all the scientists on board for their encouragement, support and help with logistic during this hard working cruise. I thank Chris Wing who helped with preparing the scientific party for the cruise. Thank you all!

Mike

AMT23 Scientific personnel

Bargery Arwen	BODC	Data Management/Instrument Calibration
Benson Jeffrey	NOC	NMF Technician
Brewin Bob	PML	Optics/phytoplankton carbon relationships
Brown Ian	PML	Carbonate system and biogenic gases
Dall'Olmo Giorgio	PML	Optics/phytoplankton carbon relationships
Edmonston Johnnie	BAS	Computing Technician
Evans Claire	NOC	Photoheterotrophy of bacterioplankton
Hackenberg Sina	Univ. York	Trace gases
Harris Carolyn	PML	Nutrients
Lam Phyllis	Univ. Southampton	Mesopelagic N-cycling
Lange Priscilla	Univ. Oxford	Phytoplankton remote sensing
Lorenzo Jose	Univ. Vigo	Community production/respiration, O_2
Minaeian Jamie	Univ. York	Trace gases
Misra Ankita	POGO Fellow	Primary production, CDOM
Moniz Mónica	Univ. Warwick	Novel strains of phytoplankton
Pitt Fran	Univ. Warwick	*Synechococcus* molecular ecology
Rees Andy	PML	Nitrogen cycle
Tarran Glen	PML	Phytoplankton flow cytometry
Thomas Seth	BAS	CTD Technician
Tilstone Gavin	PML	Primary production, CDOM
Wager Natalie	Univ. East Anglia	Climatically active gases
Zubkov Mike	NOC	Microbial dynamics

Ship's Officers

Chapman Graham	Master
Evans Simon	Chief officer
Hipsey Christopher	2nd Officer
Delph Georgina	3rd Officer
Waddicor Charles	ETO (Coms)
Parnell Luke	Chief Engineer
Collard Glynn	2nd Engineer
Hardy Aleksandr	3rd Engineer
Eadie Steven	4th Engineer
Wright Simon	Deck Engineer
Dunbar Nicholas	ETO (Eng)
Gibson James	Purser
Hunt Julie	Doctor

Ship's Crew

Stewart George	Bosun SciOps
Mullaney Clifford	Bosun
O'Duffy John	Bosun's Mate
Triggs David	SG1
Leggett Colin	SG1
Riddell Terence	SG1
Cordiner Norman	SG1
Horton Richard	SG1
Boyd David	MG1
Herbert Ian	MG1
Walker Keith	Cook
Molloy Padraig	2nd Cook
Weston Kenneth	Senior Steward
Newall James	Steward
Lee Derek	Steward
Patterson Thomas	Steward

Scientific Reports

CTD and other instruments

Jeff Benson (National Oceanography Centre, NMF-SS)
Seth Thomas (British Antarctic Survey)

CTD system configuration

1) Two CTD systems were prepared; the first water sampling arrangement was the BAS 24-way stainless steel frame system, and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-30856-0707
Sea-Bird 3P temperature sensor, s/n 03P-4472, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-2222, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 89973, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-2366, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-2289, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-1813, (primary)
Sea-Bird 5T submersible pump, s/n 05T-3415, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-46833-0636
Sea-Bird 11plus V1 deck unit, s/n 11P-15759-0458

2) The auxiliary input initial sensor configuration was as follows:

WETLabs C-Star 25cm path transmissometer, s/n CST-846DR (V0)
Chelsea MKIII Aquatracka fluorometer, s/n 088216 (V1)
Biospherical PAR irradiance sensor, DWIRR, s/n 7235 (V2)
Tritech PA200 altimeter, s/n 244740 (V3)
Sea-Bird 43 dissolved oxygen sensor, s/n 43-2290 (V4)
WETLabs light scattering sensor, s/n BBRTD-849 (V5)
WETLabs light scattering sensor, s/n BBRTD-949 (V7)

3) Additional instruments:

Ocean Test Equipment 20L ES-120B water samplers, s/n's 1A -12A, 15A-21A, 24A, 26A, 34A, 45A, 47A
TRDI WorkHorse 300kHz LADCP, s/n 15060 (downward-looking)
BAS WorkHorse LADCP battery pack
Chelsea FRRF MKI, s/n 05-4845-001

4) Sea-Bird 9*plus* configuration file JR300_BAS.xmlcon was used for all BAS stainless steel frame CTD casts. The LADCP command file used for all casts was SingleLADCP_script.

5) The second water sampling arrangement was a NOC 24-way stainless steel frame system, (s/n SBE CTD 6), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-39607-0803
Sea-Bird 3P temperature sensor, s/n 03P-4712, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-2858, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 93896, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-5660, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-3054, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-2371, (primary)
Sea-Bird 5T submersible pump, s/n 05T-2395, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-34173-0493
Sea-Bird 11plus V1 deck unit, s/n 11P-15759-0458

6) The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-1940 (V0)
Chelsea MKII 25cm path Alphatracka transmissometer, s/n 161-2642-002 (V2)
Chelsea MKIII Aquatracka fluorometer, s/n 88-2615-126 (V3)

CTG 2pi PAR irradiance sensor, DWIRR, s/n PAR 10 (V4)
CTG 2pi PAR irradiance sensor, UWIRR, s/n PAR 11 (V5)
WETLabs light scattering sensor, s/n BBRTD-169 (V6)
Tritech PA200 altimeter, s/n 6196.112522 (V7)

7) Additional instruments:

Ocean Test Equipment 10L 110B water samplers, s/n's 1 through 24

8) Sea-Bird 9*plus* configuration file JR300_NOC.xmlcon was used for all NOC stainless steel frame CTD casts.

Other instruments

1) Autosal salinometer---One salinometer was configured for salinity analysis, and the instrument details are as below:

Guildline Autosal 8400B, s/n 68959, installed in Chemistry Laboratory as the primary instrument, Autosal set point 21C for the first crate, then 24C for the following crates. Samples were processed according to non-WOCE cruise guidelines: The salinometer was standardized at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling, unless the set point was changed as above. Additional standards were analysed every ca. 24 samples to monitor & record drift. These were labeled sequentially and decreasing, beginning with number 999. Standard deviation set to 0.00005

2) Fast Repetition Rate Fluorometer---One FRRF system was installed as follows:

Chelsea MKI, s/n 05-4845-001---Configured for CTD sampling: Protocol 0 for latitudes less than approximately 40 degrees, Protocol 1 for latitudes greater than approximately 40 degrees as per Gavin Tilsdale.

CTD and underway sensor calibrations

Arwen Bargery (British Oceanographic Data Centre)

CTD profiles

A total of 65 CTD casts were completed during the cruise. 54 casts were conventional profiling casts (BAS casts) with water sampling by 24 x 20L OTE Niskin bottles. The remaining 11 casts (NOC casts) had water sampling by 24 x 10L OTE Niskin bottles. Casts were carried out at ~5.00 GMT and ~13:00 GMT each day.
CTD casts were recorded using the Sea-Bird data collection software Seasave-Win32 (Seasave V 7.22.3). The software outputs were then processed following the BODC recommended guidelines using SBE Data Processing-Win32 v7.22.5; the processing routines are named after each stage in brackets < >. The software applied the calibrations as appropriate through the instrument configuration file to the data in engineering units output by the CTD hardware.

An ascii file (CNV) containing the 24 Hz data for up and down casts was generated from the binary Sea-Bird files for each cast <DatCnv>. Files were created for each cast containing the mean values of all the variables at the bottle firing events <Bottle Summary>. Using the CNV files processing routines were applied to remove pressure spikes <WildEdit>, the oxygen sensor was then shifted relative to the pressure by 2 seconds, to compensate for the lag in the sensor response time <AlignCTD> and the effect of thermal 'inertia' on the conductivity cells was removed <CellTM>. The surface soak was identified for each cast, removed and LoopEdit run. Salinity and oxygen concentration were re-derived and density (sigma-theta) values were derived <Derive> after the corrections for sensor lag and thermal 'inertia' had been applied. The CTD files produced from Sea-Bird processing were converted from 24 Hz ascii files into 2 Hz ascii files of the complete cast (down and upcasts) with all channels for archive at BODC and also to 1 dbar downcast files for calibration and visualisation onboard <BinAverage>. The initial salinity and oxygen channels produced at the DatCnv stage, along with the conductivity, voltage and altimeter channels were removed from the 1 dbar downcast files <Strip>.

The sensor values at bottle firing produced by the Bottle Summary routine were collated and used to generate calibrations for the salinity, oxygen channels. Calibration for the fluorometer channel will be performed after the cruise due to an issue with the fluorometer values. Water samples were collected from each cast for measurement of salinity (bench salinometer) and chlorophyll-a (filtration, acetone extraction and fluorometer measurement) and from the pre-dawn cast each day for oxygen (Winkler titration).

Discrete chlorophyll and oxygen samples were taken from the BAS casts only, so the NOC casts will remain uncalibrated. Discrete salinity samples were taken from both BAS and NOC casts.
The method used for calibration was to generate an offset between the discrete water sample measurement (salinity/oxygen) and the nominal value from the sensor at bottle firing. The offsets were then plotted against the discrete sample values and a linear regression applied.

Where the regression was significant the calibration equation was derived from the residual offset:

$$\text{offset } \epsilon \cong A * \text{Discrete sample} + B,$$

where
$$\text{offset } \epsilon = \text{Discrete sample} - \text{Sensor value}.$$

Letting V represent a value to be calibrated:

$$\epsilon = V_{discrete} - V_{sensor}$$

A linear regression was used to find A and B in:

$$\epsilon \cong A\, V_{discrete} + B.$$

Rearranging this:

$$V_{discrete} \cong \frac{1}{A}(\epsilon - B),$$

and so:

$$\begin{aligned} V_{discrete} &= V_{sensor} + \epsilon \\ &\cong V_{sensor} + (A\, V_{discrete} + B) \\ (1 - A)V_{discrete} &\cong V_{sensor} + B \\ V_{discrete} &\cong \frac{1}{1 - A} V_{sensor} + \frac{B}{1 - A}, \end{aligned}$$

So the calibrated value is:

$$V_{cal} = a\, V_{sensor} + b,$$

where

$$a = \frac{1}{1-A} \text{ and } b = \frac{B}{1-A}.$$

Where the regression was not significant the mean value of the offset was applied. All calibration datasets are available upon request from BODC, post cruise.

- **Temperature**

There were no independent measurements of temperature made during the cruise and the sensors on the rig returned consistent data. No further calibration of these sensors has been carried out. The section generated below shows the temperature throughout the cruise in fig. 1.

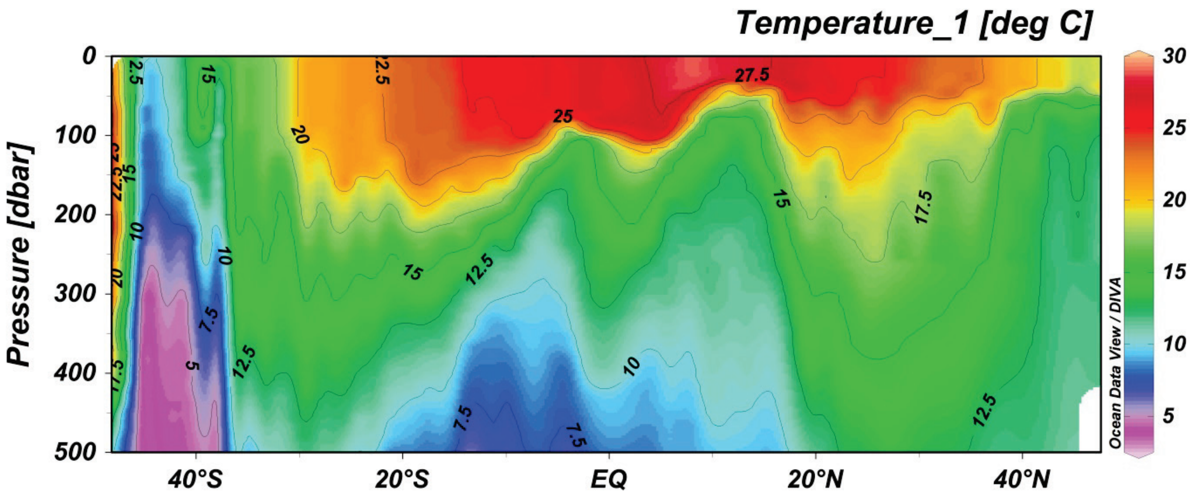


Fig. 1. Temperature section plot along the AMT23 transect by latitude from the vane mounted sensor.

- **Salinity**

The salinity channels were calibrated against bench salinometer measurements from 4 to 6 depths collected from each cast. Several outliers were removed. The calibrations will be applied to the data post cruise at BODC. Offsets were generated between the salinometer and CTD sensor values and plotted against cast and salinometer values. The linear regressions from the offset against bench salinometer data were slight for both sensors on the BAS rig, and barely significant for Sensor 1.

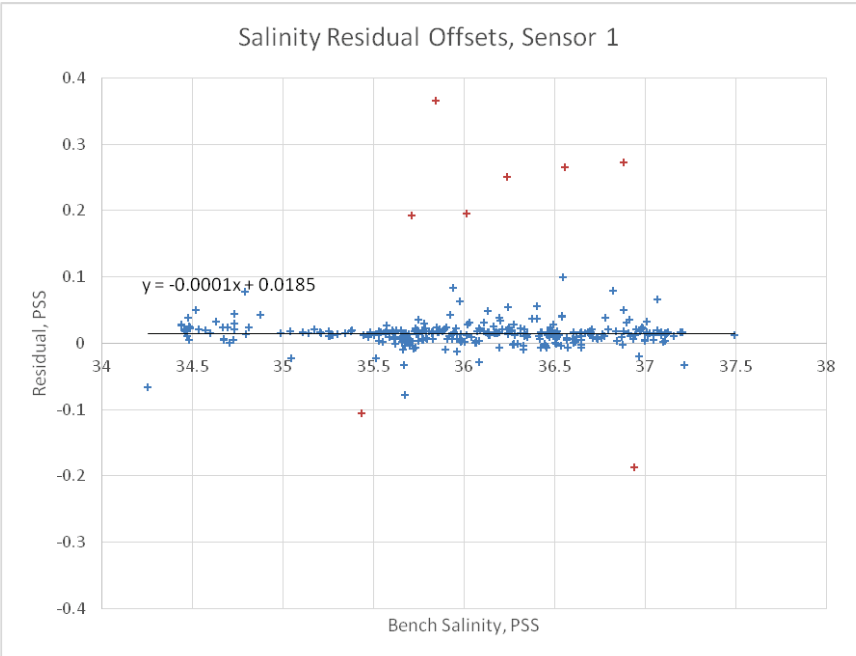


Fig. 2. Salinity offsets for salinity 1 against discrete sample salinity measured with a bench salinometer.

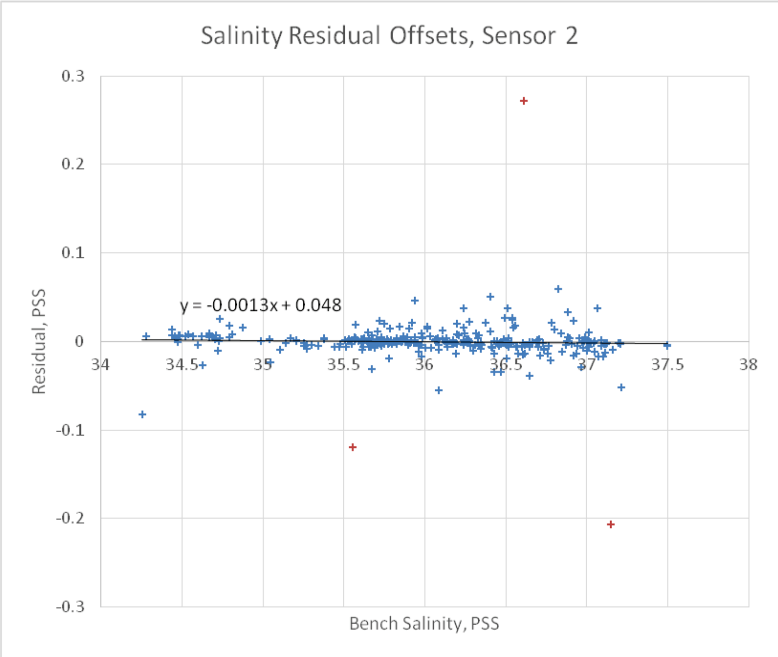


Fig. 3. Salinity offsets for salinity 2, against discrete sample salinity measured with a bench salinometer.

The conductivity sensors operated without problem during the cruise. The calibration equations for the 2 BAS rig sensors were:

Salinity_1_calibrated = 1.000402 * Salinity_1_SBEcal + 0.000843

Salinity_2_calibrated = 0.998715 * Salinity_2_SBEcal + 0.046064

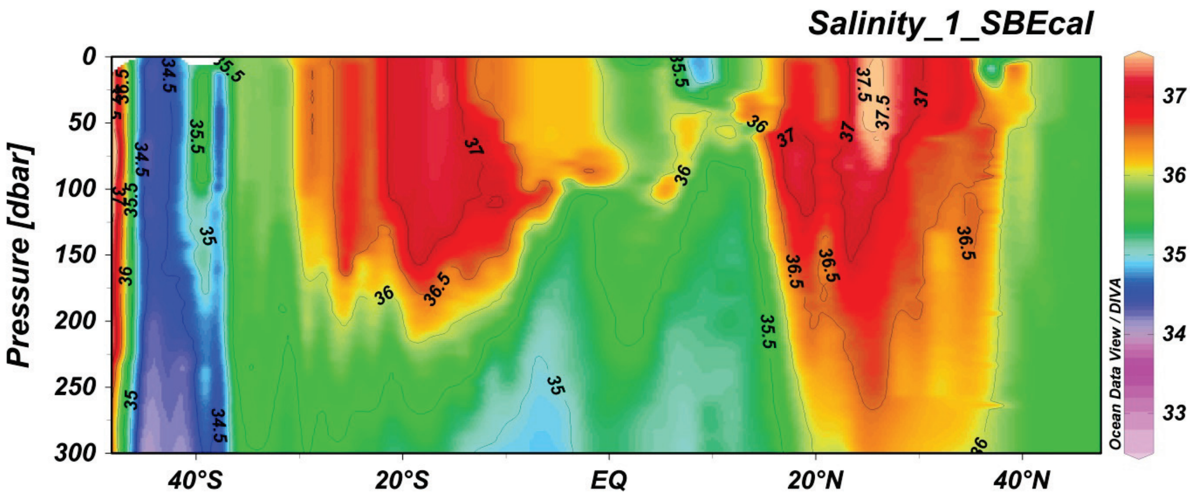


Fig. 4. Uncalibrated CTD salinity 1 section plot along the AMT23 transect by latitude from the vane mounted sensor.

- **Oxygen**

The oxygen sensor was calibrated against discrete oxygen sample Winkler titration measurements from up to 9 samples collected from the pre-dawn CTD. More details can be found in Jose's report.

The oxygen sensor operated without problem. Several outliers have been excluded from the calibration after discussion with Jose.

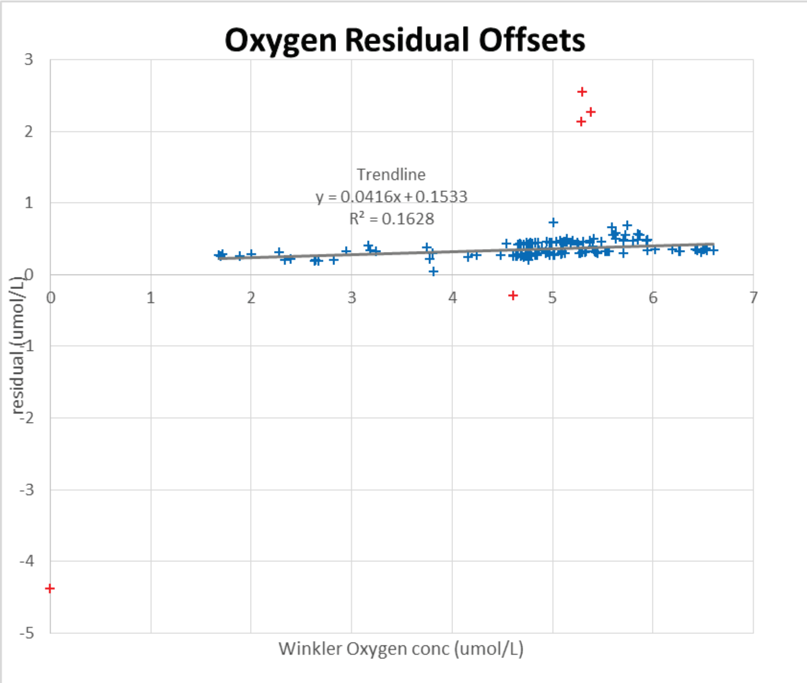


Fig. 5. Oxygen concentration offsets against Winkler titration measurements from discrete samples.

The calibration equation for the oxygen sensor is:

$$O_{cal} = 1.04336\, O_{sensor} + 0.15992$$

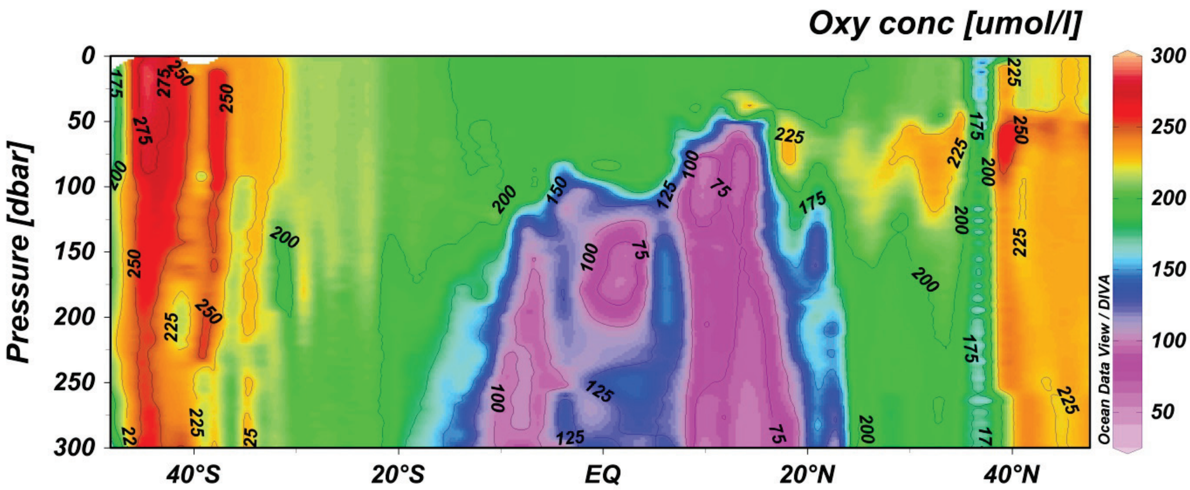


Fig. 6. Uncalibrated oxygen concentration section plot along the AMT23 transect by latitude from the SBE43 oxygen sensor.

- **Fluorometer**

The CTD fluorometer operated without problem during the cruise. The fluorometer data was calibrated against the extracted chlorophyll-a measurements made on seawater samples collected from 10 depths at each station. More details of the samples collected and protocols can be found in the appropriate cruise report section. The pre-calibrated fluorometer produced anomalous results during analysis throughout the cruise, however as there were no dilutions of pure chlorophyll stock available, the calibration was not checked or modified. To compensate for this, the fluorometer was back-calibrated at PML after the cruise and the results were updated based on the new fluorometer calibration.

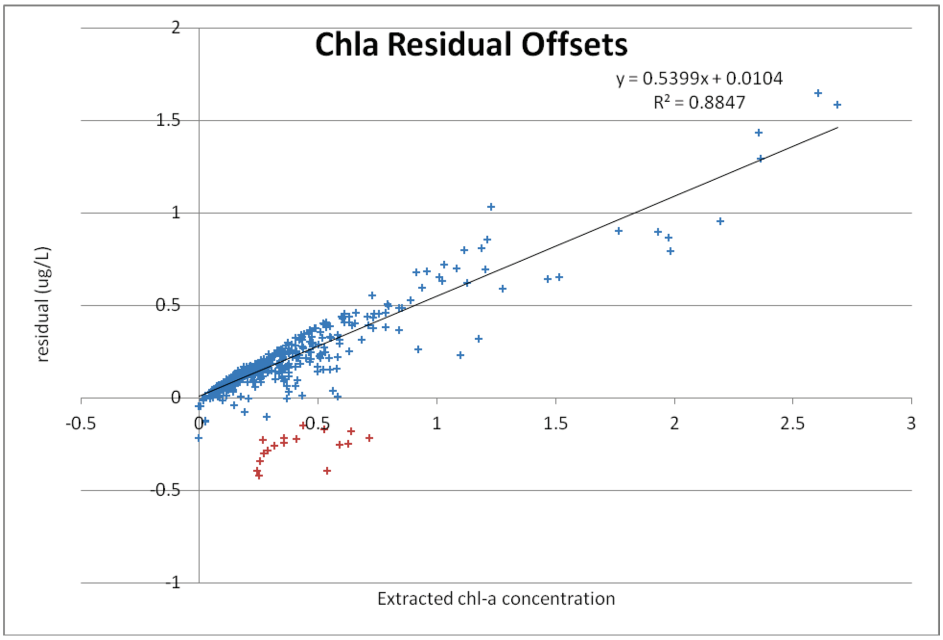


Fig. 7. Chlorophyll offsets against chlorophyll concentration measurements from discrete samples.

The calibration equation for the fluorometer is:

Calibrated fluorescence = 2.17330 * CTD fluorescence + 0.02270

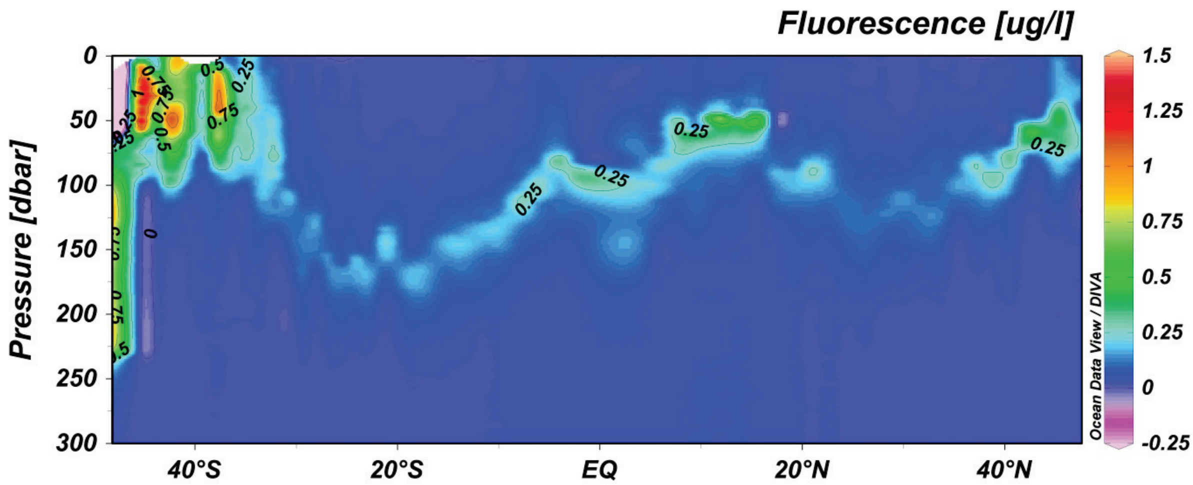


Fig. 8. Uncalibrated CTD fluorescence section plot along the AMT23 transect by latitude.

Underway sensors

The ship's underway meteorological and surface systems were run continuously through the cruise. The system started logging from 07/10/2013 07:50 (UT) and was switched off outside the 200 nm limit of Falkland Island and Argentinean territorial waters at 09/11/2013 11:25 (UT).

Samples were collected to calibrate the TSG and fluorometer connected to the ship's non-toxic flow-through system, which draws water from approximately 6 m below the water line.

- **Salinity**

The TSG sensor salinity data were calibrated against samples collected and analysed with a bench salinometer. Up to four samples were collected each day. There was a slight regression of the offset with bench salinity measurement, producing a calibration of:

Calibrated salinity = 1.00191 * sensor salinity - 0.05809

The correction will be applied during BODC processing after the cruise before the data is made available online.

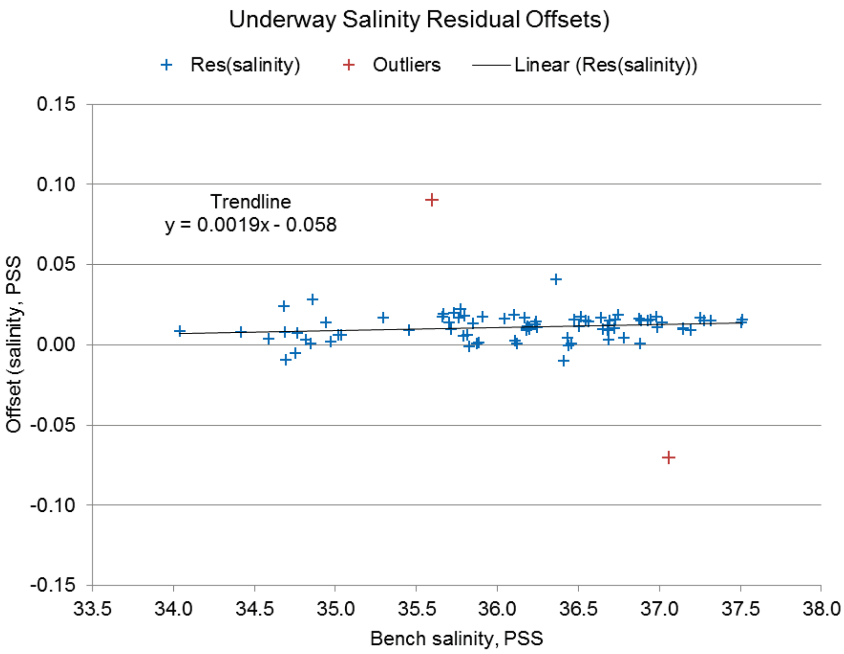


Fig. 9. Salinity offsets against bench salinometer measurements on discrete underway samples.

- **Fluorometer**

The underway fluorometer data was calibrated against samples collected and analysed with a bench fluorometer after the cruise. Up to five underway samples were collected each day. The correction will be applied during BODC processing after the cruise before the data is made available online.

There was a significant relationship between the offset and extracted chl-a concentration. The calibration equation is: Calibrated chlorophyll = 0.47576 * sensor chlorophyll + 0.09277

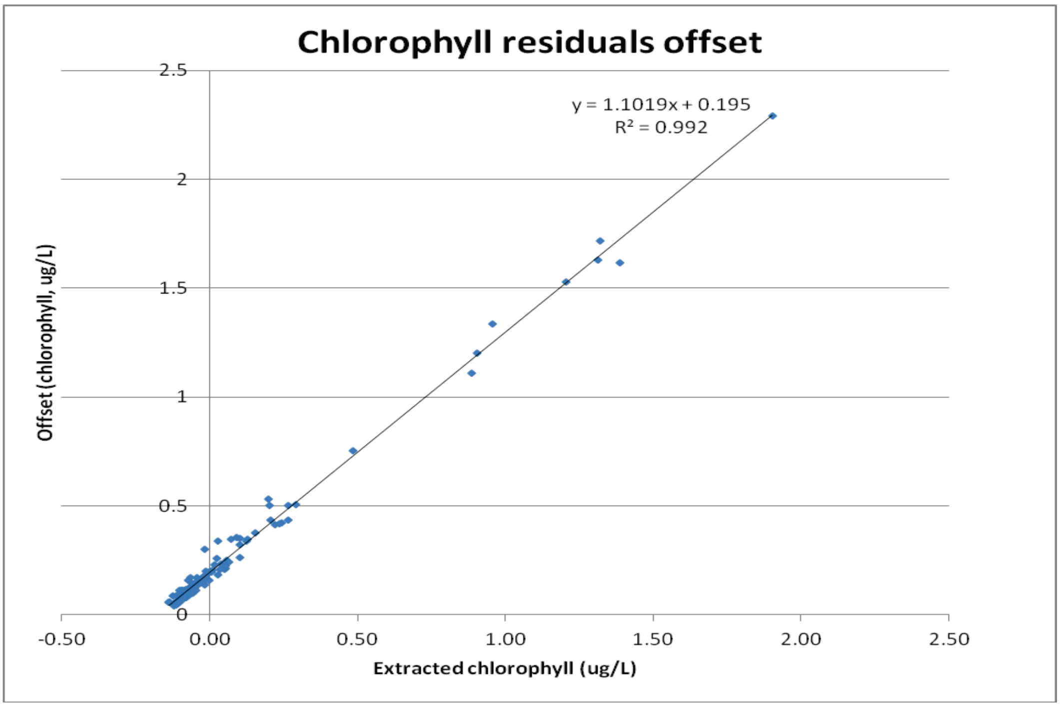


Fig. 10. Chlorophyll offsets against extracted chlorophyll measurements on discrete underway samples.

- **Temperature**

The hull temperature sensor data were calibrated against the CTD temperature sensors during the cruise. The data from the hull sensor at the CTD start time were compared with the temperature from the externally mounted CTD temperature at 6 decibars. The temperature offsets (CTD - Hull) were plotted against date/time and CTD sensor temperature and no outliers were identified. The relationships in the offset between sensors were then compared to the date/time and the CTD sensor temperature in separate linear regressions. There was a reasonably significant relationship between the offset and the CTD temperature. The calibration equation is:
Calibrated temperature = 1.00835 * sensor temperature + 0.003175

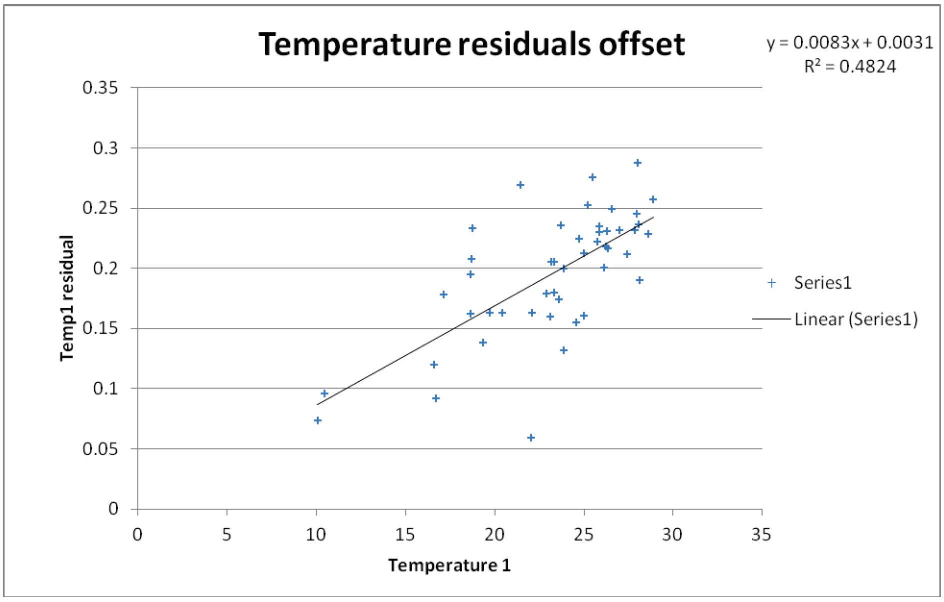


Fig. 11. Temperature offsets against CTD sensor temperature measurements.

Extracted chlorophyll-a sampling for calibration of CTD and underway fluorometers

Samples of seawater from CTD niskin bottles and the ship's non-toxic supply were collected to calibrate the CTD and underway system fluorometers following Welschmeyer (1994). Samples of 250 ml were filtered through 47mm 0.2 um polycarbonate filters. The filters were then transferred into vials and 10 ml of 90% acetone was added to each vial. The samples were left in a freezer for 24 hours. The samples were then analysed on a pre-calibrated Turner Designs Trilogy fluorometer. During the cruise, it was noted that the chlorophyll values looked suspect. The fluorometer calibration could not be checked throughout the cruise against dilutions of pure chlorophyll stock because none were available. The raw fluorescence (RFU) reading was taken for each sample to be re-calibrated back at PML. Calibration of the CTD and underway fluorescence will be done after the cruise at BODC.

Underway samples
A total of 130 samples were collected from the underway supply. A list of date, time and position for the underway samples can be found in the appendices.

CTD samples
Samples were collected at 54 stations from 10 depths including, where available, light depths of 97, 55, 33, 20, 14, 7 and 0.1%.
A total of 515 samples were collected from the CTD casts. The depths and stations sampled are listed in Table 1.

Data submission
The dataset will be submitted to BODC at the end of the cruise.

References
Welschmeyer N.A., 1994. Fluorometric analysis of chlorophyll-a in the presence of chlorophyll-b and phaeopigments. *Limnology and Oceanography*, 39:1985-1992

Table 1: List of stations and depths sampled for extracted chlorophyll-a measurement

Date/time (GMT)	Lat (+ve N)	Lon (+ve E)	CTD	Niskin Bottle	Depth (m)
2013-10-09T12:08:00	46.6187	-10.6285	CTD001	5, 6, 7, 10, 12, 13, 16, 21, 23	120, 90, 75, 60, 50, 35, 20, 10, 2
2013-10-10T04:43:00	45.0132	-13.5945	CTD003	1, 2, 3, 4, 6, 9, 10, 16, 18, 24	250, 150, 100, 80, 53, 47, 30, 12, 7, 2
2013-10-10T12:11:00	44.1115	-14.2550	CTD005	4, 5, 6, 7, 10, 11, 12, 19, 20, 24	200, 120, 75, 60, 55, 35, 20, 14, 8, 2
2013-10-11T04:43:00	41.7774	-15.9685	CTD006	1, 2, 4, 6, 10, 12, 14, 16, 20, 22	200, 160, 100, 80, 60, 46, 35, 20, 8, 2
2013-11-11T12:15:00	40.8090	-16.6761	CTD007	4, 6, 7, 10, 12, 13, 14, 21, 24	200, 150, 100, 75, 55, 44, 26, 10, 2
2013-10-12T04:45:00	38.3936	-18.3731	CTD008	2, 3, 5, 6, 7, 11, 12, 13, 15, 21	200, 150, 110, 100, 95, 70, 55, 46, 33, 2
2013-10-12T12:18:00	38.2298	-20.1000	CTD009	4, 7, 9, 11, 13, 14, 16, 20, 22, 24	200, 120, 88, 85, 75, 49, 30, 20, 11, 2
2013-10-13T04:46:00	34.9491	-20.6693	CTD010	2, 5, 7, 8, 11, 12, 15, 18, 21, 23	200, 120, 100, 95, 70, 55, 40, 23, 13, 2
2013-10-13T12:13:00	33.9200	-21.2805	CTD011	4, 7, 9, 11, 12, 14, 15, 17, 22, 24	200, 150, 122, 95, 73, 55, 44, 30, 14, 2
2013-10-14T04:48:00	31.3048	-22.6734	CTD012	2, 4, 7, 10, 11, 12, 14, 17, 21, 23	200, 150, 105, 95, 80, 65, 55, 25, 14, 2
2013-10-14T12:13:00	30.3690	-23.1565	CTD014	8, 10, 12, 14, 15, 16, 17, 18, 21, 24	125, 115, 90, 64, 60, 55, 39, 26, 14, 2
2013-10-15T05:16:00	27.8052	-24.4850	CTD016	4, 6, 7, 11, 13, 14, 15, 18, 21, 23	150, 135, 120, 91, 78, 70, 55, 29, 16, 2
2013-10-15T13:21:00	26.6549	-25.0630	CTD017	6, 7, 9, 11, 13, 14, 16, 17, 21, 24	180, 150, 132, 115, 92, 75, 46, 31, 17, 2
2013-10-16T05:12:00	24.2153	-26.2562	CTD019	3, 5, 6, 9, 10, 11, 13, 15, 18, 23	175, 150, 130, 115, 105, 87, 67, 40, 25, 2
2013-10-16T13:18:00	23.0794	-26.8148	CTD020	7, 8, 10, 12, 13, 14, 15, 16, 21, 24	125, 110, 95, 85, 75, 55, 33, 23, 13, 2
2013-10-17T05:13:00	20.6433	-27.9901	CTD021	5, 7, 10, 12, 13, 14, 17, 19, 21, 23	125, 105, 88, 69, 60, 52, 32, 22, 12, 2
2013-10-17T13:15:00	19.6535	-28.3986	CTD023	7, 8, 10, 12, 13, 15, 16, 17, 20, 24	120, 105, 94, 80, 70, 55, 33, 23, 13, 2
2013-10-18T05:12:00	17.0641	-29.1590	CTD024	4, 5, 7, 10, 12, 14, 17, 19, 21, 23	140, 110, 100, 90, 70, 52, 32, 22, 12, 2
2013-10-18T13:12:00	15.8951	-29.5015	CTD025	6, 7, 8, 11, 13, 14, 18, 19, 21, 24	150, 100, 75, 50, 40, 29, 18, 12, 5, 2
2013-10-19T05:13:00	13.3133	-29.6706	CTD026	6, 7, 9, 12, 14, 15, 16, 18, 20, 23	90, 75, 60, 45, 38, 34, 29, 18, 12, 2
2013-10-19T13:14:00	12.0820	-29.6427	CTD027	8, 9, 10, 12, 15, 16, 18, 19, 21, 24	100, 75, 60, 50, 25, 29, 20, 12, 5, 2
2013-10-20T05:14:00	9.2751	-29.5408	CTD028	5, 6, 7, 10, 12, 14, 17, 19, 20, 23	100, 80, 70, 57, 46, 35, 20, 14, 8, 2

2013-10-20T13:19:00	8.1197	-29.5112	CTD029	6, 7, 9, 11, 12, 13, 17, 19, 21, 24	110, 80, 58, 46, 42, 35, 20, 14, 8, 2
2013-10-21T05:29:00	5.4575	-29.4207	CTD030	5, 7, 11, 13, 15, 16, 17, 20, 21, 23	125, 100, 85, 65, 55, 49, 30, 20, 11, 2
2013-10-21T13:17:00	4.3636	-29.5397	CTD032	6, 7, 9, 11, 12, 13, 14, 15, 22, 24	125, 105, 93, 85, 72, 55, 33, 23, 13, 2
2013-10-23T05:43:00	2.5469	-28.9829	CTD033	6, 7, 11, 13, 14, 16, 17, 19, 21, 23	110,100,90,68,52,40,32,22,12,2
2013-10-23T13:19:00	-3.6566	-28.7440	CTD034	7, 8, 10, 12, 13, 14, 15, 16, 22, 24	120, 90, 77, 70, 61, 46, 28, 20, 11, 2
2013-10-24T05:42:00	-6.3375	-28.1792	CTD035	4, 5, 7, 9, 11, 15, 17, 19, 21, 23	140, 115, 104, 99, 80, 61, 37, 25, 14, 2
2013-10-24T13:16:00	-7.4258	-27.9441	CTD036	7, 8, 10, 13, 14, 15, 17, 18, 21, 23	140, 125, 109, 100, 84, 64, 39, 26, 15, 2
2013-10-25T05:10:00	-10.0021	-27.3968	CTD037	3, 5, 6, 9, 10, 11, 12, 13, 21, 23	180, 165, 150, 133, 123, 115, 103, 78, 18, 2
2013-10-25T13:15:00	-11.1183	-27.1614	CTD039	6, 7, 9, 11, 12, 14, 16, 17, 22, 24	165, 150, 132, 123, 103, 78, 47, 32, 20, 2
2013-10-26T05:11:00	-13.9450	-26.5583	CTD040	3, 7, 8, 9, 12, 14, 15, 17, 19, 23	170, 145, 125, 110, 84, 62, 51, 35, 20, 2
2013-10-26T13:13:00	-15.0023	-26.3297	CTD041	6, 7, 9, 11, 12, 13, 15, 16, 21, 24	170, 155, 145, 125, 110, 84, 51, 35, 20, 2
2013-10-27T05:15:00	-17.7016	-25.7049	CTD042	4, 9, 10, 11, 12, 15, 16, 18, 19, 22	200, 163, 150, 126, 96, 79, 59, 39, 23, 2
2013-10-27T13:15:00	-18.9973	-25.3874	CTD043	5,6,8,10,11,12,14,15,17,24	200, 185, 160, 150, 134, 102, 63, 41, 25, 2
2013-10-28T05:13:00	-21.5293	-25.1630	CTD044	3, 4, 7, 9, 10, 13, 15, 18, 20, 22	175, 160, 135, 120, 110, 84, 62, 35, 20, 2
2013-10-28T13:15:00	-22.5710	-25.9105	CTD045	6, 10, 11, 13, 14, 15, 17, 18, 20, 24	185, 159, 150, 130, 120, 99, 61, 40, 20, 2
2013-10-29T05:13:00	-24.4279	-27.6452	CTD047	4, 5, 8, 10, 12, 13, 16, 18, 19, 22	180, 165, 155, 140, 118, 90, 55, 37, 20, 2
2013-10-29T13:13:00	-25.1620	-28.3389	CTD049	6, 7, 10, 11, 12, 13, 14, 15, 17, 23	185, 170, 161, 150, 126, 96, 59, 39, 20, 2
2013-10-30T05:15:00	-26.9248	-30.0403	CTD050	4, 5, 8, 10, 14, 15, 16, 18, 20, 23	175, 165, 155, 120, 90, 68, 55, 37, 20, 2
2013-10-30T13:15:00	-27.7894	-30.8696	CTD051	7, 8, 11, 12, 13, 14, 16, 17, 21, 24	165, 140, 127, 115, 99, 75, 46, 31, 17, 2
2013-10-31T05:13:00	-29.5215	-32.6628	CTD052	4, 5, 8, 11, 13, 15, 16, 18, 19	180, 160, 135, 106, 89, 60, 49, 34, 20, 2
2013-10-31T13:15:00	-30.3320	-33.3747	CTD053	7, 8, 9, 12, 14, 15, 16, 17, 21, 24	160, 140, 120, 100, 80, 61, 37, 25, 14, 2
2013-11-01T05:19:00	-32.2612	-35.2995	CTD054	6, 7, 8, 12, 13, 15, 18, 21, 23	120, 105, 90, 71, 57, 44, 32, 26, 10, 2
2013-11-01T13:19:00	-33.2498	-36.2561	CTD055	8, 9, 10, 13, 14, 15, 16, 19, 21, 24	125, 110, 80, 60, 46, 35, 20, 14, 8, 2
2013-11-02T05:13:00	-35.1589	-38.2738	CTD056	7, 8, 10, 13, 14, 15, 17, 18, 20, 23	85, 75, 50, 40, 30, 23, 17, 14, 10, 2
2013-11-02T13:12:00	-35.9998	-39.1634	CTD057	7, 10, 11, 12, 14, 15, 16, 19, 20, 24	120, 80, 65, 50, 39, 30, 23, 14, 10, 2
2013-11-03T05:33:00	-38.0544	-41.3468	CTD058	4, 6, 7, 8, 11, 12, 15, 19, 21, 23	100, 70, 60, 50, 34, 27, 20, 12, 8, 2
2013-11-03T13:22:00	-38.7540	-42.1109	CTD060	8, 9, 10, 11, 12, 14, 16, 19, 21, 24	100, 80, 70, 60, 50, 30, 20, 15, 10, 2
2013-11-04T05:23:00	-40.6108	-44.1283	CTD061	4, 6, 7, 8, 12, 13, 14, 19, 21, 23	100, 75, 65, 50, 35, 25, 20, 15, 10, 2
2013-11-04T05:13:00	-42.8963	-46.7243	CTD062	5, 6, 7, 10, 11, 13, 14, 20, 21, 23	100, 70, 60, 45, 40, 34, 26, 16, 10, 2
2013-11-05T13:15:00	-43.7087	-47.6670	CTD063	7, 9, 10, 11, 12, 13, 19, 20, 22, 24	120, 80, 60, 45, 30, 22, 17, 11, 7, 2
2013-11-06T05:42:00	-45.4049	-49.6908	CTD064	6, 7, 9, 12, 13, 16, 17, 18, 20, 23	80, 60, 40, 30, 23, 17, 13, 11, 7, 2
2013-11-06T14:13:00	-46.2731	-50.7435	CTD065	4, 6, 8, 10, 11, 13, 14, 15, 20, 24	250, 200, 150, 80, 60, 40, 30, 23, 17, 2

Optical properties

Giorgio Dall'Olmo & **Bob Brewin** (Plymouth Marine Laboratory)

Objectives

- To determine the optical properties along the AMT23 transect in support of satellite calibration/validation activities.
- To establish empirical relationships between depth-resolved measurements of optical scattering and the concentrations of particulate organic carbon and suspended particles.

Methods

- The following optical measurements from the ship's underway water were determined quasi-continuously (Dall'Olmo et al. 2009):
    - particulate backscattering coefficient (470, 532, 595 nm)
    - particulate beam-attenuation and absorption coefficients (400 – 750 nm)
- In-situ optical backscattering measurements were also collected by means of a profiling package mounting a WETLabs ECO-BB3 sensor (3 channels) and a HobiLabs Hydroscat 6 sensor (6 channels plus chlorophyll fluorescence).
- Discrete water samples were collected from the noon rosette and filtered for determining total suspended matter (Table 1; Van der Linde, 1998) and particulate organic carbon (Table 1; Menzel, 1967).
- Above-water radiometric measurements were taken quasi-continuously using a Satlantic HyperSAS system. The HyperSAS optical remote sensing system provided high precision hyperspectral measurements of spectral water-leaving radiance and downwelling spectral irradiance, from which the above-water remote-sensing reflectance was computed. The 136-channel HyperOCR radiance and irradiance sensors were mounted onboard the ship for simultaneous viewing of the sea surface and sky. Above-water remote-sensing reflectance data are to be used for calibration and validation of satellite ocean colour products and alongside measurements of in-water optical properties obtained simultaneously with HyperSAS, for use in bio-optical modelling.
- Secchi depth measurements were derived at each station by attaching a 30cm white disk onto the optics rig. Additionally, Forel Ule measurements were taken at each station using a LaMotte Forel-Ule Color Comparator Kit.
- Microtops sunphotometer measurements were taken along the AMT23 cruise track using a MICROTOPS II Ozone Monitor Sunphotometer, in support of the AERONET network and for use in computing aerosol optical thickness.

Table 1. Total suspended matter and particulate organic carbon sampling.

Station	CTD	Time GMT	Date	Lat	Lon	depth #1	depth #2	depth #3	depth #4	depth #5	depth #6
9	11	12:13	13/10/2013			500	400	300	200	122	30
11	14	12:13	14/10/2013			500	400	300	200	115	26
13	17	13:21	15/10/2013			500	400	300	200	132	31
15	20	13:18	16/10/2013	23.0794167	-26.81475	500	400	300	200	95	23
17	23	13:15	17/10/2013	19.6534667	-28.398552	500	400	300	200	94	23
19	25	13:12	18/10/2013	15.8950833	-29.501483	500	400	300	200	50	12
21	27	13:14	19/10/2013	12.082	-29.642733	500	400	300	200	50	12
23	29	13:19	20/10/2013	8.11965	-29.51115	500	400	300	200	58	14
25	32	13:17	21/10/2013	4.36361667	-29.3897	500	400	300	200	93	23
27	34	13:19	23/10/2013	-2.3433833	-28.744033	500	400	300	200	77	20
29	36	13:16	24/10/2013	-7.42575	-27.944067	500	400	300	200	109	26
31	39	13:15	25/10/2013	-10.881733	-27.161417	500	400	300	200	132	32
33	41	13:15	26/10/2013	-14.997717	-26.329717	500	400	300	200	145	35
35	43	13:15	27/10/2013	-17.002733	-25.38735	500	400	300	200	160	41
37	45	13:15	28/10/2013	-21.429	-25.910517	500	400	300	300	159	40
39	49	13:15	29/10/2013	-24.837967	-28.338933	500	500	400	300	161	39
41	51	13:15	30/10/2013	-26.2106	-30.869617	500	400	400	300	127	31
43	53	13:15	31/10/2013	-29.668017	-33.374683	500	400	300	300	100	25
45	55	13:19	01/11/2013	-32.750167	-36.2561	500	500	400	300	60	15
47	57	13:12	02/11/2013	-34.0002	-39.163383	500	400	300	200	100	10
49	60	13:22	03/11/2013	-37.246033	-42.110933	500	400	300	200	100	15
52	63	13:15	05/11/2013	-42.291333	-47.667	500	400	300	200	100	7
54	65	14:13	06/11/2013	-45.726883	-50.743533	500	400	300	200	100	10

References

Dall'Olmo et al. (2009) Significant contribution of large particles to optical backscattering in the open ocean. Biogeosciences, 6, 947–967.

Menzel, D. W. (1967), Particulate organic carbon in deep sea, Deep Sea Res., 14(2), 229–238, doi:10.1016/0011-7471(67)90008-3.

Van der Linde (1998) Protocol for the determination of total suspended matter in oceans and coastal waters. Technical Note No. I.98.182, European Commission, Join Research Centre.

Carbonate system: Total alkalinity (A_T) and pH

Ian Brown (Plymouth Marine Laboratory)

Rationale and Method

Dissolved CO_2 reacts with water to form carbonic acid (H_2CO_3). H_2CO_3 dissociates to bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) with the concomitant release of H^+, causing a reduction in pH. Total alkalinity (A_T) of seawater describes the sum of all ionic charges in seawater, including HCO_3^-, CO_3^{2-}, H^+, inorganic and organic ions. Samples for the determination of A_T and pH_T (measured on the total scale) were collected in order to constrain the carbonate system along the cruise track. These samples are complemented by underway surface measurements of CO_2 partial pressure (pCO_2) measured with the PML, *Live-pCO₂* system. These measurements will contribute to our understanding of the distribution of C sources and sinks in the Atlantic Ocean and the capacity of the ocean to take up anthropogenic CO_2.

Table 1 lists cast numbers and Niskin bottle numbers for all samples collected. A_T samples were collected in 250 mL borosilicate glass bottles with glass stoppers (Schott, Duran) and preserved with $HgCl_2$ until analysis at PML (100 µL of saturated $HgCl_2$ added). The glass stoppers were greased with Apiezon-M grease.

The pH_T method employed here has typical precision in the low 10^{-3} to 10^{-4} pH-unit range. Samples were collected in 500 mL amber glass bottles and placed in a water bath at 25 ^oC. pH_T was determined spectrophotometrically using the m-cresol-purple dye (Dickson et al., 2007). The dye has two absorbance maxima at 434 nm and 578 nm, the ratio of which is pH-, T- and salinity-dependent. Absorbance measurements of the seawater blank, and following addition of dye (100 µL of a 2 mmol L^{-1} solution), were carried out on a Perkin Elmer, lamda 35 spectrophotometer, using 10 cm cells. The temperature of the sample was recorded in the spectrophotometer cell with a NIST-traceable thermometer. pH_T measurements were corrected for the pH_T change due to the addition of dye according to Dickson et al. (2007). Figure 1 shows preliminary data for pH_T along-track for AMT 23 (JR300) (stations 1-65). Final quality controlled A_T and pH_T data will be submitted to BODC within 12 months.

Reference

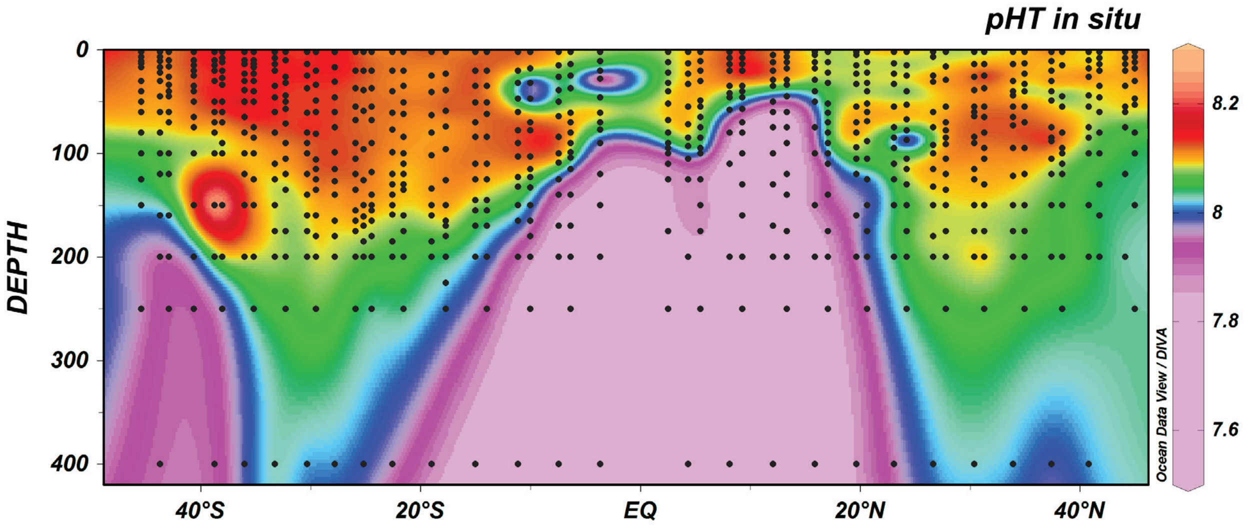
Dickson, A.G., Sabine, C.L. and J.R. Christian (eds.), 2007, Guide to Best Practice for Ocean CO_2 measurements, PICES Special Publication 3, 191p.

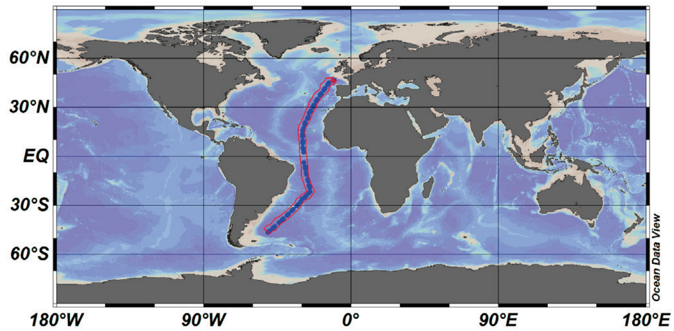
Table 1. Samples collected from CTD hydrocast.

Date	CTD cast no.	A_T (Niskin no.)	pH_T (Niskin no.)
09/10/13	C-001	4,9,23	1,2,3,4,5,6,7,9,13,14,21,23
10/10/13	C-003	1,9,23	1,2,3,5,6,9,12,13,16,18,23
10/10/13	C-005	4,9,23	4,5,6,9,10,11,12,19,20,23
11/10/13	C-006	1,10,24	1,2,3,4,6,10,12,14,16,18,20,24
11/10/13	C-007	4,11,23	2,4,6,7,8,11,12,13,14,19,21,23
12/10/13	C-008	1,7,23	1,2,3,4,5,6,7,10,11,13,15,23
12/10/13	C-009	2,12,24	2,4,6,7,8,9,12,13,14,15,16,20,22,24
13/10/13	C-010	1,8,24	1,2,3,4,6,8,11,12,15,17,18,21,24
13/10/13	C-011	2,10,24	2,4,6,7,10,11,12,13,14,15,16,17,22,24
14/10/13	C-012	1,10,24	1,2,3,4,6,7,10,11,12,14,16,17,21,24
14/10/13	C-014	1,6,23	2,4,6,7,8,11,12,13,14,15,16,17,18,21,23
15/10/13	C-016	1,7,24	1,2,3,5,6,7,10,11,12,13,14,15,18,21,24
15/10/13	C-017	1,10,23	2,4,6,7,10,11,12,13,14,15,17,19,21,23
16/10/13	C-019	1,8,24	1,2,3,4,6,8,10,11,12,13,14,15,18,21,24
16/10/13	C-020	2,11,23	2,4,6,7,8,11,12,13,14,15,16,21,23
17/10/13	C-021	1,12,24	1,2,3,4,6,7,9,12,13,14,15,17,19,21,24
17/10/13	C-023	1,11,23	1,4,6,7,8,11,12,13,185,16,17,20,21,23

18/10/13	C-024	1,9,23	1,2,3,4,6,7,9,11,12,13,14,17,19,21,24
18/10/13	C-025	1,12,23	2,4,6,7,8,12,13,14,18,19,21,23
19/10/13	C-026	1,11,240	1,2,3,4,5,6,8,9,11,15,16,18,20,21,24
19/10/13	C-027	2,11,23	2,5,6,7,8,9,10,11,15,16,18,19,23
20/10/13	C-028	1,9,24	1,2,3,4,5,6,7,9,12,13,14,17,19,20,24
20/10/13	C-029	1,10,23	1,4,6,7,10,11,12,13,17,19,21,23
21/10/13	C-030	1,8,24	1,3,4,5,7,8,10,12,13,15,16,17,20,21,24
21/10/13	C-032	2,10,24	2,3,6,7,10,11,12,13,14,15,22,24
23/10/13	C-033	1,10,24	1,3,5,6,7,8,10,12,13,14,16,17,19,21,24
23/10/13	C-034	2,7,11,24	2,5,6,7,8,11,12,13,14,15,16,22,24
24/10/13	C-035	1,8,25	1,2,3,4,5,8,9,10,12,13,15,17,19,21,24
24/10/13	C-036	1,12,24	2,5,6,7,8,,12,13,14,15,16,17,18,21,23
25/10/13	C-037	1,8,24	1,2,3,4,6,8,10,11,12,13,15,17,19,21,24
25/10/13	C-039	2,10,24	2,5,6,7,10,11,12,13,14,15,16,17,22,24
26/10/13	C-040	1,8,24	1,2,3,4,6,8,9,12,14,15,17,19,24
26/10/13	C-041	2,10,24	2,5,6,7,10,11,12,13,14,15,16,21,24
27/10/13	C-042	1,8,23	1,2,3,5,6,8,10,11,12,15,16,18,19,23
27/10/13	C-043	5,9,24	1,5,6,9,10,11,12,13,14,15,17,24
28/10/13	C-044	1,6,24	1,2,3,4,6,8,9,10,12,13,15,16,18,20,24
28/10/13	C-045	5,10,24	2,5,6,10,11,12,13,14,15,16,17,18,20,24
29/10/13	C-047	1,7,24	1,2,3,5,7,9,10,12,13,15,16,18,19,24
29/10/13	C-049	6,10,23	3,5,6,7,10,11,12,13,14,15,17,23
30/10/13	C-050	1,7,24	1,2,3,5,7,9,10,11,14,15,16,18,20,24
30/10/13	C-051	5,11,24	2,5,6,7,8,11,12,13,14,15,16,17,21,24
31/10/13	C-052	1,4,14	1,2,4,5,7,9,10,11,13,15,16,18,19,24
31/10/13	C-053	7,12,24	2,5,6,7,8,9,12,13,14,15,16,17,21,24
01/11/13	C-054	1,5,11,24	1,2,3,4,5,7,8,11,13,14,15,17,18,21,24
01/11/13	C-055	2,8,13,24	2,5,6,7,8,9,10,13,14,15,16,19,21,24
02/11/13	C-056	1,4,12,24	1,2,3,4,5,6,8,10,12,14,15,17,18,20,24
02/11/13	C-057	2,5,14,25	2,5,6,7,8,10,11,12,14,15,16,19,20,24
03/11/13	C-058	1,7,10,24	1,2,3,4,5,6,7,8,10,12,15,19,21,24
03/11/13	C-060	2,9,14,24	2,5,6,8,9,10,11,12,14,16,19,21,24
04/11/13	C-061	1,6,11,23	1,2,3,4,6,7,8,9,11,13,14,19,21,23
04/10/13	C-062	1,6,11,24	1,2,3,4,5,6,7,9,11,13,14,20,21,24
05/10/13	C-063	2,10,13,24	2,5,6,7,8,9,10,11,12,13,19,20,22,24
06/10/13	C-064	1,7,10,24	1,3,4,5,6,7,8,9,11,13,16,17,18,20,24
06/10/13	C-065	1,10,13,24	2,4,5,6,8,10,11,13,14,15,20,21,24

Figure 1. Preliminary pH_T data along-track for AMT 23 (JR300). Dots show samples location.





Inorganic macronutrients

Carolyn Harris (Plymouth Marine Laboratory)

Objectives:

To investigate the spatial and temporal variations of the micro-molar nutrient species Nitrate, Nitrite, Phosphate, and Silicate during the research cruise along the Atlantic Meridional Transect (AMT) cruise track, departing the from Immingham, UK and sailing through the North Atlantic Gyre (NAG), south to the equator, through the South Atlantic Gyre (SAG), before turning south-west to end the cruise at Port Stanley Falkland Islands.

Sampling & Methodology

Micro-molar nutrient analysis was carried out using a 4 channel (nitrate (Brewer & Riley, 1965), nitrite (Grasshoff,K., 1976), phosphate, silicate (Kirkwood, D.S., 1989) (Mantoura, R.F.C. & Woodward, E.M. S., 1983) Bran & Luebbe AAIII segmented flow, colourimetric, auto-analyser. Established, proven analytical protocols were used.

Water samples were taken from a 24 x 20 litre bottle stainless steel framed CTD / Rosette system (Seabird). These were sub-sampled into clean (acid-washed) 60ml HDPE (Nalgene) sample bottles. Subsequent nutrient analysis was complete within 3-4 hours of sampling.

CTD samples analysed

A total of 64 vertical profiles were analysed along the axis of the AMT and are listed in the table below, (CTD geographic positions and corrected bottle firing depths being available from the CTD Log.) :-

References

Brewer & Riley, 1965. The automatic determination of nitrate in seawater. *Deep Sea Research*, 12: 765-772
Grasshoff, K., 1976. Methods of sea-water analysis, *Verlag Chemie*, Weiheim: pp.317.
Kirkwood, D.S. 1989. Simultaneous determination of selected nutrients in sea-water, *ICES CM* 1989/C:29
Mantoura, R.F.C. & Woodward, E.M.S-., 1983. *Estuarine, Coastal and Shelf Science,* 17, 219-224.

I would like to thank colleagues and the officers & crew of the RRS James Clark Ross for making the cruise a pleasant and rewarding trip.

Table, AMT 23 - Nutrient Analysis - Station & CTD Sampling Summary

Date	Time (GMT)	Ship Stn.	CTD ID	Niskin sampled
09.10.2013	12:20	JCR300 001	01	22, 21, 14, 13, 12, 8, 7, 6, 5, 4 , 3 , 2 , 1, .
10.10.2013	04.43	JCR300_002	03	24, 19, 16, 13, 10, 9 , 6, 5 , 3 , 2 ,1
10.10.2013	12:11	JCR300_003	05	22, 20 , 19 , 12 , 11 , 10 , 7 , 5 , 4
11.10.2013	04:43	JCR300_004	06	22 ,20 ,19 ,16 ,14 ,12 ,11 ,10 ,7 ,6 ,4 ,3 ,2 ,1
11.10.2013	12:15	JCR300_005	07	24 , 21 , 19 , 14 , 13 , 12 ,9 , 8 , 7 , 6 , 4 , 3 , 2 ,1
12.10.2013	04:45	JCR300_006	08	21 ,16 ,15 ,13 ,12 ,11 ,10 ,7 ,6 ,5 ,4 ,3 ,2 ,1
12.10.2013	12:10	JCR300_007	09	24 , 22 , 20 ,16 ,15 ,14 ,13 ,10 ,9 ,8 ,7 ,6 ,4 ,3 2,1
13.10.2013	04:46	JCR300_008	010	23, 21, 18, 17, 15, 12, 11, 8, 7, 5, 4, 3, 2, 1
13.10.2013	12:13	JCR300_009	011	24, 22, 17, 16, 15, 14, 13, 12, 11, 8, 7, 6, 4, 3, 2, 1
14.10.2013	04:48	JCR300-010	012	23, 21, 17, 16, 14, 12, 11, 10, 7, 6, 4, 3, 2, 1
14.10.2013	12:13	JCR300_0011	014	23, 21, 18, 17, 16, 15, 14, 13, 12, 9, 8, 7, 6, 4, 3, 2, 1
15.10.2013	05:16	JCR300_0012	016	23, 21, 18, 16, 15, 14, 13, 12, 11, 10, 7, 6, 4, 3, 2, 1
15.10.2013	13:21	JCR300_0013	017	23, 21, 19, 17, 16, 15, 14, 12, 11, 8, 7, 6, 4, 3, 2, 1
16.10.2013	05:12	JCR300_0014	019	23, 21, 18, 15, 14, 13, 12, 11, 10, 9, 6, 5, 3, 2, 1

16.10.2013	13:18	JCR300_0015	20	23, 21, 16, 15, 14, 13, 12, 9, 11, 7, 6, 4, 3, 2, 1
17.10.2013	05:13	JCR300_0016	21	23, 21, 19, 17, 15, 14, 13, 12, 11, 10, 7, 5, 4, 3, 2, 1
17.10.2013	13:15	JCR300_0017	23	23, 21, 20, 17, 16, 15, 13, 12, 9, 8, 7, 6, 4, 3, 2, 1
18.10.2013	05:12	JCR300_0018	24	23, 21, 19, 17, 15, 14, 13, 12, 11, 10, 7, 5, 4, 3, 2, 1
18.10.2013	13:12	JCR300_0019	25	23, 21, 19, 18, 14, 13, 10, 8, 7, 6, 4, 3, 2, 1
19.10.2013	05:15	JCR300_020	26	23, 21, 20, 18, 16, 15, 14, 12, 9, 7, 6, 5, 4, 3, 2, 1
19.10.2013	13:14	JCR300_021	27	23, 19, 18, 16, 15, 11, 10, 9, 8, 7, 6, 5
20.10.2013	05:14	JCR300_022	28	23, 20, 19, 17, 14, 13, 12, 10, 7, 6, 5, 4, 3, 2, 1
20.10.2013	13:19	JCR300_023	29	23, 21, 19, 17, 13, 12, 11, 8, 7, 6, 4, 3, 2, 1
21.10.2013	05:24	JCR300_024	30	23, 21, 20, 17, 16, 15, 13, 12, 10, 8, 7, 5, 4, 3, 2, 1
21.10.2013	13:17	JCR300_025	32	24, 22, 15, 14, 13, 12, 11, 8, 7, 6, 5, 3, 2, 1
23.10.2013	05:43	JCR300_026	33	23, 19, 17, 16, 14, 13, 12, 11, 8, 7, 6,5, 4, 3, 2, 1
23.10.2013	13:19	JCR300_027	34	24, 22, 16, 14, 13, 12, 11, 8, 7, 6, 5, 3, 2, 1
24.10.2013	05:42	JCR300_028	35	23, 21, 19, 17, 15, 13, 11, 10, 9, 7, 5, 4, 3, 2, 1
24.10.2013	13:16	JCR300_029	36	23, 21, 18, 17, 16, 15, 14, 13, 10, 8, 7, 6, 5, 3, 2, 1
25.10.2013	05:10	JCR300_030	37	23, 21, 15, 13, 12, 11, 10, 9, 6, 5, 3, 2, 1
25.10.2013	13:15	JCR300_031	39	23, 22, 17, 16, 15, 14, 13, 12, 11, 9, 7, 6, 5, 3, 2, 1
26.10.2013	05:11	JCR300_032	40	23, 19, 17, 15, 14, 12, 9, 8, 7, 4, 3, 2, 1
26.10.2013	13:10	JCR300_033	41	24, 21, 16, 15, 14, 13, 12, 11, 9, 7, 6, 5, 3, 2, 1
27.10.2013	05:15	JCR300_034	42	22, 19, 18, 16, 15, 12, 11, 10, 9, 6, 5, 4, 2, 1
27.10.2013	13:15	JCR300_035	43	24, 17, 15, 14, 13, 12, 11, 10, 8, 6, 5, 3, 2, 1
28.10.2013	05:13	JCR300_036	44	22, 20, 18, 16, 15, 13, 12, 10, 9, 8, 7, 4, 3, 2, 1
28.10.2013	13:15	JCR300_037	45	24, 20, 18, 17, 16, 15, 14, 13, 12, 11, 10, 6, 5, 3, 2, 1
29.10.2013	05:13	JCR300_-038	47	22, 19, 18, 16, 15, 13, 12, 10, 9, 8, 5, 4, 2, 1
29.10.2013	13:13	JCR300_039	49	23, 17, 15, 14, 13, 12, 11, 10, 7, 6, 5, 4, 3, 1
30.10.2013	05:15	JCR300_040	50	23, 20, 18, 16, 15, 14, 11, 10, 9, 8, 5, 4, 2, 1
30.10.2013	13:15	JCR300_041	51	24, 21, 17, 16, 15, 14, 13, 12, 11, 8, 7, 6, 5, 4, 2, 1
31.10.2013	05:13	JCR300_042	52	23, 19, 18, 16, 15, 13, 11, 10, 9, 8, 5, 4, 2, 1
31.10.2013	13:15	JCR300_043	53	24, 21, 17, 16, 15, 14, 13, 12, 9, 8, 7, 6, 5, 3, 2, 1
01.11.2013	05:19	JCR300_044	54	23, 21, 18, 17, 15, 14, 13, 12, 8, 7, 6, 4, 3, 2, 1
01.11.2013	13:19	JCR300_045	55	24, 21, 19, 16, 15, 14, 13, 10, 9, 8, 7, 6, 5, 4, 3, 1
02.11.2013	05:13	JCR300_046	56	23, 20, 18, 17, 15, 14, 13, 10, 8, 7, 5, 4, 3, 2, 1
02.11.2013	13:12	JCR300_047	57	24, 20, 19, 16, 15, 14, 12, 11, 10, 8, 7, 6, 4, 3, 2, 1
03.11.2013	05:33	JCR300_048	58	23, 21, 19, 15, 12, 11, 8, 7, 6, 5, 4, 3, 2, 1
03.11.2013	13:22	JCR300_049	60	24, 21, 19, 16, 14, 12, 11, 10, 9, 8, 6, 5, 3, 2, 1

04.11.2013	05:23	JCR300_050	61	23, 21, 19, 14, 13, 12, 9, 8, 7, 6, 4, 3, 2, 1
05.11.2013	05:13	JCR300_051	62	23, 21, 20, 14, 13, 11, 10, 7, 6, 5, 4, 3, 2, 1
05.11.2013	13:15	JCR300_052	63	24, 22, 20, 19, 13, 12, 11, 10, 9, 8, 7, 6, 5, 3, 2, 1
06.11.2013	05:42	JCR300_053	64	23, 20, 18, 17, 16, 13, 12, 9, 8, 7, 6, 5, 4, 3, 2, 1
06.11.2013	14:13	JCR300_054	65	24, 21, 15, 14, 13, 11, 10, 9, 8, 6, 5, 4, 3, 2, 1

Nitrous oxide & methane

Andy Rees & **Ian Brown** (Plymouth Marine Laboratory)

Nitrous oxide and methane are biogenically produced trace gases whose atmospheric concentrationsare increasing at a rate in the order of 0.7 ppbv y-1. Both gases are radiatively active, contributingapproximately 6% and 15% of “greenhouse effect” respectively, whilst N2O contributes to stratosphericozone depletion and CH4 limits tropospheric oxidation capacity.

The oceans are generally considered to be close to equilibrium relative to the atmosphere for bothgases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient statusand regulatory processes are complicatedand are currently not well understood. Ocean areas overlying sub-oxic waters and upwelling areasdominate the ocean source and saturations of up to 300% have been reported.

Aim - To perform vertical profiles of N2O and CH4 concentration in order to assess variability in the source-sink strength and exchange with the atmosphere along the AMT transect.

Methods
Samples were collected from CTD bottles at stations identified below. 1 litre samples were equilibratedwith compressed air and headspace analysis performed onboard using FID-gas chromatography andECD-gas chromatography1 for CH4 and N2O respectively. Atmospheric concentrations were determined bythe same methods using samples collected from the ships bow into a sealed Tedlar bag.

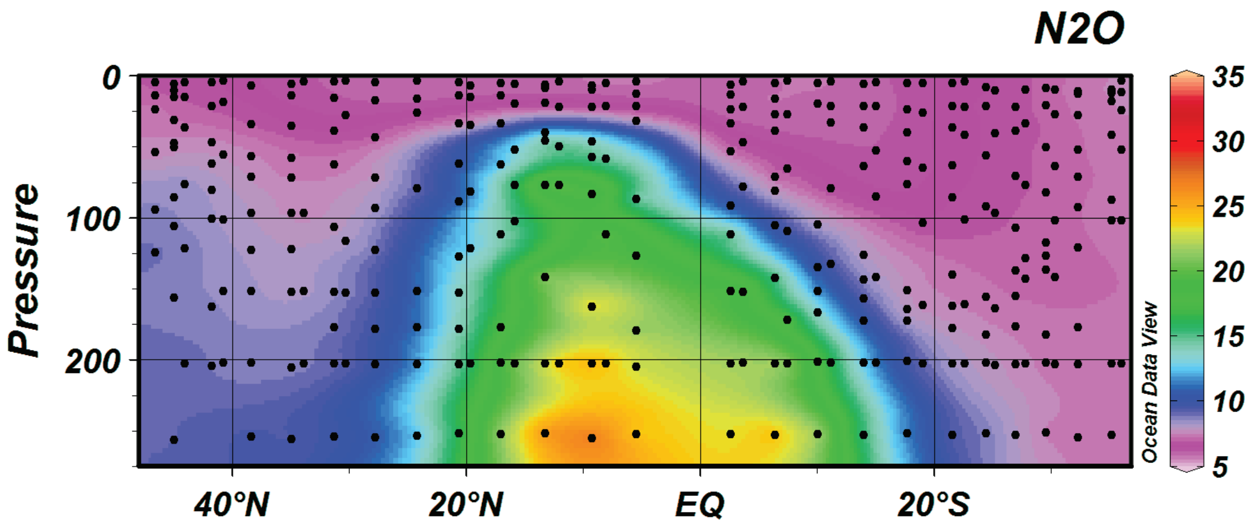


Figure 1. N_2O concentration (nmol L^{-1}) during AMT23, October-November 2013.

Reference
Upstill-Goddard R.C., A.P. Rees & N.J.P. Owens (1996) Simultaneous high-precision measurements of methane and nitrousoxide in water and seawater by single phase equilibration gaschromatographyDeep-Sea Research I. Vol. 43, No. 10, PP. 1669-1682

Table 1. N_2O, CH_4 Sampling Date and position– AMT23.

Date	Time	CTD No.	Latitude	Longitude	No. Depths	Depth Range (m)
09.10.13	1300	1	46.6187	-10.6284	6	0 - 120
10.10.13	444	3	45.0020	-13.5946	10	0 - 250
10.10.13	1211	5	44.1115	-14.2550	6	0 - 200

11.10.13	530	6	41.7774	-15.9685	8	0 - 200
11.10.13	1215	7	40.8090	-16.6761	6	0 - 200
12.10.13	445	8	38.3936	-18.3731	9	0 - 250
13.10.13	446	10	34.9491	-20.6693	10	0 - 250
13.10.13	1213	11	33.9200	-21.2800	4	0 - 200
14.10.13	448	12	31.3048	-22.6733	9	0 - 250
14.10.13	1213	14	30.3690	-23.1565	5	0 - 200
15.10.13	516	16	27.8052	-24.4993	10	0 - 250
16.10.13	512	19	24.2153	-26.2562	8	0 - 250
17.10.13	513	21	20.6433	-27.9985	10	0 - 250
17.10.13	1315	23	19.6535	-28.3986	6	0 - 200
18.10.13	512	24	17.0640	-29.1590	8	0 - 250
18.10.13	1312	25	15.8952	-29.5015	6	0 - 200
19.10.13	513	26	13.3133	-29.6706	9	0 - 250
19.10.13	1315	27	12.0821	-29.6428	6	0 - 200
20.10.13	514	28	9.2750	-29.5399	9	0 - 250
20.10.13	1319	29	8.1195	-29.5101	5	0 - 200

Date	Time	CTD No.	Latitude	Longitude	No. Depths	Depth Range (m)
21.10.13	524	30	5.4575	-29.4131	9	0 - 250
23.10.13	543	33	-2.5469	-28.9828	10	0 - 250
23.10.13	1319	34	-3.6566	-28.7440	6	0 - 200
24.10.13	542	35	-6.3375	-28.1792	10	0 - 250
24.10.13	1316	36	-7.4258	-27.9441	6	0 - 200

25.10.13	510	37	-10.0021	-27.3968	8	0 - 250
25.10.13	1315	39	-11.1183	-27.3968	6	0 - 200
26.10.13	511	40	-13.9450	-26.5583	10	0 - 250
26.10.13	1313	41	-15.0023	-26.3297	6	0 - 200
27.10.13	515	42	-17.7015	-25.7048	10	0 - 250
27.10.13	1315	43	-18.9972	-25.3873	6	0 - 200
28.10.13	513	44	-21.5294	-25.1628	10	0 - 250
28.10.13	1315	45	-22.5710	-25.9105	6	0 - 200
29.10.13	513	47	-24.4278	-27.6452	8	0 - 250
29.10.13	1313	49	-25.1620	-28.3388	5	0 - 200
30.10.13	515	50	-26.9247	-30.0403	9	0 - 250
30.10.13	1315	51	-27.7893	-30.8695	6	0 - 200
31.10.13	513	52	-29.5222	-32.5792	10	0 - 250
31.10.13	1315	53	-30.3320	-33.3747	6	0 - 200
01.11.13	514	54	-32.2612	-35.3025	10	0 - 250
2.11.13	513	56	-35.1588	-38.2738	8	0 - 250

Date	Time	CTD No.	Latitude	Longitude	No. Depths	Depth Range (m)
2.11.13	1312	57	-35.9998	-39.1634	6	0 - 200
3.11.13	533	58	-38.0497	-41.3447	8	0 - 250
3.11.13	1322	60	-387.7540	-42.1109	6	0 - 200
4.11.13	523	61	-40.6112	-44.1299	10	0 - 250
5.11.13	513	62	-42.8963	-46.7243	9	0 - 250
5.11.13	1315	63	-43.7087	-47.6670	6	0 - 200

6.11.13	542	64	-45.4055	-47.6670	9	0 - 250
6.11.13	1413	65	-46.2708	-50.7468	6	0 – 200

Trace gas (isoprene, monoterpenes, DMS and halocarbons) air and water concentrations and flux calculations

Sina Hackenberg & **Jamie Minaeian** (at sea)
Stephen J. Andrews, Lucy J. Carpenter, Rosie Chance, Katie Read & **Alastair C. Lewis** (ashore) *(*University of York)

Background

A number of biogenic trace gases produced in the surface ocean and emitted to the atmosphere are thought to impact on aerosol and cloud properties.

Isoprene (C_5H_8) and monoterpenes ($C_{10}H_{16}$), highly reactive biogenic volatile organic compounds thought to be emitted by phytoplankton, may form secondary organic aerosol (SOA) in the atmosphere, which can in turn act as cloud condensation nuclei (CCN). Increased CCN concentrations lead to higher cloud albedo (reflectivity), and hence greater radiative cooling. The sources and impacts of isoprene and monoterpenes on the remote marine boundary layer are currently poorly understood, mainly due to a lack of measurements (Shaw et al. 2010, Yassaa et al. 2008, Colomb et al. 2009).

Dimethyl sulphide (DMS) derives from the breakdown of dimethylsulfoniopropionate (DMSP), which is produced by phytoplankton. Once vented to the atmosphere, DMS is oxidised to sulphate aerosol, and is the major source of CCN in clean marine environments.

Halocarbon compounds (e.g. iodomethane, CH_3I, bromoform, $CHBr_3$) undergo photolysis in the atmosphere to release reactive halogen atoms which are involved in a number of processes which impact on the radiative and oxidative capacity of the atmosphere. Halogens atoms react with boundary layer ozone, and iodine atoms have also been implicated in ultrafine particle formation at high concentrations.

During AMT23, DMS, halocarbons, isoprene and monoterpenes were measured in air and water samples simultaneously, in order to better constrain their sources and to improve understanding of their impacts on aerosol and clouds. Ozone (O_3) was also monitored continuously, in order to provide supporting data to help interpret trace gas measurements.

Objectives

- Use simultaneous measurements of air and water concentrations alongside modelling approaches to infer sea-air fluxes in the remote marine boundary layer
- Investigate links between trace gas emissions and phytoplankton community structure, using data collected by other AMT23 participants.
- Comparison of cruise data with isoprene data from the Cape Verde Atmospheric Observatory
- Model studies of the impact of oceanic terpenes on marine SOA and atmospheric chemistry (in collaboration with Dr Steve Arnold, University of Leeds).

Methods

Air sampling: The trace gas and ozone air sample inlet was situated on the meteorological platform at the bow of the ship. A ~90 m sample line (shrouded 1/2" od, Swagelok PFA) led from the inlet to the instruments located in the main laboratory of the ship. Discrete trace gas air samples were collected over periods of 10 min (1 L air; increased to 20 min (2 L) during the cruise), and O_3 was measured near continuously throughout the cruise.

Water sampling: Underway samples were collected from the pumped non-toxic seawater supply using a semi-automated purge and trap system plumbed directly into the underway supply. The sample lines and valves were flushed with underway water and then a ~80 mL sample pumped into the purge vessel (7 minute sampling time). Flow was controlled using a peristaltic pump operating at ca. 11 mL/min. These samples passed through an in-line 0.7µm glass fibre syringe filter unit.

Samples were also taken from CTD casts at varying intervals and depths (see Table 1). These were sub-sampled from the Niskin bottles into amber glass stoppered bottles or directly into glass syringes via a pre-combusted GF/F filter. Unfiltered bottle samples were analysed within approximately one hour on the semi-automated system (via an in-line filter) or transferred into glass syringes via a precombusted GF/F filter. Syringe samples were injected into the purge vessel manually, bypassing the in-line filter. CTD samples were stored at 4^{o}C and analysis took place within 10 hours of collection.

Table 1: Depths sampled for trace gas analysis at stations

Date	Latitude (+ve N)	Longitude (+ve E)	CTD #	Niskin #	Depth (m)
10/10-06/11/13 (most stations)			3-64	23/24 (most stations)	2

09/10/13	46° 37.122'	-10° 37.710'	1	24, 21, 14, 13, 12, 8, 7	2, 20, 35, 50, 60, 75
09/10/13	46° 37.122'	-10° 37.706'	2		20
12/10/13	38° 23.617'	-18° 22.583'	8	23, 11, 10, 7	2, 70 (x2), 80, 95
21/10/13	04° 21.817'	-29° 23.382'	32	24, 15, 14, 13, 12, 11, 10, 6	2, 23, 33, 55, 72, 85, 93, 125
24/10/13	-06° 20.281'	-28° 10.751'	35	23, 19, 17, 13, 11, 10, 9, 7, 5	2, 25, 37, 79, 80, 90, 99, 104, 115
28/10/13	-22° 34.265'	-25° 54.631'	45	24, 17, 15, 14, 13, 12, 10, 6	2, 61, 99, 120, 130, 140, 159, 185
03/11/13	-38° 03.265'	-41° 20.810'	58	23, 19, 12, 11, 8, 7, 6, 5	2, 12, 27, 34, 50, 60, 70, 90

Table 2: Periods of data collection and missing data (preliminary)

Date	**Comment**
Data collection:	
08/10 - 06/11/2013	Air trace gas data collected
09/10 - 06/11/2013	Underway water trace gas data collected
Missing data:	
12/10 - 14/10/2013	Water data missing
20/10/2013	Water data missing
20/10-23/10/2013	O_3 data missing
From 17/10/2013	Reduced monoterpenes data (air and water)

Analysis: Analysis was performed on two coupled Thermal Desorption- Gas Chromatography- Mass Spectrometry systems (TD-GC-MS). At any one time, one instrument was dedicated to air analysis and the other to water and air analysis; however this configuration was changed between instruments several times during the cruise due to instrument problems. Both instruments were calibrated near-daily using pre-mixed gas standards.

For water analysis, dissolved gases were extracted using an automated purge-and-trap method (Andrews et al., in preparation) similar to that described by Broadgate et al. (1997). Each 80 mL water sample was purged with 1.5 L of zero-grade nitrogen gas. Water analyses were alternated with air analyses, to provide carbon tetrachloride concentrations to correct for instrument sensitivity drift (see below). The duration of each sampling cycle (air-water) was 65-75 minutes; the second instrument acquired one air sample every 30-40 minutes.

Atmospheric ozone levels were measured continuously (data logged every 10 s) with a photometric ozone analyser along the cruise track from the same air inlet as the GC-MS air samples (inlet on the meteorology platform at the bow of the ship).

Data processing and quality control

Measurements will be corrected for instrument drift using ambient levels of atmospheric carbon tetrachloride, and quantified using gas standard calibrations. Data processing will initially focus on isoprene and monoterpenes data. Instrument problems resulted in some periods of poor quality data and/or irregular sampling (see Table 2). It is noted that instrument sensitivity also decreased significantly throughout the cruise, resulting in higher limits of detection and quantification towards the end. Data will be filtered for contamination events arising from the ship's exhaust, using relative wind direction and speed and pollution markers in chromatograms.

Sea-air fluxes will be determined using the measured concentrations in air and water and relationships between trace gas concentrations, phytoplankton abundance (as chlorophyll-a) and functional type (if available), light levels and wind data investigated.

Ozone data will be quality controlled post-cruise. Problems with the instrument resulted in some periods of missing data (see Table 2). A post-cruise calibration (using a TEI Primary Standard) will be carried out on the instrument and applied to the data. Calibrations are traceable to WMO GAW internationally recognized standards.

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Climatically active gases:
1) Sea surface and atmospheric measurements of the carbon dioxide, nitrous oxide, methane and carbon monoxide;
2) Net community production and gross photosynthesis from dissolved oxygen and oxygen analogues.

Natalie Wager (at sea) & **Jan Kaiser** (ashore - data contact) (University of East Anglia, School of Environmental Sciences)

Rationale
Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are long-lived climatically active gases with atmospheric lifetimes of decades to centuries (Cicerone and Oremland, 1988; Nevison et al., 1995; Solomon et al., 2007). Carbon monoxide (CO) has a shorter lifetime of the order of months and is not a greenhouse gas in itself, but indirectly influences the atmospheric residence times of other climatically active gases, such as CH_4, by acting as the primary sink of tropospheric hydroxyl radicals (OH) (Stubbins, 2006). There are currently large uncertainties over the air-sea exchange rates of these four climatically active gases due to the spatial and temporal sparseness of available data (Solomon et al., 2007).

Objectives

- To simultaneously measure sea surface and atmospheric CO_2 and CH_4 along the AMT23 transect, using two Los Gatos CO_2/CH_4 integrated-cavity laser spectrometers.
- To alternate between sea surface and atmospheric measurements of N_2O and CO along the transect using a single Los Gatos N_2O/CO laser spectrometer.
- To quantify air-sea exchange fluxes of CO_2, CH_4, N_2O and CO along the AMT23 transect from Southampton, UK to the Falklands.
- To collect discrete headspace samples from mixed layer and oxygen maximum from both pre-dawn and solar noon hydrocasts throughout the AMT23 cruise to calculate gross photosynthesis and net community production rates from oxygen triple isotopes and oxygen-to-argon ratios.

Work on the ship
A glass-bed equilibrator was connected to the uncontaminated water sampling system of *RRS* James Clark Ross. The headspace was sampled continuously by a daisy chain of two Los Gatos analysers, one measuring combined $CO_2/CH_4/H_2O$ mole fractions, the other measuring $N_2O/CO/H_2O$ mole fraction. These measurements were taken predominantly from the uncontaminated seawater supply, only disrupted twice a day for 15 minute-atmospheric mole fraction measurements from an uncontaminated air source. A third Los Gatos spectrometer measured $CO_2/CH_4/H_2O$ mixing ratios continuously from the air inlet at the bow of the ship. Sea surface and atmospheric measurements were taken continuously throughout the cruise transect, interrupted only by a daily calibration with three standard gas mixtures, running 20 minute each. The results will be combined with ship-based wind-speed measurements and suitable wind speed-gas exchange parameterisations (Ho et al., 2006; Nightingale et al., 2000; Sweeney et al., 2007) to calculate air-sea gas exchange fluxes. The measurements will also compared with analyses of discrete N_2O and CH_4 concentrations using gas chromatography (Andy Rees & Ian Brown).

Discrete water samples were collected from both the mixed layer and oxygen maximum (alternatively the deep chlorophyll maximum) in 300 ml-evacuated glass bottles from both pre-dawn and solar noon hydrocasts stations throughout the cruise (Table 1). These samples will be analysed for their oxygen triple isotope composition and oxygen-to-argon ratios back at the UEA using an isotope ratio mass spectrometer. The ^{17}O isotope excess in the dissolved O_2 will be used to estimate the contribution of atmospheric and photosynthetic O_2 in the mixed layer. These will be used to calculate gross photosynthesis net community production rates using suitable wind-speed gas exchange parameterisations (Kaiser 2011; Kaiser et al. 2005). Comparisons of production rates will be made between estimates derived from these measurements and those calculated from oxygen titration (Pablo Serret & José Lozano) during the AMT23 cruise.

Table 1. Triple O_2 isotope samples collected from the CTD

Station	Cast	Sample bottle	Long.	Lat.	Depth (m)	Time (GMT)	Date	Niskin bottle	Other comments
001	001	099	10.37.706	46.37.122	20	13:20	09/10/13	15	ML 33%
001	001	121	10.37.706	46.37.122	50	13:20	09/10/13	12	O2 max
002	003	107	13.35.699	44.00.81	12	04:43	10/10/13	17	ML 33%
002	003	119	13.35.699	44.00.81	53	04:43	10/10/13	06	O2 max
003	005	117	14.15.300	44.06.690	55	12:11	10/10/13	10	O2 max
003	005	120	14.15.300	44.06.690	14	12:11	10/10/13	19	ML 33%

004	006	125	15.58.11	41.46.646	20	04:43	11/10/13	17	ML 33%
004	006	127	15. 58.11	41.46.646	55	04:43	11/10/13	11	O2 max
005	007	112	16.40.566	40.48.542	55	12:15	11/10/13	17	O2 max
005	007	122	16.40.566	40.48.542	18	12:15	11/10/13	11	ML 33%
006	008	083	18.23.383	38.23.617	23	04:45	12/10/13	16	ML 33%
006	008	118	18.23.383	38.23.617	70	04:45	12/10/13	11	O2 max
007	009	157	19.02.665	37.23.79	88	12:15	12/10/13	09	O2 max
007	009	196	19.02.665	37.23.79	20	12:15	12/10/13	20	ML 33%
008	010	098	20.40.158	34.56.943	55	04:46	13/10/13	12	O2 max
008	010	195	20.40.158	34.56.943	23	04:46	13/10/13	19	ML 33%
009	011	130	21.16.827	33.55.20	30	12:13	13/10/13	17	ML 33%
009	011	169	21.16.827	33.55.20	65	12:13	13/10/13	13	O2 max
010	012	006	22.40.402	31.18.290	65	04:48	14/10/13	12	O2 max
010	012	139	22.40.402	31.18.290	25	04:48	14/10/13	18	ML 33%
011	014	043	23.09.391	30.22.141	60	12:13	14/10/13	15	O2 max
011	014	128	23.09.391	30.22.141	26	12:13	14/10/13	18	ML 33%
012	016	021	24.29.097	27.48.310	78	05:16	15/10/13	13	O2 max
012	016	186	24.29.097	27.48.310	29	05:16	15/10/13	19	ML 33%
013	017	016	25.03.782	26.39.293	???	13:21	15/10/13	17	O2 max 3%
013	017	013	25.03.782	26.39.293	92	13:21	15/10/13	13	ML 33%
014	019	020	26.15.373	24.12.917	78	05:12	16/10/13	12	O2 max
014	019	153	26.15.373	24.12.917	25	05:12	16/10/13	18	ML 33%
016	021	158	27.59.404	20.38.597	60	05:13	17/10/13	13	O2 max
016	021	031	27.59.404	20.38.597	22	05:13	17/10/13	19	ML 33%
017	023	145	28.23.9131	19.39.208	70	13:15	17/10/13	13	O2 max 3%
017	023	047	28.23.9131	19.39.208	23	13:15	17/10/13	17	ML 33%
018	024	182	29.09.539	17.03.844	70	05:12	18/10/13	12	O2 max 3%
018	024	028	29.09.539	17.03.844	22	05:12	18/10/13	19	ML 33%
020	026	014	29.40.236	13.18.797	34	05:13	19/10/13	15	O2 max
020	026	046	29.40.236	13.18.797	12	05:13	19/10/13	20	ML 33%
021	027	192	29.38.564	12.04.920	35	13:14	19/10/13	15	O2 max
021	027	152	29.38.564	12.04.920	12	13:14	19/10/13	19	ML 33%
022	028	165	29.32.449	09.16.504	35	05:14	20/10/13	14	O2 max 7%
022	028	147	29.32.449	09.16.504	14	05:14	20/10/13	19	ML 33%
024	030	162	29.25.239	05.27.448	85	05:24	21/10/13	11	DCM
024	030	187	29.25.239	05.27.448	20	05:24	21/10/13	20	ML 33%
025	032	049	29.23.382	04.21.817	93	13:17	21/10/13	10	DCM
025	032	042	29.23.382	04.21.817	23	13:17	21/10/13	15	ML 33%
026	033	029	28.56.974	02.32.816	20	05:13	23/10/13	20	ML 30%
026	033	170	28.56.974	02.32.816	90	05:13	23/10/13	11	DCM
027	034	004	28.44.642	03.39.397	20	13:19	23/10/13	16	ML 33%
027	034	149	28.44.642	03.39.397	77	13:19	23/10/13	11	DCM
028	035	189	28.10.751	06.20.248	99	05:42	24/10/13	09	O2 max
028	035	041	28.10.751	06.20.248	25	05:42	24/10/13	19	ML 33%
029	036	002	27.56.644	07.25.545	100	13:16	24/10/13	13	O2 max on way down?
029	036	048	27.56.644	07.25.545	26	13:16	24/10/13	18	ML
030	037	146	27.23.800	10.00.125	123	05:10	25/10/13	10	O2 max
030	037	138	27.23.800	10.00.125	32	05:10	25/10/13	19	ML
031	039	141	27.09.685	11.07.096	32	13:15	25/10/13	17	ML 33%
031	039	039	27.09.685	11.07.096	123	13:15	25/10/13	11	O2 max
032	040	135	26.33.498	13.56.701	35	05:11	26/10/13	17	ML 33%
032	040	164	26.33.498	13.56.701	125	05:11	26/10/13	08	O2 max
033	041	015	26.19.783	15.00.137	125	13:13	26/10/13	11	O2 max
033	041	129	26.19.783	15.00.137	35	13:13	26/10/13	16	ML 33%
034	042	038	25.42.295	17.42.0945	163	05:15	27/10/13	09	DCM
034	042	056	25.42.295	17.42.0945	39	05:15	27/10/13	18	ML 33%
035	043	052	25.23.241	18.59.836	160	13:15	27/10/13	09	DCM
035	043	009	25.23.241	18.59.836	41	13:15	27/10/13	15	ML 33%
036	044	053	25.09.779	21.31.755	135	05:13	28/10/13	07	DCM
036	044	053	25.09.779	21.31.755	35	05:15	28/10/13	18	ML
037	045	191	25.54.631	22.34.26	159	13:15	28/10/13	10	DCM
037	045	044	25.54.631	22.34.26	40	13:15	28/10/13	18	ML 33%
038	047	001	27.38.711	24.25.674	155	05:13	29/10/13	08	DCM
038	047	181	27.38.711	24.25.674	37	05:13	29/10/13	18	ML 33%
039	049	172	28.20.336	25.09.722	161	13:13	29/10/13	10	DCM
039	049	143	28.20.336	25.09.722	39	13:13	29/10/13	15	ML 33%
040	050	120	30.02.419	26.55.486	120	05:15	30/10/13	10	O2 max
040	050	037	30.02.419	26.55.486	37	05:15	30/10/13	18	ML
041	051	059	30.52.177	27.47.364	115	13:15	30/10/13	12	O2 max
041	051	027	30.52.177	27.47.364	31	13:15	30/10/13	17	ML
042	052	115	32.34.77	29.31.29	180	05:13	31/10/13	04	O2 max
042	052	054	32.34.77	29.31.29	34	05:13	31/10/13	18	ML 33%
043	053	144	33.22.481	30.19.919	100	13:15	31/10/13	12	DCM
043	053	151	33.22.481	30.19.919	25	13:15	31/10/13	17	ML 33%

044	054	133	35.17,972	32.15.669	71	05:19	01/11/13	12	DCM
044	054	156	35.17,972	32.15.669	50	05:19	01/11/13	14	ML
045	055	188	36.15.366	33.14.990	60	13:19	01/11/13	13	ML & DCM (no O2 max)
046	056	137	38.16.427	35.09.531	40	05:13	02/11/13	13	ML & DCM (no O2 max)
047	057	140	39.09.803	35.59.988	39	13:12	02/11/13	21	DCM
047	057	185	39.09.803	35.59.988	10	13:12	02/11/13	11	ML 33%
048	058	017	41.20.810	38.03.265	8	05:33	03/11/13	21	ML 33%
048	058	177	41.20.810	38.03.265	39	05:33	03/11/13	11	DCM
049	060	148	42.06.656	38.45.238	15	13:22	03/11/13	19	ML 33%
049	060	134	42.06.656	38.45.238	60	13:22	03/11/13	11	O2 max
050	061	193	44.07.700	40.36.646	35	05:23	04/11/13	12	DCM
050	061	180	44.07.700	40.36.646	10	05:23	04/11/13	21	ML 33%

The results from this cruise are expected to be available by 31 December 2014.

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Gross Primary Production, Dark Community Respiration and Net Community Production plus dissolved oxygen concentration in seawater (incl. CTD and underway calibrations)

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Dissolved oxygen (O_2) in seawater is produced by photosynthesis and consumed by respiration and photochemical reactions in the surface waters. Net community production (NCP) is the balance between gross primary production (GPP) and community respiration (CR), and represents the magnitude of biologically fixed carbon that is available to export to the deep ocean or for transference to upper levels of the marine food web. In the long term, NCP represents the planktonic contribution to the marine and atmospheric CO_2 balances.

Bacteria play an important role in this balance, although their contribution to community respiration has been difficult to characterize because of the methodological difficulty in separating bacterial respiration from respiration of the rest of the community.

Objectives

- To measure concentrations of oxygen dissolved in the seawater.
- To calibrate the oxygen sensor on the CTD profiler and the underway supply of seawater.
- To determine the daily balance of gross primary production (GPP) and community respiration (CR).

Methods

Dissolved oxygen concentration in discrete samples was measured by automated precisión Winkler titration performed with a Metrohm 848 Titrino, using a potentiometric end point as described in Serret et al. (1999). The concentration of thiosulphate was calibrated every day to a c.v. of ca. 10^{-6}. For CTD and underway calibrations, 6-7 glass 125 ml bottles were filled with seawater taken directly from the niskin bottles at 6-7 different depths using a silicone tube. Samples were fixed immediately and analysed during the following hours. In total, 26 profiles were carried out for the oxygen sensor calibration (Table 1) (see above Arwen Bargery's report). Each day 2 samples were also collected from the pre-dawn CTD cast and compared to the ^{17}O excess in the dissolved oxygen (see Kaiser/Wager report).

For the GPP, CR and NCP measurements, seawater from 5 depths down to the depth of 1% incident irradiance were collected daily from the pre-dawn CTD, directly taken from the Nikin bottles (in oligotrophic waters), or into 10 L carboys (in more productive waters). 12 125 ml glass O_2 bottles (4 light and 8 dark bottles) were sampled either from the Niskin bottles or sub-sampled from the 10 L carboys. 4 dark bottles were immediately fixed for O_2 concentration, the remaining (4 dark, 4 light) bottles were placed in deck incubators for 24 hours. The incubators were covered with neutral and blue density light filters simulating the PAR light at the corresponding depths in the water column. Temperatures were simulated with the underway water for the upper depths above the thermocline (down to 3% light) and with refrigerated wáter for the samples collected at the 1% light depth. Incubated light and dark O_2 bottles were removed from the incubators after the 24 hour incubation period and fixed and analysed for O_2. Production and respiration rates were calculated from the difference between the means of the replicated light and dark incubated bottles and zero time analyses (CR= Zero-Dark; NCP= Light-Zero; GPP=NCP + CR).

In total, 23 experiments were carried out for the determination of community production respiration along the cruise (Table 1).

Results

Productivity and respiration analyses (Winkler) were all performed on board, but data will be processed on return. It is expected that all GPP, NCP and CR data will be deposited by June 2014.

Reference

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Table 1. Stations where GPP, CR and NCP were measured.

Date, time	Latitude [+ ve deg N]	Longitude[+ve deg E]	CTD number
10-10-2013, 4:53	45,002	-13,595	03

11-10-2013, 4:43	41,777	-15,9685	06
12-10-2013, 4:45	38,39362	-18,37305	08
13-10-2013, 4:46	34,9491	-20,6693	10
14-10-2013, 4:48	31,3048	-22,6734	12
15-10-2013, 5:16	27,8052	-24,4850	16
16-10-2013, 5:12	24,2153	-26,2562	19
17-10-2013, 5:13	20,6432	-27,9901	21
18-10-2013, 5:12	17,0641	-29,1590	24
19-10-2013, 5:13	13,3133	-29,6706	26
20-10-2013, 5:14	9,2751	-29,5408	28
21-10-2013, 5:24	5,457467	-29,42065	30
23-10-2013, 5:43	-2,52	-28,989	33
24-10-2013, 5:42	-6,3375	-28,1792	35
25-10-2013, 5:10	-10,0021	-27,3968	37
26-10-2013, 5:11	-13,9450	-26,5583	40
27-10-2013, 5:15	-17,7016	-25,7049	42
28-10-2013, 5:13	-21,5293	-25,1630	44
29-10-2013, 5:13	-24,4279	-27,6451	47
30-10-2013, 5:15	-26,9248	-30,0403	50
31-10-2013, 5:13	-29,5215	-32,5796	52
01-11-2013, 5:14	-32,2612	-35,2995	54
02-11-2013, 5:13	-35,1589	-38,2737833	56
03-11-2013, 5:33	-38,0544	-41,3468	58
04-11-2013, 5:23	-40,6108	-44,1283	61
05-11-2013, 5:13	-42,8963	-46,7243	62

Phytoplankton photosynthesis, primary production and coloured dissolved organic material

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Ankita Misra (National Institute of Oceanography,Goa)

Objectives

During AMT23 integrated Primary production measurements were made at 27 stations on three size classes of phytoplankton from measurements taken from six to eight depths. Photosynthesis-irradiance curves were made at 25 stations at two depths in the water column. These measurements aim to fulfill the following objectives within:

- *The main deliverable is to provide an unique time series of spatially extensive and internally consistent observations on the structure and biogeochemical properties of planktonic ecosystems in the Atlantic Ocean that are required to validate models addressing questions related to the global carbon cycle. One of the key parameters is phytoplankton production. To this end a continuous long track series of primary production measurements have been made on AMT23 using methods synonymous to those used in previous AMT cruises.*
- *We also assessed the variation in photosynthesis in phytoplankton communities along the Atlantic Meridional transect.*
- *The absorption coefficient of Coloured dissolved organic material was also measured for satellite algorithm development.*

Methods

Primary production. Simulated in situ primary production was measured at 27 stations. Water samples were taken from pre-dawn (03:15-05:15 GMT) deployments of 21 x 10 + 3 x 20l SeaBird CTD rosette sampler on a stainless steel frame from 6 depths in the euphoic zone following the methods described in Tilstone et al. (2009). The samples were transferred from Niskin bottles to black carboys to prevent shock to the photosynthetic lamellae of the phytoplankton cells. Water from each sample was sub sampled into three 75 ml clear polycarbonate bottles and three black polycarbonate bottle; all bottles were pre cleaned following JGOFS protocols (IOC, 1994), to reduce trace metal contamination. Each sample was inoculated with between 185 and 740 kBq (5 - 15 µCi) $NaH^{14}CO_3$ according to the biomass of phytoplankton. The polycarbonate bottles were transferred to an on deck (simulated in situ) incubation system using neutral density and blue filters to simulate subsurface irradiance over depth to 97%, 55%, 33%, 20%, 14%, 7%, 3%, 1% or 0.1% of the surface value and incubated from local dawn to dusk (10 – 16 h). The incubators were maintained at surface temperature by pumping sea water from a depth of ~7 m through the upper light level incubators (97, 55, 33, 14, & 7 %) and from a chiller maintained at ±1°C of in situ temperature for the lower light level incubators (3, 1 & 0.1%). To terminate the incubations, suspended material were filtered sequentially through 0.2µm, 2µm and 10 µm polycarbonate filters to measure the pico, nano and micro-phytoplankton production respectively. The filters were exposed to concentrated HCl fumes for 8-12 h immersed in scintillation cocktail and ^{14}C disintegration time per minute (DPM) was measured on board using a Packard, Tricarb 2900 liquid scintillation counter and the external standard and the channel ratio methods were applied to correct for quenching.

Photosynthesis-Irradiance Curves.

Photosynthesis-Irradiance experiments were conducted at 36 stations at two depths in the water column; surface and Chla maxima. The experiments were run in photosynthetrons illuminated by 50 W, 12 V tungsten halogen lamps for the surface waters and LEDs for the Chla maxima following the methods described in Tilstone et al. (2003). Each incubator houses 15 sub-samples in 60 ml polycarbonate bottles which were inoculated with between 185k Bq (5 µCi) and 370 kBq (15 µCi) of ^{14}C labelled bicarbonate. The samples were maintained at *in situ* temperature using the ships non-toxic supply for the surface samples and at ambient temperature at the Chla maxima with a Polyscience chiller. After 1 to 2 h of incubation, the suspended material were filtered onto 0.2µm polycarbonate filters to measure phytoplankton photosynthetic rates. The filters were exposed to concentrated HCl fumes for 8-12 h immersed in scintillation cocktail and ^{14}C disintegration time per minute (DPM) was measured on board using a Packard, Tricarb 2900 liquid scintillation counter and the external standard and the channel ratio methods to correct for quenching. The broadband light-saturated Chla-specific rate of photosynthesis P_m^B [mg C (mg chl a)$^{-1}$ h^{-1}] and the light limited slope α^B [mg C (mg chl a)$^{-1}$ h^{-1} (µmol m^{-2} s^{-1})$^{-1}$] was estimated by fitting the data to the model of Platt *et al.* (Platt et al., 1980).

Initial Results

Figure 1 shows the variability in primary production along the cruise track in total and the three size fractions.

Higher values are associated with both micro- and pico- production in the e equatorial upwelling (150-300 mg C m^{-2} d^{-1}) and the Patagonia shelf region (530-1900 mg C m^{-2} d^{-1}), whereas lower values predominantly from pico-production occur in the North Atlantic (100-300 mg C m^{-2} d^{-1}) and South Atlantic Gyres (160-300 mg C m^{-2} d^{-1}).

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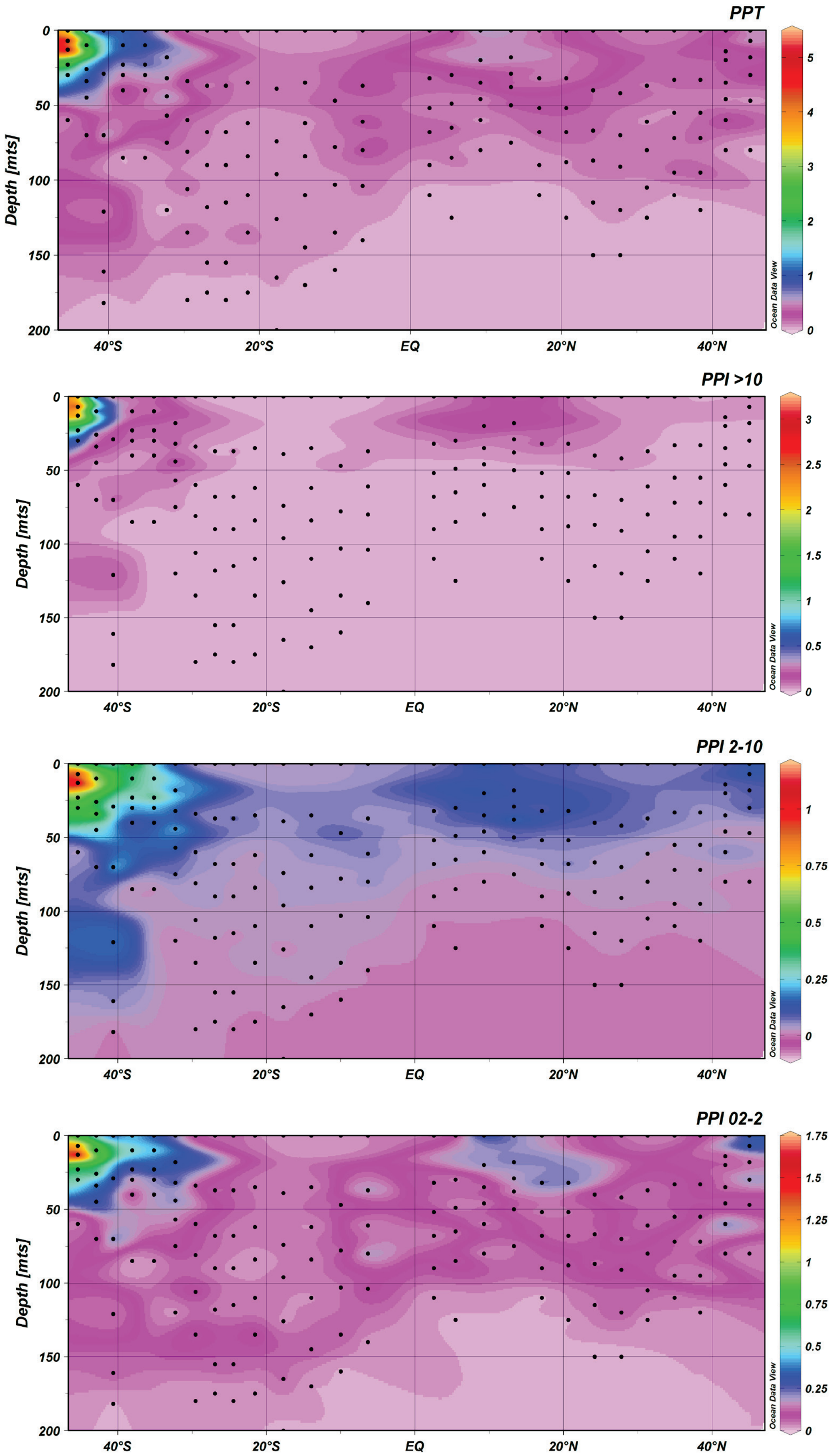
Table 1. Stations at which size fractionated primary production (PP), phytoplankton photosynthesis (PE curves) and $a_{CDOM}(\lambda)$ ("PE curves" from 22-Oct to 19-Nov) were measured.

Latitude	Longitude	Date	Julian Day	Time	CTD	Measurement
45.0135	-14.255	10-Oct-13	286	04:04	3	SIS PP
44.11157	-13.1355	10-Oct-13	283	12:10	5	PE Curves
41.77743	-15.9685	11-Oct-13	284	04:43	6	SIS PP
40.80922	-17.2666	11-Oct-13	284	12:15	7	PE Curves
38.39362	-18.3731	12-Oct-13	285	04:31	8	SIS PP
38.22983	-19.3246	12-Oct-13	285	13:03	9	PE Curves
34.94905	-20.6693	13-Oct-13	286	04:46	10	SIS PP
33.92	-21.2649	13-Oct-13	286	13:03	11	PE Curves
31.30483	-22.6734	14-Oct-13	287	04:48	12	SIS PP
30.36902	-23.0971	14-Oct-13	287	12:13	14	PE Curves
27.80517	-24.4995	15-Oct-13	288	05:26	16	SIS PP
26.65488	-25.5943	15-Oct-13	288	13:21	17	PE Curves
24.21528	-26.2562	16-Oct-13	289	05:12	19	SIS PP
23.07942	-26.8148	16-Oct-13	289	13:18	20	PE Curves
20.6432	-27.9901	17-Oct-12	290	05:13	21	SIS PP
19.65347	-28.3989	17-Oct-12	290	13:57	23	PE Curves
17.06407	-29.159	18-Oct-12	291	05:12	24	SIS PP
15.89508	-29.5015	18-Oct-12	291	13:12	25	PE Curves
13.31328	-29.6706	19-Oct-12	292	05:13	26	SIS PP
12.082	-29.6427	19-Oct-12	292	13:14	27	PE Curves
9.275067	-29.5408	20-Oct-12	293	05:14	28	SIS PP
8.11965	-29.5112	20-Oct-12	293	13:19	29	PE Curves
5.457467	-29.4207	21-Oct-12	294	05:24	30	SIS PP
4.363617	-29.3897	21-Oct-12	294	13:17	32	PE Curves
2.546933	-28.9829	23-Oct-12	295	04:52	33	SIS PP
-3.65662	-28.744	23-Oct-12	295	14:01	34	PE Curves
-6.33807	-28.1792	24-Oct-12	296	05:42	35	SIS PP
-7.42575	-27.9441	24-Oct-12	296	13:16	36	PE Curves
-10.0021	-27.3968	25-Oct-12	297	05:10	37	SIS PP
-11.1183	-27.1614	25-Oct-12	297	13:15	39	PE Curves
-13.945	-26.5583	26-Oct-12	298	05:11	40	SIS PP

-15.0023	-26.3297	26-Oct-12	298	13:13	41	PE Curves
-17.7016	-25.7049	27-Oct-12	299	05:15	42	SIS PP
-18.9973	-25.3874	27-Oct-12	299	13:15	43	PE Curves
-21.5293	-25.163	28-Oct-12	300	05:13	44	SIS PP
-22.571	-22.571	28-Oct-12	300	13:15	45	PE Curves
-24.4279	-27.6452	29-Oct-12	301	05:13	47	SIS PP
-26.162	-28.3389	29-Oct-12	301	13:13	49	PE Curves
-26.9248	-30.0403	30-Oct-12	302	05:15	50	SIS PP
-27.7894	-30.8696	30-Oct-12	302	13:15	51	PE Curves
-29.5215	-32.5796	31-Oct-12	303	05:13	52	SIS PP
-30.332	-33.3747	31-Oct-12	303	13:15	53	PE Curves
-32.2612	-35.2995	01-Nov-12	304	05:14	54	SIS PP
-33.2498	-36.2561	01-Nov-12	304	13:19	55	PE Curves
-35.1589	-38.2738	02-Nov-12	305	05:13	56	SIS PP
-35.9998	-39.1634	02-Nov-12	305	13:12	57	PE Curves
-38.0544	-41.3468	03-Nov-12	306	05:33	58	SIS PP
-38.754	-42.1109	03-Nov-12	306	14:00	60	PE Curves
-40.6108	-44.1283	04-Nov-12	307	05:23	61	SIS PP
-42.8963	-46.7243	05-Nov-12	308	05:13	62	SIS PP
-43.7087	-47.667	05-Nov-12	308	13:15	63	PE Curves
-45.4048	-49.6908	06-Nov-12	309	05:42	64	SIS PP
-46.2731	-50.7435	06-Nov-12	309	13:57	65	PE Curves

Figure 1. AMT23 Primary production (mg m^{-3} d^{-1}) in total (Pz Total), micro- (Pz >10), nano- (Pz 2-10), pico- (Pz 0.2-2) size fractions.



Extraction of phytoplankton pigments for High Performance Liquid Chromatography (HPLC) analysis

Bob Brewin & **Giorgio Dall'Olmo** (Plymouth Marine Laboratory)

Objectives
- To examine the horizontal and vertical phytoplankton pigment composition along the AMT23 transect.
- The continuation of an 18-year spatially extensive and internally consistent time series of observations on the pigment structure of phytoplankton in the Atlantic Ocean.
- Collecting phytoplankton pigment data for using the development and validation of remote-sensing algorithms and marine ecosystem models designed to predict and model the phytoplankton community structure at basin scales.

Equipment
- 25 mm glass fibre filters (GF/F)
- 1 and 2 litre measuring cylinders
- Millipore forceps
- Cryovials
- Cryopen
- Liquid nitrogen for flash freezing.

Methods
Seawater samples were collected from the predawn and noon CTD casts and from the ship underway system. Seawater was sampled into 9.5 L polypropylene carboys covered in black plastic to keep out light. Using forceps, GF/F filters were placed on the filter rig with the smoother side facing down. Filter papers were fully covered over sintered glass circles such that there were no gaps and water could only pass through GF/F filters. Seawater samples were well mixed to avoid issues with sedimentation. 1-4 L samples (depending on phytoplankton biomass, e.g. 1 litre in productive waters and 4 litres in oligotrophic gyres) were measured using the rinsed measuring cylinders, and then decanted into rinsed polypropylene bottles with siphon tubes and inverted into a 6 port vacuum filtration rig. Samples were filtered using a low-medium vacuum setting on the vacuum pump. When the last of the water passed through the filter paper, taps on the vacuum pump were closed and the resulting sample filters were folded into 2 mL cryovials and flash frozen in liquid nitrogen and stored at -80ºC. For each station, 6 samples were taken at approximately 95%, 20%, 7%, 3%, 1% (~deep chlorophyll maximum) and 0.1% light level. Duplicate HPLC measurements were taken at the surface (95%) and DCM (1% light) for every station. Two to three daily samples were also taken using the ships underway system. Frozen samples are to be analysed using HPLC methods (see Van Heukelem and Thomas, 2001) at Plymouth Marine Laboratory after the cruise. Table 1 below show the locations and stations of all the HPLC samples.

Reference
Van Heukelem, L. and Thomas, C.S. (2001) Computer-assisted high performance liquid chromatography method development with applications to the isolation and analysis of phytoplankton pigments, J. Chromatogr. A, 910, 31–49

Table 1. Temporal and spatial locations of HPLC samples on AMT 23.

STATION	CTD	Standard Day of Year	TIME (GMT)	LAT (degrees)	LON (degrees)	SAMPLE DETPH (m)
1	1	282	12:00	46.619	-10.628	2, 20, 35, 50, 60, 75
2	3	283	04:43	44.001	-13.594	2,7, 20, 30, 47, 80
3	5	283	12:11	44.112	-14.255	2, 8, 14, 20, 60, 75
4	6	284	04:43	41.777	-15.969	2, 8, 20, 46, 60, 80
5	7	284	12:15	40.809	-16.676	2, 10, 18, 26, 44, 75, 100
6	8	285	04:45	38.394	-18.373	2, 33, 55, 72, 95, 99
7	9	285	12:15	37.397	-19.044	2, 11, 30, 49, 85, 120
8	10	286	04:46	34.949	-20.669	2, 33, 55, 70, 95, 120
9	11	286	13:07	33.914	-21.282	2, 30, 73, 95, 122, 250

10	12	287	04:48	31.305	-22.673	2, 37, 61, 80, 105, 150
11	14	287	12:13	30.369	-23.157	2, 39, 64, 84, 115, 150
12	16	288	05:16	27.805	-24.485	2, 42, 70, 91, 120, 150
13	17	288	13:21	26.655	-25.063	2, 46, 75, 92, 132, 180
14	19	289	05:12	24.215	-26.256	2, 2, 40, 67, 87, 115, 150
15	20	289	13:18	23.079	-26.815	2, 33, 55, 75, 95, 125
16	21	290	05:13	20.643	-27.990	2, 32, 52, 68, 98, 125
17	23	290	13:15	19.653	-28.399	2, 33, 55, 70, 94, 120
18	24	291	05:12	17.064	-29.159	2, 32, 52, 68, 90, 110
19	25	291	13:12	15.895	-29.501	2, 18, 29, 40, 50, 75
20	26	292	05:13	13.313	-29.671	2, 18, 29, 38, 50, 75
21	27	292	13:14	12.082	-29.643	2, 20, 29, 35, 50, 75
22	28	293	05:14	9.275	-29.541	2, 20, 35, 46, 60, 80
23	29	293	13:19	8.120	-29.511	2, 20, 35, 46, 58, 80
24	30	294	05:24	5.457	-29.421	2, 30, 49, 65, 85, 125
25	32	294	13:17	4.365	-29.390	2, 33, 55, 72, 95, 125
26	33	296	05:43	-2.547	-28.983	2, 32, 52, 68, 90, 110
27	34	296	13:19	-3.657	-28.744	2, 20, 46, 61, 77, 120
28	35	297	05:42	-6.337	-28.179	2, 37, 61, 80, 104, 140
29	36	297	13:16	-7.426	-27.944	2, 39, 64, 84, 109, 140
30	37	298	05:10	-10.002	-27.397	2, 47, 78, 103, 133, 165
31	39	298	13:15	-11.117	-27.161	2, 47, 78, 103, 135, 165
32	40	299	05:11	-13.945	-26.558	2, 35, 84, 110, 145, 170
33	41	299	13:13	-15.002	-26.330	2, 51, 84, 110, 145, 170
34	42	300	05:15	-17.702	-25.705	2, 39, 96, 126, 165, 200
35	43	300	13:15	-18.998	-25.387	2, 63, 102, 124, 160, 200
36	44	301	05:13	-21.529	-25.163	2, 35, 84, 110, 135, 175
37	45	301	13:15	-22.571	-25.911	2, 61, 99, 120, 170, 185
38	47	302	05:13	-24.428	-27.645	2, 37, 90, 118, 155, 180
39	49	302	13:13	-25.162	-28.339	2, 59, 96, 126, 161, 185
40	50	303	05:15	-26.925	-30.040	2, 37, 90, 118, 155, 175
41	51	303	13:15	-27.789	-30.870	2, 46, 75, 99, 127, 165
42	52	304	05:13	-29.522	-32.580	2, 34, 81, 106, 135, 180
43	53	304	13:15	-30.324	-33.375	2, 37, 61, 80, 100, 160
44	54	305	05:14	-32.261	-35.300	2, 18, 44, 57, 75, 120
45	55	305	13:19	-33.250	-36.256	2, 20, 35, 46, 60, 125
46	56	306	05:13	-35.159	-38.274	2, 10 , 23, 30, 40, 85
47	57	306	13:12	-36.000	-39.163	2, 14, 23, 30, 39, 80
48	58	307	05:33	-38.054	-41.347	2
48	58	307	05:33	-38.054	-41.347	2, 10, 23, 30, 40, 70
49	60	307	13:11	-38.754	-42.011	2, 15, 20, 30, 60, 80
50	61	308	05:23	-40.611	-44.128	2, 10, 15, 20, 35, 75
51	62	309	05:13	-42.896	-46.724	2, 10, 26, 34, 45, 70
52	63	309	13:15	-43.709	-47.667	2, 11, 17, 23, 30, 60
53	64	310	05:42	-45.405	-49.691	2, 11, 17, 23, 30, 60
54	65	310	14:13	-46.273	-50.744	10, 17, 23, 30, 40, 80

Underway	N/A	282	10:40	46.772	-10.332	5
Underway	N/A	282	15:10	46.437	-10.961	5
Underway	N/A	283	04:53	45.002	-13.595	5
Underway	N/A	283	12:55	44.112	-14.255	5
Underway	N/A	283	16:59	43.511	-14.711	5
Underway	N/A	284	04:40	41.777	-15.967	5
Underway	N/A	284	14:56	40.504	-16.881	5
Underway	N/A	285	05:01	38.394	-18.377	5
Underway	N/A	285	12:59	37.397	-19.004	5
Underway	N/A	285	15:22	37.058	-19.278	5
Underway	N/A	286	04:55	34.949	-20.669	5
Underway	N/A	286	13:07	33.914	-21.282	5
Underway	N/A	287	05:46	31.305	-22.673	5
Underway	N/A	287	13:53	30.360	-23.157	5
Underway	N/A	288	05:03	27.809	-24.485	5
Underway	N/A	288	13:53	26.665	-25.063	5
Underway	N/A	288	19:19	25.875	-25.453	5
Underway	N/A	289	05:07	24.215	-26.256	5
Underway	N/A	289	14:00	23.080	-26.815	5
Underway	N/A	290	04:41	20.698	-27.968	5
Underway	N/A	290	13:55	19.653	-28.399	5
Underway	N/A	290	18:01	18.963	-28.609	5
Underway	N/A	291	05:01	17.064	-29.160	5
Underway	N/A	291	13:45	15.895	-29.501	5
Underway	N/A	291	18:16	15.234	-29.682	5
Underway	N/A	292	05:06	13.313	-29.671	5
Underway	N/A	292	13:56	12.082	-29.643	5
Underway	N/A	292	15:52	11.760	-29.636	5
Underway	N/A	293	05:08	9.275	-29.541	5
Underway	N/A	293	13:57	8.119	-29.508	5
Underway	N/A	293	15:34	7.900	-29.506	5
Underway	N/A	294	05:08	5.457	-29.423	5
Underway	N/A	294	14:10	4.362	-29.388	5
Underway	N/A	294	15:26	4.148	-29.389	5
Underway	N/A	296	05:23	-2.520	-28.989	5
Underway	N/A	296	13:57	-3.657	-28.744	5
Underway	N/A	296	16:28	-4.065	-28.662	5
Underway	N/A	297	04:57	-6.245	-28.201	5
Underway	N/A	297	13:56	-7.426	-27.944	5
Underway	N/A	297	15:47	-7.712	-27.888	5
Underway	N/A	298	04:54	-9.984	-27.404	5
Underway	N/A	298	13:42	-11.118	-27.161	5
Underway	N/A	298	15:28	-11.345	-27.110	5
Underway	N/A	299	05:09	-13.945	-26.558	5
Underway	N/A	299	13:41	-15.002	-26.330	5
Underway	N/A	299	15:47	-15.299	-26.262	5

Underway	N/A	300	05:42	-17.702	-25.706	5
Underway	N/A	300	13:41	-18.997	-25.387	5
Underway	N/A	300	15:51	-19.227	-25.319	5
Underway	N/A	301	05:02	-21.530	-25.164	5
Underway	N/A	301	13:44	-22.571	-25.910	5
Underway	N/A	301	16:14	-22.772	-26.076	5
Underway	N/A	302	05:02	-24.428	-27.645	5
Underway	N/A	302	13:50	-25.162	-28.339	5
Underway	N/A	302	15:19	-25.200	-28.459	5
Underway	N/A	303	04:59	-26.924	-30.035	5
Underway	N/A	303	13:48	-27.789	-30.870	5
Underway	N/A	303	15:38	-27.957	-31.037	5
Underway	N/A	304	04:56	-29.509	-32.568	5
Underway	N/A	304	13:49	-30.332	-33.375	5
Underway	N/A	304	15:16	-30.480	-33.519	5
Underway	N/A	305	05:57	-32.261	-35.301	5
Underway	N/A	305	13:45	-33.250	-33.375	5
Underway	N/A	305	16:00	-33.454	-36.520	5
Underway	N/A	306	04:59	-35.155	-38.274	5
Underway	N/A	306	13:35	-36.000	-39.164	5
Underway	N/A	306	15:05	-36.129	-39.301	5
Underway	N/A	307	05:00	-38.060	-41.351	5
Underway	N/A	307	14:04	-38.746	-42.096	5
Underway	N/A	307	15:32	-38.904	-42.265	5
Underway	N/A	308	05:06	-40.610	-44.127	5
Underway	N/A	308	13:54	-41.246	-44.840	5
Underway	N/A	308	17:32	-41.611	-45.242	5
Underway	N/A	309	05:06	-42.896	-46.724	5
Underway	N/A	309	13:45	-43.709	-47.667	5
Underway	N/A	309	15:01	-43.810	-47.791	5
Underway	N/A	310	05:30	-45.405	-49.687	5
Underway	N/A	310	15:25	-46.288	-50.748	5
Underway	N/A	310	16:27	-46.419	-50.796	5

Abundance and composition of microbial plankton communities by flow cytometry

Glen Tarran (Plymouth Marine Laboratory)
Priscilla Lange (University of Oxford)
Mike Zubkov (National Oceanography Centre)

Objective

To determine the distribution, abundance and community structure of nano- and picophytoplankton, heterotrophic bacteria and heterotrophic nano- and picoplankton from CTD casts by flow cytometry.

Phytoplankton community structure and abundance by flow cytometry.

Fresh seawater samples from 200 m to the surface were collected in clean 250 mL polycarbonate bottles from a Seabird CTD system containing a 24 bottle rosette of 20 L Niskin bottles from predawn and solar noon CTD casts. Samples were stored in a refrigerator and analysed within 3 hours of collection. Fresh samples were measured using a Becton Dickinson FACSort flow cytometer which characterised and enumerated *Prochlorococcus* sp. and *Synechococcus* sp. (cyanobacteria) and picoeukaryotic phytoplankton, based on their light scattering and autofluorescence properties. Data were saved in listmode format and analysed onboard. Table 1 summarises the CTD casts sampled and analysed during the cruise.

Bacteria and heterotrophic flagellate community structure and abundance by flow cytometry.

Samples for bacteria and heterotrophic flagellate enumeration were collected from all depths of predawn and solar noon CTD casts in clean 50 mL centrifuge tubes and fixed with paraformaldehyde within half an hour of surfacing. Samples (see below) were stained with the DNA stain SYBR Green I (Sigma) in order to separate particles in suspension based on DNA content and light scattering properties. Samples were generally analysed flow cytometrically within 4 hours of surfacing. Each stained sample was run twice through a Becton Dickinson FACSort flow cytometer: once to analyse sub-micron sized particles and once to analyse particles greater than 1 µm in diameter. Data were saved in listmode format and will be analysed ashore.

Table 1. CTD casts sampled for phytoplankton, heterotrophic bacteria and heterotrophic flagellate community structure & abundance. Depths in italics represent depths analysed for heterotrophs but not for phytoplankton.

DATE	STATION	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS: phytoplankton and *heterotrophs*
09-Oct	1	1	12:47	46.62	-10.63	2 10 20 35 50 60 75 90 120 150 *250 300 403*
10-Oct	2	3	05:13	45.01	-13.59	5 9 15 19 31 47 50 85 105 155 *254*
10-Oct	3	5	12:54	44.11	-14.26	2 8 14 20 35 55 60 75 120 200 *300 400 500*
11-Oct	4	6	05:16	41.78	-15.97	2 8 14 20 35 46 55 60 70 80 100 130 160 200
11-Oct	5	7	12:55	40.81	-16.68	2 10 18 20 26 44 55 75 85 100 150 200 *300 400 500*
12-Oct	6	8	05:24	38.39	-18.37	2 20 23 33 40 45 55 70 80 95 100 110 120 150 200 *250*
12-Oct	7	9	12:59	38.23	-19.04	2 11 20 30 40 49 75 85 88 105 120 150 200 *300 400 500*
13-Oct	8	10	05:31	34.95	-20.67	2 13 23 33 40 55 70 95 100 120 150 175 200 *250*
13-Oct	9	11	12:53	33.92	-21.28	2 14 20 30 40 44 55 65 73 95 122 150 175 200 *300 400 500*
14-Oct	10	12	05:26	31.30	-22.67	2 14 25 37 40 55 61 65 80 95 105 130 150 175 200 *250*
14-Oct	11	14	12:56	30.37	-23.16	2 14 20 26 39 55 60 64 84 90 110 125 150 175 200 *300 400 500*
15-Oct	12	16	05:53	27.81	-24.48	2 16 29 42 55 70 78 85 91 105 120 135 150 175 200 *250*
15-Oct	13	17	14:02	26.65	-25.06	2 17 20 31 46 60 75 92 100 115 132 150 180 200 *300 400 500*
16-Oct	14	19	05:54	24.22	-26.26	2 15 20 25 28 40 53 67 78 87 105 115 130 150 175 200 *250*
16-Oct	15	20	13:56	23.08	-26.81	2 13 20 23 55 75 85 95 110 125 150 200
17-Oct	16	21	06:00	20.64	-27.99	2 12 22 32 40 52 60 69 80 88 105 125 150 175 200 *250*
17-Oct	17	23	13:56	19.65	-28.40	2 5 13 20 23 33 55 70 80 95 105 120 160 200
18-Oct	18	24	05:59	17.06	-29.16	2 12 22 32 42 52 61 70 80 90 100 110 140 175 200 *250*
18-Oct	19	25	13:53	15.90	-29.50	2 5 12 18 20 29 40 50 60 75 100 150 200
19-Oct	20	26	06:03	13.31	-29.67	2 7 12 18 29 34 38 45 60 75 90 120 140 175 200 *250*
19-Oct	21	27	13:56	12.08	-29.64	2 5 12 20 29 35 50 75 100 130 170 200
20-Oct	22	28	05:59	9.28	-29.54	2 8 14 20 30 35 40 46 57 70 80 100 130 160 200 *250*
20-Oct	23	29	13:58	8.12	-29.51	2 8 14 20 35 42 46 60 80 110 200
21-Oct	24	30	06:08	5.46	-29.42	2 11 20 30 49 55 65 75 85 95 100 125 175 200 *250*
21-Oct	25	32	13:57	4.36	-29.39	2 13 20 23 33 55 72 85 93 105 125 200
23-Oct	26	33	06:28	-2.55	-28.98	2 12 22 32 40 52 68 80 90 95 100 110 125 150 175 200 *250*
23-Oct	27	34	13:59	-3.66	-28.74	2 11 20 46 61 70 80 95 120 150 200

24-Oct	28	35	06:26	-6.34	-28.18	2 14 20 25 37 61 70 80 90 99 104 115 140 170 200 *250*
24-Oct	29	36	13:57	-7.43	-27.94	2 15 20 26 39 50 64 84 100 109 125 140 170 200 *300 400 500*
25-Oct	30	37	05:55	-10.00	-27.40	2 18 20 47 60 70 78 103 115 123 133 150 165 180 200 *250*
25-Oct	31	39	13:58	-11.12	-27.16	2 20 32 47 60 78 90 103 125 132 150 165 200 *300 400 500*
26-Oct	32	40	05:54	-13.95	-26.56	2 20 35 51 62 84 90 110 125 145 155 170 200 *250*
26-Oct	33	41	13:55	-15.00	-26.33	2 20 35 51 70 84 110 125 145 155 170 200 *300 400 500*
27-Oct	34	42	06:02	-17.70	-25.70	2 23 39 59 79 90 96 126 150 163 170 180 200 *250*
27-Oct	35	43	13:58	-19.00	-25.39	2 20 25 41 63 80 102 134 155 160 185 200 *300 400 500*
28-Oct	36	44	05:58	-21.53	-25.16	2 20 35 51 62 84 100 110 120 130 135 160 175 200 *250*
28-Oct	37	45	13:57	-22.57	-25.91	2 20 40 61 77 99 120 130 140 150 159 185 200 *300 400 500*
29-Oct	38	47	05:56	-24.43	-27.65	2 20 37 55 68 90 118 135 140 150 155 165 180 200 *250*
29-Oct	39	49	13:52	-28.34	5482	2 20 39 59 96 126 150 161 170 185 200 *300 400 500*
30-Oct	40	50	05:58	-26.92	-30.04	2 20 37 55 68 90 95 105 120 135 155 165 175 200 *250*
30-Oct	41	51	13:53	-27.79	-30.87	2 17 20 31 46 60 75 99 115 127 145 165 185 200 *300 400 500*
31-Oct	42	52	05:54	-29.52	-32.58	2 20 34 49 60 81 95 106 115 125 135 160 180 200 *250*
31-Oct	43	53	13:55	-30.33	-33.37	2 14 20 25 37 61 80 90 100 120 140 160 175 200 *300 400 500*
01-Nov	44	54	05:57	-32.26	-35.30	2 10 18 26 32 44 50 57 71 80 90 105 120 135v 175 200 *250*
01-Nov	45	55	13:58	-33.20	-36.26	2 8 14 20 35 46 60 80 110 125 150 175 200 *300 400 500*
02-Nov	46	56	05:54	-35.16	-38.27	2 10 14 17 20 23 30 40 50 75 85 100 125 150175 200 *250*
02-Nov	47	57	13:53	-36.00	-39.16	2 10 14 20 23 30 39 50 65 80 100 120 150 200
03-Nov	48	58	06:13	-38.05	-41.35	2 10 14 20 23 30 40 50 60 70 90 100 150 200 *250*
03-Nov	49	60	13:58	-38.75	-42.11	2 10 15 20 30 50 60 70 80 100 150 200 *300 400 500*
04-Nov	50	61	05:58	-40.61	-44.13	7 10 15 20 25 35 40 50 65 75 80 100 150 200 *250*
05-Nov	51	62	05:55	-42.90	-46.72	2 10 16 20 26 34 40 60 70 100 120 160 200 *250*
05-Nov	52	63	13:57	-43.71	-47.67	2 7 11 17 20 22 30 45 60 80 100 120 160 200 *300 400 500*
06-Nov	53	64	06:17	-45.40	-49.69	2 7 11 17 23 30 40 50 60 80 100 125 150 200 *250*
06-Nov	54	65	14:52	-46.27	-50.74	2 10 17 20 23 30 40 60 80 100 150 200 *300 400 500*

Culturing strains of *Synechococcus* and phototrophic picoeukaryotes

Mónica Moniz (University of Warwick)

The central aim of this project is to collect and isolate *Synechococcus* and picoeukaryotes which have not yet been successfully put into culture. In parallel, we would like to understand several factors that contribute to variability of populations in the environment by performing grazer experiments and phage infection experiments.

1. Culturing strains of *Synechococcus* and picoeukaryotes

Objectives

- To collect sea water from different depths and enrich it with different combinations and concentrations of nutrients with the expectation of isolating strains and organisms not yet put into culture.

- **Sampling strategy**

  Core sampling (pre dawn and noon CTD) – 1 litre from 2 depths (0.1% light and surface). 1Liter vol from each depth was pre-filtered through 5 µm polycarbonate (PC) filters and added to flasks previously filled with either K media, PCR-SII, ASW or ASW with NH4. A selection was also plated with agarose and SN media or collected to be plated back at Warwick University.

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Proposed analysis

Single cell isolations either by cell flow sorting or by plating will be performed to establish monoclonal cultures. These will be identified by the amplification and sequencing of *petB* for *Synechococcus* strains and 18S and rbcL for picoeukaryotes.

Log of samples collected for culturing:

Date	Station	CTD
	1	2
10.10.13	2	3
	3	5
11.10.13	4	6
	5	7
12.10.13	6	8
	7	9
13.10.13	8	10
	9	11
14.10.13	10	12
	11	15
15.10.13	12	16
	13	18
16.10.13	14	19
	15	20
17.10.13	16	21
	17	23
18.10.13	18	24

	19	25
19.10.13	20	26
	21	27
20.10.13	22	28
	23	29
21.10.13	24	30
	25	32
23.10.13	26	33
	27	34
24.10.13	28	35
	29	36
25.10.13	30	37
	31	39
26.10.13	32	40
	33	41
	34	42
27.10.13	35	43
	36	44
	37	46
28.10.13	38	47
	39	49
	40	50
29.10.13	41	51
	42	52
	43	53
30.10.13	44	54
	45	55
	46	56
31.10.13	47	57
	48	58
01.11.13	49	60
03.11.13	50	61 62
	51	63
04.11.13	52	64 65
	53	
05.11.13	54	
06.11.13	A1	
	A2	
07.11.13	A3	
08.11.13		

2. Grazing preference

Objectives

- To analyse possible grazing preference by known *Synechococcus* grazer *Pteridomonas.*

- **Sampling strategy**

. Incubation of *Pteridomonas* sp. with material collected in cell traps from different depths in order to analyze grazing preference. Samples collected at 15 min, 30 min, 45 min, 1 hour, 1h 30, 2 h, 6h, 12h, 24h and 36 h after feeding *Pteridomonas* sp culture.

Proposed analysis

Sorting of *Pteridomonas* sp by cell sorting and extraction of DNA from these cells. Gene library analyses of *Synechoccocus* targeted gene *petB* in order to see what was present in the water column and also consumed by the grazer.

Log of Grazing preference experiments:

Date	Station	CTD
11.10.13	5	7
17.10.13	16	21
20.10.13	23	29
23.10.13	27	34
29.10.13	39	49
04.11.13	underway	

3. Phage infection preference

- **Objective -** To analyse possible infection preference by 3 cyanophages.

Sampling strategy

Incubation of three different phages with material collected in cell traps and concentrated by filtration from different depths in order to analyse infection preference. Samples were flash frozen 2 hours after infection.

Proposed analysis:

The phages have been tagged with SYBRGold. This will allow to cell sort for cells which have been infected and amplify the gene *petB* in order to identify which cells were preferably infected and which were not.

Log of phage infection preference experiments:

Date	Station	CTD
26.10.13	32	40
06.11.13	53	64

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Basin-scale adaptation and functional potential of a ubiquitous oxyphototrophic bacterium

Frances Pitt (University of Warwick)

The central aim of this project is to elucidate functional potential (genomics) and activity (transciptomics) in natural populations of an ecologically important marine phototroph, *Synechococcus*, which inhabits the euphotic zone of temperate, tropical and equatorial regions of the North and South Atlantic Ocean.

1. High-resolution community structure analyses of the *phytoplankton* populations along the AMT transect to assess annual variations in diversity and distribution: size fractionated single membrane water filtration

Objectives

- To determine the distribution and abundance of marine *Synechococcus* from predawn and solar noon CTD casts using a targeted pyrosequencing approach to determine fine scale community structure.

- **Sampling strategy**

Core sampling (pre dawn CTD) – 10 litres from 4 depths capturing both above and below the mixed layer. Up to 10 l vol from each depth was pre-filtered through 100 µm mesh and 10.0 µm polycarbonate (PC) filters while the 0.45 µm (Supor) fractions were retained and flash frozen. Combined CT40 cell trap capture for surface sample allows multiple marker profiling of sorted picophytoplankton to support both grazing and transcriptomic profiles.

Proposed analysis

DNA will be extracted from filters using established techniques and analysed by a variety of methods in the laboratory. Quantitative estimates of the abundance of *Synechococcus* (*Syn*) genotypes will be carried out via pyrosequencing using selected multi-locus markers such as *petB* (Mazard et al., 2011.). Estimates of species/ribotype abundance will complement the flow cytometric analsyses of underway and CTD samples (Glen Tarran Core AMT measurement) as well as allow for direct comparison with similar data obtained on AMT-18, 19 (Ostrowski, unpublished), AMT-22 (Pitt unpublished) AMT-15 (Zwirglmaier et al., 2008) and AMT-13 (Johnson et al., 2006).

Bulk Community DNA Sample Log:

Date	Station	CTD	Bottle No.	Depth	Light %	Volume	CT40 cell trap run 20m
10.10.13	2	3	3	100m		10 litres	✔
			7	47m	DCM	10 litres	
			17	12m	33	10 litres	
			21	2m	97	10 litres	
11.10.13	4	6	2	160m	-	10 litres	
			9	60m	DCM	10 litres	
			17	20m	20%	10 litres	
			21	2m	97%	10 litres	
12.10.13	6	8	2	200m	-	10 litres	✔
			8	95m	DCM	10 litres	
			17	23m	33%	10 litres	
			19	2m	97%	10 litres	
13.10.13	8	10	2	200m	-	10 litres	

			9	95m	DCM		10 litres	
			19	23m		33	10 litres	
			22	2m		97	10 litres	
14.10.13	10	12	2	200m	-		10 litres	
			8	105m	DCM		10 litres	
			18	29m		33	10 litres	
			22	2m		97	10 litres	
15.10.13	12	16	2	200m	-		10 litres	
			8	120	DCM		10 litres	
			19	29m		33	10 litres	
			22	2m		97	10 litres	
16.10.13	14	19	2	200m	-		10 litres	✔
			7	115m	DCM		10 litres	
			18	25		33	10 litres	
			22	2		97	10 litres	
17.10.13	16	21	2	200m	-		10 litres	
			12	69m	DCM		10 litres	
			18	32m		33	10 litres	
			22	2m		97	10 litres	
18.10.13	18	24	2	200m	-		10 litres	
			8	90m	DCM		10 litres	
			19	22m		33	10 litres	
			22	2m		97	10 litres	
19.10.13	20	26	2	200m	-		10 litres	
			10	45m	DCM		10 litres	
			20	12m		33	10 litres	
			22	2		97	10 litres	
20.10.13	22	28	2	200m	-		10 litres	
			8	57m	DCM		10 litres	
			19	14		33	10 litres	
			22	2		97	10 litres	
21.10.13	24	30	2	200m	-		10 litres	
			9	85	DCM		10 litres	
			20	20		33	10 litres	
			22	2		97	10 litres	
23.10.13	26	33	2	200m	-		10 litres	
			9	90m	DCM		10 litres	
			20	22		33	10 litres	
			22	2		97	10 litres	
24.10.13	28	35	2	200m	-		10 litres	
			6	105m	DCM		10 litres	
			19	25		33	10 litres	
			22	2		97	10 litres	

25.10.13	30	37	2	200m		-		10 litres	
			7	135m		DCM		10 litres	
Bottle failure			19		39		33	10 litres	
			22		2		97	10 litres	
26.10.13	32	40	2	200m		-		10 litres	✔
			5	145m		DCM		10 litres	
			16		35		33	10 litres	
			22		2		97	10 litres	
27.10.13	34	42	2	200m		-		10 litres	
			7	163m		DCM		10 litres	
			17		39		33	10 litres	
			21		2		97	10 litres	
28.10.13	36	44	2	200m		-		10 litres	
			5	135m		DCM		10 litres	
			17	35m			33	10 litres	
			21	2m			97	10 litres	
29.10.13	38	47	2	200m		-		10 litres	
			6	155m		DCM		10 litres	
			17	37m			33	10 litres	
			21	2m			97	10 litres	
30.10.13	40	50	2	200m		-		10 litres	
			6	155m		DCM		10 litres	
			17	37m			33	10 litres	
			22	2m			97	10 litres	
31.10.15	42	52	2	200m		-		10 litres	✔
			6	155m		DCM		10 litres	
			16	49m			20	10 litres	
			22	2m			97	10 litres	
01.11.13	44	54	2	200m		-		10 litres	
			10	78m		DCM		10 litres	
			20		18		33	10 litres	
			22	2m			97	10 litres	
02.11.13	46	56	2	200m		-		10 litres	
			10	40m		DCM		10 litres	
			20	10m			33	10 litres	
			22	2m			97	10 litres	
03.11.13	48	58	2	200m		-		10 litres	✔
			10	34m		DCM		10 litres	
			20	8m			33	10 litres	
			22	2m			97	10 litres	
04.11.13	50	61	2	200m		-		10 litres	✔
			10	34m		DCM		10 litres	
			20	8m			33	10 litres	
			22	2m			97	10 litres	
05.11.14	51	62	2	200m		-		10 litres	

			10	34m	DCM		10 litres	
			20	8m		33	10 litres	
			22	2m		97	10 litres	
06.11.14	53	64	2	200m	-		10 litres	✔
			10	30m	DCM		10 litres	
			19	7m		33	10 litres	
			22	2m		97	10 litres	

2. *Synechococcus* population genomics and transcriptomics of distinct communities along ecological gradients: size fractionated water filtration with cell recovery from ceramic filter units (cell traps)

Objectives

- To determine the factors that influence *Synechococcus* community structure and the relationship between environmental niche and genetic potential (i.e. gene complement).

  To compare the genomic potential of specific *Synechococcus* populations with the actual genes expressed i.e. a population genome versus population transcriptome comparison.

- **Sampling strategy**

For group specific transcriptomics (midday CTD) – One large volume surface sample (20 meters) i.e 40-60 litres collected from the CTD for maximum biomass loading + cell recovery via high volume 0.2 micron cell traps once per station. Water was pre-filtered with a 35 micron cartridge filter, with large volumes (>100 litres) filtered via CellTrap 400 filters (CT400 Memteq) and lower volumes (<100 litres) filtered via CellTrap100 filters (CT100 Memteq) and CellTrap40 (CT40 Memteq). Cells were recovered from the ceramic filter filaments via elution into 20-50ml and snap frozen in Liquid nitrogen prior to -80^{o}C storage. Total filtration time for transcriptomic profiling was restricted to 20 minutes. Cell Traps were re-used to collect DNA samples from the remaining seawater collected.

Proposed analysis

DNA and RNA will be extracted from targeted populations of *Synechococcus*, sorted using flow cytometry. Both Amplified and non-amplified nucleic acids will then be sequenced to a high depth-of coverage using illumina sequencing at the NERC Molecular Genetics Facility (Liverpool).

CT100/CT400 Sample Log:

Date	Station/UW	CTD	CT40	CT100	CT400	pre-filter	UW or CTD	Amount of water filtered for RNA
09.10.13	1	2			1	35 um	CTD	120 litres
10.10.13	3	5		1		35 um	CTD	55 litres
11.10.13	5	7		1		35 um	CTD	70 litres
12.10.13	7	9	3			10 um	CTD	10 litres
13.10.13	9	11	3			10 um	CTD	12 litres
14.10.13	11	15			1	-	CTD	120 litres
15.10.13	13	18			1	35 um	CTD	160 litres
16.10.13	15	20	3			10 um	CTD	15 litres
18.10.13	19	25	3			10 um	CTD	15 litres
20.10.13	23	29		1		35 um	CTD	60 litres
21.10.13	25	32			1	35 um	CTD	70 litres
23.10.13	27	34		1		35 um	CTD	70 litres

25.10.13		31	39	3			10 um	CTD	17 litres
26.10.13		33	41	3			10 um	CTD	17 litres
27.10.13		35	43			1	35 um	CTD	80 litres
28.10.13		37	46			1	35 um	CTD	180 litres
29.10.13		39	49		1		35 um	CTD	70 litres
30.10.13		41	51	3			10 um	CTD	17 litres
31.10.13		43	53	3			10 um	CTD	17 litres
01.11.13		45	55	3			10 um	CTD	17 litres
2.11.13		47	57	3			10 um	CTD	17 litres
3.11.13		49	60	3			10 um	CTD	17 litres
4.11.13	UW	-			1		35 um	CTD	100 litres
5.11.13		51	62		1		35 um	CTD	60 litres
5.11.13		52	63		1		35 um	CTD	80 litres
6.11.13		54	65		1		30 um	CTD	80 litres

3. Investigation of novel *Synechococcus* clade emergence during the transition zones between the major water bodies of the Atlantic Basin: High Frequency water sampling

Objectives

To map *Synechococcus* gene expression over a 24hr period in order to observe a 'day in the life" community profile.
Perform high frequency sampling to assess fine scale emergence and/or disappearance of novel *Synechococcus* clades in order to assess their potential to act as seeding populations for the major water bodies of the Atlantic.

- **Sampling strategy**

☐ 1 litre Water samples from the underway water supply were taken during the major water body transitions. See UW High Frequency Log table below for sample frequency and location. Samples were processed in the same manor as the predawn core sampling strategy.

Proposed analysis

Pyrosequencing using the high resolution marker *petB* (Mazard et al., 2011.) will reveal potential fine scale emergence of transient Synechococcus clades during the major water body transitions.

Under Way High Frequency Sample Log

Date	Station	CTD	Lat	Long	Frequency	Sample source
	15	20	22o 29.1693N	27o 06.2436W	2 hour	Wet Lab UW
17.10.13	16	21			2 hour	Wet Lab UW
	17	23	19o 39.1600N	28o 23.7700W	1 hour	Wet Lab UW
18.10.13	18	24			1 hour	Wet Lab UW
	19	25	15o 24.4407N	29o 37.8241W	30 min	Wet Lab UW
19.10.13	20	26			1 hour	Wet Lab UW
	21	27	12o 04.8600N	29o 38.6900W	10 min	Wet Lab UW
20.10.13	22	28			1 hour	Wet Lab UW
	23	29	07o 44.2461N	29o 30.3505W	5 min	Wet Lab UW
21.10.13	24	30			1 hour	Wet Lab UW
	25	32	04o 21.8159N	29o 23.3788W	1 hour	Wet Lab UW
24.10.13	28	35	07o 14.83395S	27o 59.2496W	10 min	Wet Lab UW
	29	36	09o 27.6105S	27o 30.8400W	10 min	Wet Lab UW

01.11.13	44	54	32o 07.7196S	35o 10.1460W	1 hour	Wet Lab UW
	45	55			1 hour	Wet Lab UW
02.11.13	46	56			1 hour	Wet Lab UW
	47	57			1 hour	Wet Lab UW
03.11.13	48	58			1 hour	Wet Lab UW
	49	60	39o 50.0280S	43o 25.6203W	1 hour	Wet Lab UW

References

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Photoheterotrophy of dominant bacterioplankton

Claire Evans & **Mike Zubkov** (National Oceanography Centre)

Objectives:

- To determine the ambient concentration and uptake rate of the amino acids methionine and leucine, and organic phosphate in the form of adenosine triphophate (ATP)
- To compare the capacity for light-enhanced (relative to the dark) uptake of methionine, leucine and ATP by prokaryotic assemblages in the surface waters with those at the base of the mixed layer.
- To establish whether the dominant prokaryotic groups behaved congruently over depth with regards to organic nutrient uptake and light-enhanced uptake

Materials and methods

Bacterioplankton were enumerated by flow cytometry (FACSort, Becton Dickinson, UK) from samples fixed with 1% final concentration paraformaldehyde and stained with the DNA dye SYBR Green I. An internal standard containing 0.5 and 1.0 µm beads (Fluoresbrite microparticles, Polysciences), the concentration of which was determined by syringe pump flow cytometry (Zubkov and Burkill, 2006), was added to each of the samples. Bacterioplankton groups were distinguished according to their DNA content and scatter properties.

The ambient concentrations and turnover rates of leucine, methionine and ATP in the waters were determined using the isotopic dilution time series bioassay (Wright and Hobbie, 1966, Zubkov et al. 2004). L-[4,5-3H]-leucine (specific activity 140 Ci mmol-1) was preloaded into 2 mL polypropylene crystal clear microcentrifuge tubes (Starlab, Milton Keynes) to make a final concentration series ranging from 0.1 to 1 nM when combined with the 1.6 mL seawater samples. Immediately after collection, seawater was combined with the labelled substrate (marking the start of the experiment) and a sample from each concentration was fixed at 10, 20, 30 and 40 min by addition of 1% final concentration paraformaldehyde. Particulate matter in the samples was harvested by filtration onto 0.2 µm pore-size polycarbonate filters, which were then washed twice with 4 mL of deionised water. To determine the radioactivity of the retained particulate matter the filters were analysed by liquid scintillation counting (Tri-Carb, 3100TR, Perkin-Elmer, Beaconsfield, UK). Substrate concentration, uptake rate and turnover time were calculated as previously described by Zubkov and colleagues (2007). The L-[35S]-methionine (specific activity >1000 Ci mmol-1) bioassay was completed in a similar manner, except that the labelled substrate was added at a standard concentration of 0.05 nM and diluted with unlabelled (cold) methionine, using a dilution series ranging from 0.05 to 1.0 nM. For the [α 33P]-ATP (specific activity 3000 Ci mmol-1) bioassay the labelled substrate was added at a standard concentration of 0.15 nM and also diluted with unlabelled (cold) ATP, using a dilution series ranging from 0.2 to 1.0 nM. Samples were fixed at 15, 30, 45, and 60 min.

Uptake of organic substrates by prokaryotes in the light and dark were determined by incubation experiments. Seawater samples were placed in 30 mL borosilicate glass bottles, to which either 0.4 nM final concentration L-[4,5-3H]-leucine or 0.1-0.4 nM final concentration [α 33P]-ATP was added, bioassay experiments had determined the methionine was faulty and so this was not tested. The bottles were incubated in 6 L water-filled tanks that were maintained at ambient seawater temperature by continual water recirculation through a thermostatically controlled bath. For the dark incubations the water tank was sealed in two layers of black, plastic bags. For the light incubations a light intensity of 160 µmol photons m-2 s-1 was used at stations south to 27°S, and 250-300 µmol photons m-2 s-1 thereafter. To examine uptake of the isotopes the experiments were sub-sampled every two hours over a time period of six hours, starting at either one or two hours post isotope addition. The subsamples were fixed, filtered and analysed as described above and the difference between radioactivity taken up in the light and dark treatments was calculated. Additional subsamples were also taken from the incubations at the six hour time point to determine the isotope uptake by specific microbial groups. This was achieved by radioassaying individual flow-sorted bacterioplankton populations. After fixing and staining, cells were sorted onto pre-washed 0.2 µm polycarbonate filters at a rate of <300 particles s-1 in single-cell sort mode for 1, 2, 3, and 4 min for each group. At stations located within the South Atlantic gyre (SAG) the sorted bacterioplankton groups were: total bacterioplankton, SAR11 and *Prochlorococcus*, whilst in the South temperate waters (STW) *Prochlorococcus* declined sharply and could not be sorted. For each group the isotope uptake per cell was calculated by dividing the radioactivity taken up by the number of cells sorted, and then deriving an average from the four sorts conducted per group. For both the light and dark treatments an uptake rate in nmol cell-1 h-1 was calculated, according to the method of Gómez-Pereira and colleagues (2012). Briefly, the uptake per cell (c.p.m. cell-1) for either the light or dark treatment was divided by the total uptake (c.p.m. l-1) from that same treatment, and then multiplied by the microbial uptake rate in nmol l-1 h-1 (as derived from the isotopic dilution assay). Total uptake was then calculated from the filtered whole-water subsamples, as described above. To finally calculate leucine and ATP uptake rates in molecules per cell this rate was multiplied by

Avogadro's number.

Results
Light significantly enhanced the microbial uptake of ATP and leucine in waters from both the surface (20 m) and the BML (27-135 m) at the 13 stations sampled in the South Atlantic Ocean (Figs. 1&2). In the SAG total microbial 33P-ATP uptake at a light intensity range of 160 to 300 µmol photons m-2 s-1 resulted in, on average, identical levels of light-stimulated uptake at both depths when compared to uptake in the dark (surface 19 ± 7% and BML 19 ± 5%). In the STW levels of light-stimulated microbial ATP uptake were also similar at the surface and at the BML at 23 ± 2% and 19 ± 3%, respectively. However, gross uptake rates were higher in this region at 0.30 ± 0.13 and 0.17 ± 0.003 nM day-1 for the surface and BML respectively, compared to 0.10 ± 0.07 and 0.08 ± 0.05 nM day-1 at the corresponding depths in the SAG.

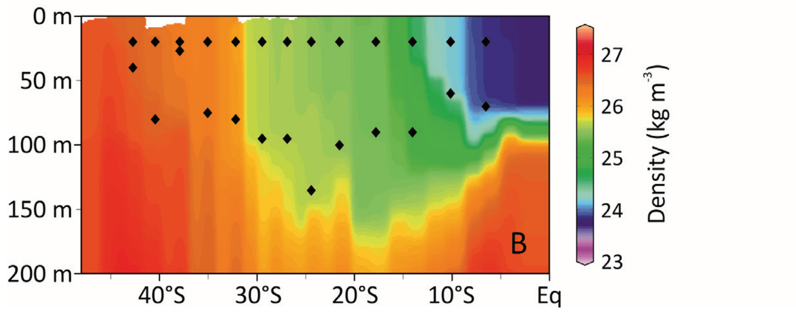

Figure 1. Contour plot of seawater density in the top 200 m of the water column of the South Atlantic showing the locations of the stations and depths sampled.

Contrary to the observations of ATP uptake, levels of light-stimulated microbial leucine uptake at a light intensity range of 160 to 300 µmol photons m-2 s-1 differed significantly with depth in the SAG (Figure 2, n=9, t-test P-value <0.05). The increase in uptake rate was approximately double at the BML (17 ± 12%) compared to the surface waters (8 ± 5%), although no difference between the two depths was observed in the three stations located in the STW (6 ± 4% and 7 ± 3% increase for the surface and BML, respectively). As for ATP, the STW were characterised by much greater absolute uptake of the leucine substrate (1.12 ± 0.37 and 0.75 ± 0.38 nM day-1 for surface and BML, respectively) when compared to the SAG (0.27 ± 0.23 and 0.21 ± 0.10 nM day-1 for surface and BML, respectively).

The depth origin of the *Prochlorococcus* and SAR11 populations examined here did not result in an appreciable difference of their absolute uptake rates of the organic substrates tested (Table 1), and hence average values for both the surface waters and BML are presented here. The Prochlorococcus populations in the SAG took up similar amounts of both ATP and leucine at around 2000 and 2400 molecules cell-1 h-1, respectively, in the presence of light (Table 1). Conversely, uptake rates of ATP and leucine by the SAR11 populations in the SAG differed by more than an order of magnitude, at 600 molecules cell-1 h-1 compared to 7500 molecules cell-1 h-1, respectively (Table 1). SAR11 uptake rates were on average greater in the STW compared to the SAG, being almost double for leucine, at on average 13000 molecules cell-1 h-1, and approximately five times as much for ATP, at 3100 molecules cell-1 h-1.

In contrast, while the depth origins of SAR11 and Prochlorococcus did not significantly influence their absolute organic substrate uptake rates in the light, the observed degree of light stimulation was different in the surface populations compared to those at the BML. For Prochlorococcus, light stimulation increased the uptake of leucine by on average 24% at the surface compared with 36% at the BML, and increased the uptake of ATP by 21% at the surface compared with only 12% at the BML, although these differences did not quite reach statistical significance (Table 1). For SAR11, light-stimulated uptake of leucine was higher at the BML (average 21%) compared to the surface (average 7%) at 7 out of the 8 stations in the SAG where both depths were tested, and this difference was statistically significant (Table 1, t-test P-value <0.05). This pattern of greater light-stimulated uptake of leucine by SAR11 over depth was also observed at the 3 stations located in the STW, where the increase was on average 21% at the BML compared to only 6% in the surface waters. Conversely, light-enhanced ATP uptake by SAR11 was not significantly different over depth, being 21% and 19% in the surface and BML, respectively in the SAG, and 16% and 13% for the corresponding depths in the STW.

The cyanobacteria *Synechococcus* encountered in the STW had similar ATP uptake rates in the presence of light as *Prochlorococcus* (average 1900 molecules cell-1 h-1), and as with *Prochlorococcus* and SAR11 these were consistent over depth (Table 1). However, rates of leucine uptake in the light by *Synchecoccus* were double those of *Prochlorococcus* in the surface water, at 4200 molecules cell-1 h-1, and three times higher at the BML, at 8200 molecules cell-1 h-1. *Synchecoccus* also showed a highly variable response to light stimulation of organic substrate uptake, which for leucine was 16% in the surface waters compared to 113% at the BML, and for ATP was 6% versus 1% at the corresponding depths. However, due to a combination of few replicate stations and, at times, low cell numbers these results were not found to be statistically significant.

Conclusions

Here we provide new insight into the biogeochemical role of specific bacterial clades over depth within the photic layer of the subtropical ocean. Our results indicate that the contribution by SAR11 was not homogeneous over depth, and that due to either acclimation or adaption its capacity to utilize light for organic nutrients acquisition was greater at the base of the mixed layer. Whereas, for *Prochlorococcus* no difference was found in their capcitiy for light enhanced organic nutrient uptake over depth. Our results also show that the response of SAR11 influences the response of the bulk microbial community, and finally that photoheterophic organic nutrient uptake is a process of biogeochemical significance in not only the surface waters, but throughout the entire photic zone of the open ocean.

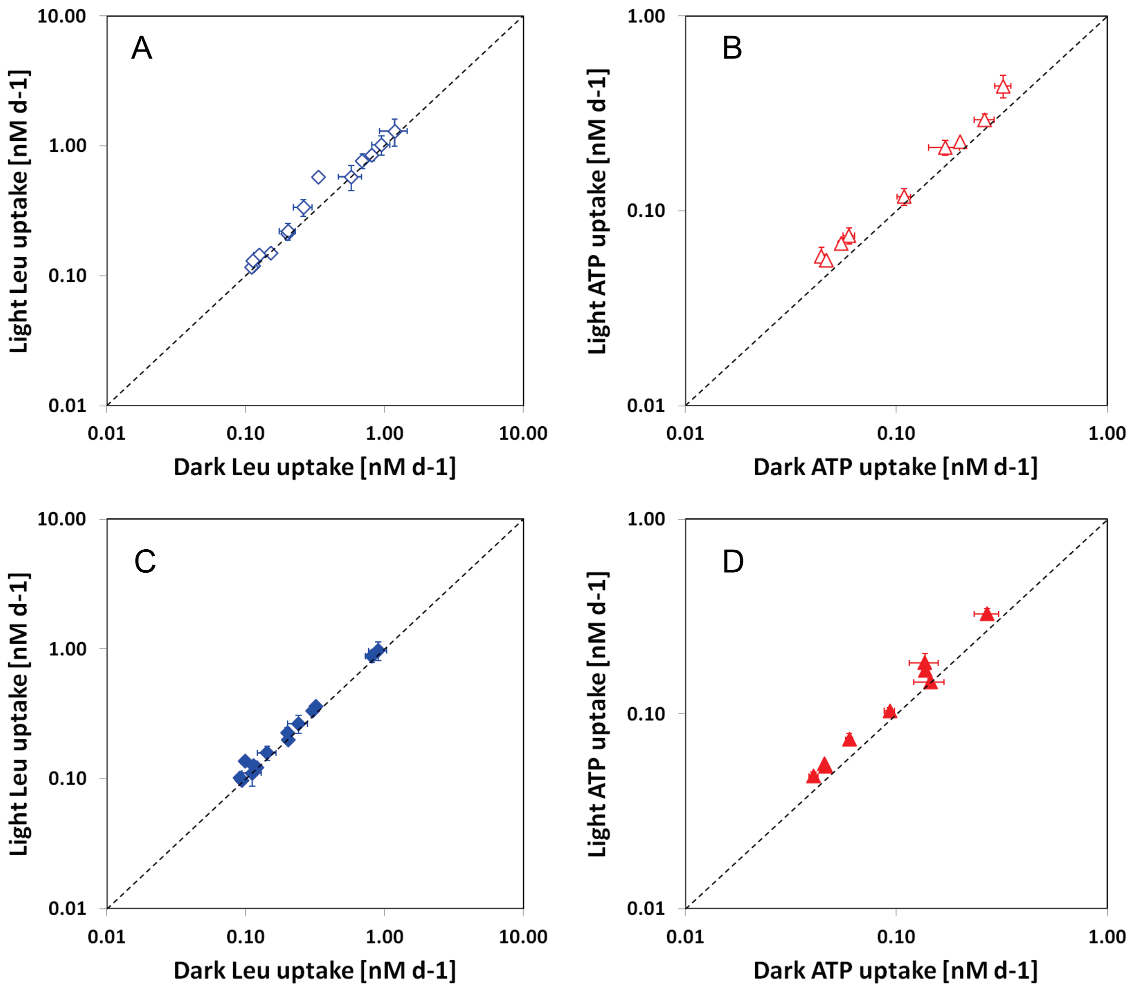

Figure 2. Scatter plot comparison of the total bacterioplankton uptake of (A, C) Leucine, (B, D) ATP (Leu) from (A, B) surface waters and from the (C, D) base of the mixed layer (BML). The dashed line indicates the unity line and error bars show standard errors.

Table 1. Average leucine and ATP uptake rate of bacteriaoplankton (Bpl), SAR11, Prochlorococcus (Pro) and Synechococcus (Syn) in the light, dark and the percentage light-enhanced uptake according to depth and water mass.

	All depths				Surface (20 m)				Light enhanced uptake at SUR versus BML	Base of mixed layer (27 to 135 m)			
	Average uptake rate (x 10^3 molecules $cell^{-1}$ $hour^{-1}$)			Light enhanced	Average uptake rate (x 10^3 molecules $cell^{-1}$ $hour^{-1}$)			Light enhanced		Average uptake rate (x 10^3 molecules $cell^{-1}$ $hour^{-1}$)			Light enhanced
	Dark		Light	(%)	Dark		Light	(%)	BML	Dark		Light	(%)
Leucine													
Transect (SAG + STW)													
Bpl	8.4 ± 4.4	<**	9.4 ± 4.6	13.7 ± 10.7	9.5 ± 4.6	<**	10.3 ± 5.3	7.7 ± 5.3	<*	7.3 ± 4.0	<**	8.5 ± 3.9	19.8 ± 11.5
SAR11	8.2 ± 3.9	<**	9.2 ± 4.3	14.0 ± 12.9	9.3 ± 4.2	<	10.1 ± 4.8	6.7 ± 12.1	<*	7.1 ± 3.4	<**	8.5 ± 3.7	20.7 ± 9.8
SAG													
Bpl	6.6 ± 2.6	<**	7.6 ± 3.1	15.7 ± 11.7	7.6 ± 3.2	<**	8.3 ± 4.2	7.6 ± 6.0	<*	5.7 ± 1.4	<**	7.0 ± 1.3	23.8 ± 10.4
SAR11	6.5 ± 1.9	<**	7.5 ± 2.5	14.2 ± 13.8	7.3 ± 2.2	<	8.0 ± 3.5	7.0 ± 14.0	<*	5.8 ± 1.1	<**	6.9 ± 1.1	20.7 ± 10.4
Pro	1.8 ± 0.4	<**	2.4 ± 0.8	29.7 ± 28.5	1.7 ± 0.5	<**	2.1 ± 0.8	23.6 ± 24.1	<	2.0 ± 0.3	<**	2.7 ± 0.7	35.8 ± 32.8
STW													
Bpl	12.1 ± 4.5	<*	13.0 ± 4.7	7.8 ± 2.7	15.2 ± 3.5	<	16.3 ± 3.3	8.0 ± 3.2	>	12.1 ± 5.6	<	13.0 ± 6.0	7.8 ± 2.8
SAR11	11.0 ± 4.5	<*	13.0 ± 4.3	20.8 ± 11.0	14.7 ± 3.5	<	15.5 ± 3.2	5.9 ± 6.7	<	11.0 ± 5.4	<**	13.0 ± 5.6	20.8 ± 9.4
Syn	6.4 ± 4.5	<	8.2 ± 4.5	112.7 ± 120.7	3.5 ± 2.7	<	4.2 ± 3.8	16.4 ± 20.6	<	6.4 ± 6.0	<	8.2 ± 5.0	112.7 ± 170.5
ATP													
Transect (SAG + STW)													
Bpl	2.5 ± 1.3	<**	3.1 ± 1.4	24.8 ± 24.2	2.6 ± 1.4	<**	3.4 ± 1.5	34.7 ± 29.9	>	2.4 ± 1.2	<**	2.7 ± 1.4	13.4 ± 6.5
SAR11	1.1 ± 1.4	<**	1.3 ± 1.6	18.5 ± 16.8	1.1 ± 1.6	<**	1.3 ± 1.8	19.6 ± 17.1	>	1.1 ± 1.2	<**	1.2 ± 1.5	17.1 ± 17.9
SAG													
Bpl	1.9 ± 0.6	<**	2.5 ± 0.8	28.6 ± 27.2	2.0 ± 0.7	<*	2.7 ± 0.8	39.5 ± 33.7	>	1.8 ± 0.5	<*	2.1 ± 0.6	15.5 ± 6.5
SAR11	0.5 ± 0.3	<**	0.6 ± 0.2	20.0 ± 18.9	0.5 ± 0.2	<*	0.6 ± 0.2	20.9 ± 20.0	>	0.6 ± 0.4	<*	0.6 ± 0.3	18.9 ± 19.8
Pro	1.7 ± 0.3	<*	2.0 ± 0.4	16.5 ± 13.6	1.8 ± 0.1	<*	2.2 ± 0.3	21.1 ± 16.3	>	1.6 ± 0.4	<*	1.7 ± 0.3	12.0 ± 10.5
STW													
Bpl	4.1 ± 1.4	<	4.7 ± 1.7	14.3 ± 7.6	4.5 ± 1.0	<	5.4 ± 1.1	20.2 ± 3.5	>	3.7 ± 1.3	<	4.0 ± 1.5	8.3 ± 1.9
SAR11	2.6 ± 2.1	<	3.1 ± 2.5	14.2 ± 10.0	3.0 ± 2.1	<*	3.4 ± 2.4	15.6 ± 0.0	>	2.3 ± 1.4	<	2.7 ± 1.8	12.8 ± 12.1
Syn	1.8 ± 0.7	<	1.9 ± 1.0	3.3 ± 18.8	1.8 ± 0.0	<	1.9 ± 0.2	5.8 ± 13.2	>	1.8 ± 0.8	<	2.0 ± 1.2	0.8 ± 18.6

*P-value ≤ 0.05; **< 0.001

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Remineralisation of nitrogen in the upper mesopelagic zone

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Introduction

While much has been learnt in the past decade on the losses and gains of oceanic N, such as the discovery of new N_2-fixing organisms, novel N_2 production pathway and the tightly coupled concurrent N-transformations; disproportionally less attention has been given to remineralization that forms the link between organic and inorganic N pools. It is a major determinant of how much organic matter can sink to the deep ocean, how much nutrients can be recharged to surface ocean to stimulate growths, and variations in remineralization depths have direct impacts on the efficiency of the biological pump (Kwon *et al.* 2009). The objective of my research on the AMT23 cruise was to decipher how organic nitrogen is converted back to NO_3^- in the ocean´s lower euphotic and upper mesopelagic zones; and how these processes may differ from one biogeochemical province to another. Recent studies have suggested that simple organic nitrogen compounds, such as urea, might be directly used by nitrifying organisms (Alonso-Sáez *et al.* 2012), thus bypassing the need of associated microorganisms for ammonification (i.e. regeneration of NH_4^+) before nitrification can take place ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$). However, direct evidence of such occurrence *in situ* is still lacking. This project particularly aims to quantitatively assess the direct use of organic nitrogen compounds (e.g. urea, amino acids, DON) in the nitrification process, relative to the conventional combined ammonification-nitrification pathway, via incubation experiments with various ^{15}N-labeled tracers. The responsible microorganisms involved and the associated functional gene expression would also be examined alongside.

Sampling and Methodology

Water samples were collected from seven stations along the AMT23 transect, representative of different biogeochemical provinces ranging from oligotrophic waters in the north and south Atlantic gyres, subsurface hypoxic water column at low latitudes and the more productive temperate waters (Table 1). At each station, four depths were chosen for ^{15}N-incubation experiments: including two depths in the lower euphotic zone (the deep chlorophyll maximum and the 0.1% light depth), and two depths in the upper mesopelagic (ca. 130-500 m), especially aiming towards depths with signs of reduced oxygen.

For each experimental depth, 4.5L water subsamples were amended respectively with tracer levels of ^{15}N-labeled amino acids, urea, dissolved organics and particulate algal matter, then incubated in the dark (or in on-deck incubators with natural light-dark cycle for the lower euphotic zone depths at the first two stations). Parallel incubations with ^{15}N-labeled ammonium and nitrate were also conducted to assess the 'conventional' nitrification and assimilation rates. Subsampling from the 4.5L incubations was performed at 5 subsequent time intervals during the time-series incubations – ca. 0, 6, 12, 24 and 48 hours: (1) 2x12 ml subsamples were collected in sterile glass exetainers and fixed with saturated mercuric chloride for later nitrogen stable isotopic analyses in a shorebased laboratory, (2) 1x30 ml subsample for shipboard nutrient analyses (3) 1x15 ml immediately frozen for later total dissolved nitrogen analyses, (4) 1 x30 ml fixed with 1% paraformaldehyde (final concentration) for Catalyzed Reporter Deposition Fluorescence In situ Hybridization/ nanoSIMS analyses (Musat *et al.* 2008). For the latter subsample (4), 1.5 ml of the paraformaldehyde-fixed samples were transferred to cryovials and frozen at -80 ^oC for later cell enumeration via flow cytometry; while the remaining water subsamples were filtered onto 25 mm diameter, 0.2 □m polycarbonate membrane filters after a 12-h fixation at 4 ^oC, and the filters were then frozen at -80 ^oC until further processing on shore.

At the end of the 48-hour incubations, in addition to the four subsamplings above, a 1L subsample was filtered through a 0.22□m Sterivex filter and treated with RNAlater solution for subsequent gene expression analyses. Lastly, the remaining water subsamples (~2-3 L) from the incubations were filtered through combusted glass-fibre filters (GF/F) for later ^{15}N-assimilation measurements. Furthermore, during initial sampling from the CTD, 4.5 L water samples from each of the four experimental depths were also collected and filtered through combusted glass-fibre filters (GF/F) for the analyses for natural stable isotopic composition of particulate organic carbon and nitrogen without any tracer amendments; while another 10 L of seawater was filtered through 0.22 □m Sterivex filters for DNA analyses.

Planned Analyses

In order to see how different forms of organic nitrogen is partitioned into ammonification, direct nitrification and assimilation, nitrogen stable isotopic analyses are planned for each time-series subsample, including those of $^{15}NH_4^+$, $^{15}NO_2^-/^{15}NO_3^-$, $DO^{15}N$ and $P^{15}N/PO^{13}C$ to target the rates measurements of ammonification, nitrification, DON release and assimilation, respectively, which were likely occurring simultaneously in the same incubations.

Table 1: Sampling Stations for ^{15}N Incubation Experiments

Station	CTD Cast	Latitude	Longitude	Sampling Depths (m)
2	004	45° 00.122 N	13°35.683 W	301/2, 152/3, 82/3, 50
10	013	31° 18.288 N	22° 40.402 W	301/2, 200/1, 150/1, 105/6
16	022	20° 38.591 N	27° 59.402 W	338/340, 253, 148/9, 88/9
24	031	5° 27.477 N	29° 24.440 W	498/500, 262/263, 128/9, 83
30	038	10° 00.126 S	27° 23.805 W	402/3, 270, 164/5, 130/1
38	048	24° 25.664 S	27° 38.706 W	402/3, 275/6, 180/1, 151
48	059	38° 02.773 S	41° 19.507 W	264/5, 126/8, 69/70, 28

CARD-FISH analyses would be performed to identify and enumerate active nitrifying organisms, and qualitative/ quantitative functional genomics and expression analyses would be conducted to examine and compare the various potential microbial pathways (via biomarker gene analyses) involved in the degradation of organic nitrogen as well as nitrification. In addition, nanoscale secondary ion mass spectrometry coupled with CARD-FISH is intended for selected samples to examine the incorporation of 15N-labeled compounds into biomass at a single-cell level.

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Mesoplankton community size structure

Glen Tarran & **Andy Rees** (Plymouth Marine Laboratory)

Introduction
The mesozooplankton sampling programme aboard AMT23 had three principal components. The first two were based on a daily vertical bongo (double) WP-2 net haul before dawn. One of the net samples was run through an Optical Plankton Recorder (OPC) to give a reliable indication of size-distributed mesozooplankton biomass at each station. The sample from the second net on the bongo system was preserved in buffered 4% formaldehyde solution for subsequent taxonomic analysis in the laboratory. Thirdly, throughout the cruise transect the OPC sampled the ship's non-toxic seawater supply (depth 6-7m) to give a continuous measure of size-distributed mesozooplankton biomass and abundance.

Methods
Vertical net hauls were made each day at the pre-dawn stations. A bongo (double) net frame was deployed, with 0.57m diameter openings and carrying 2 WP-2 nets with 200 µm nylon mesh, fitted with cod ends with 200 µm mesh windows.

OPC biomass size distribution
The OPC is capable of reliable and rapid characterization of marine plankton populations between 0.25 and 16mm equivalent spherical diameter (ESD, Herman, 1992) in up to 4096 size classes and at data rates of up to 200 events sec^{-1}. The OPC measures cross-sectional area of each particle passing between a collimated rectangular beam of red light and a rectangular light sensor as digital size. This digital size is converted to ESD using a semi-empirical formula, representing the diameter of a spherical particle presenting the same cross-sectional area as that detected for the particle. In our work on the AMT series (Gallienne & Robins, 1998; Gallienne & Robins, 2001; Gallienne et al., 2001), we have substituted a formula representing an ellipsoidal rather than a spherical model of particle size as being more representative of typical mesoplankton shape. The volume of the ellipsoid determined in this way is calculated, and presented as biovolume in mm^3 m^{-3}. We convert biovolume to biomass using an empirical factor of 0.0475, derived from a regression analysis of biovolume against analytic carbon content (Gallienne et al, 2001).

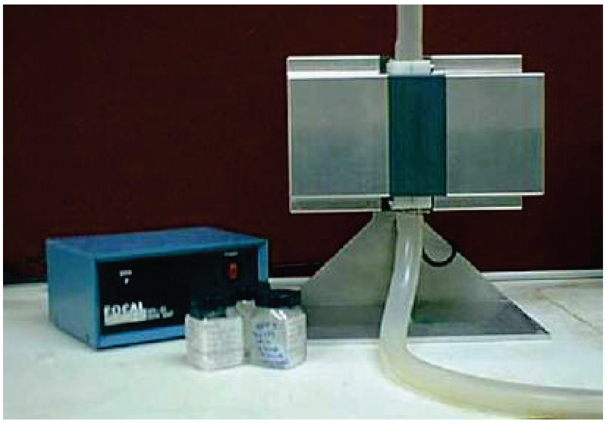

Figure 1. OPC-1L used during AMT23

Table 1 provides details of bongo net hauls and sample analysis using the OPC. Table 2 provides details of underway sampling using the OPC.

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Table 1. Details of bongo net deployments and mesoplankton sample analysis by OPC

DATE	Day of year	STATION	TIME on deck (GMT)	LAT +N, -S	LONG E	Bottom depth m	OPC filename	preserved sample name
10-Oct	283	2	05:12	45.01	-13.59	3620	AMT23_283.D00	AMT23_283
11-Oct	284	4	05:15	41.78	-15.97	5341	AMT23_284.D00	AMT23_284
12-Oct	285	6	05:15	6.00	-0.22	4902	AMT23_285.D00	AMT23_285
13-Oct	286	8	05:17	34.95	-20.67	5077	AMT23_286.D00	AMT23_286
14-Oct	287	10	05:14	31.30	-22.67	5198	AMT23_287.D00	AMT23_287
15-Oct	288	12	05:38	27.81	-24.48	5147	AMT23_288.D00	AMT23_288
16-Oct	289	14	05:39	24.22	-26.26	5352	AMT23_289.D00	AMT23_289
17-Oct	290	16	05:41	20.64	-27.99	5098	AMT23_290.D00	AMT23_290
18-Oct	291	18	05:40	17.06	-29.16	4898	AMT23_291.D00	AMT23_291
19-Oct	292	20	05:41	13.31	-29.67	5510	AMT23_292.D00	AMT23_292
20-Oct	293	22	06:20	9.28	-29.54	4882	AMT23_293.D00	AMT23_293
21-Oct	294	24	06:00	5.46	-29.42	3489	AMT23_294.D00	AMT23_294
23-Oct	296	26	06:10	-2.55	-28.98	4838	AMT23_296.D00	AMT23_296
24-Oct	297	28	06:05	-6.34	-28.18	5578	AMT23_297.D00	AMT23_297
25-Oct	298	30	05:35	-10.00	-27.40	5470	AMT23_298.D00	AMT23_298
26-Oct	299	32	05:38	-13.95	-26.56	5323	AMT23_299.D00	AMT23_299
27-Oct	300	34	05:39	-17.70	-25.70	5573	AMT23_300.D00	AMT23_300
28-Oct	301	36	05:39	-21.53	-25.16	5299	AMT23_301.D00	AMT23_301
29-Oct	302	38	05:47	-24.43	-27.65	5546	AMT23_302.D00	AMT23_302
30-Oct	303	40	05:32	-26.92	-30.04	5261	AMT23_303.D00	AMT23_303
31-Oct	304	42	05:36	-29.52	-32.58	3064	AMT23_304.D00	AMT23_304
01-Nov	305	44	05:37	-32.26	-35.30	3176	AMT23_305.D00	AMT23_305
02-Nov	306	46	05:29	-35.16	-38.27	4813	AMT23_306.D00	AMT23_306
05-Nov	309	51	05:38	-42.90	-46.72	5150	AMT23_309.D00	AMT23_309
06-Nov	310	53	06:07	-45.40	-49.69	5617	AMT23_310.D00	AMT23_310

Table 2. Details of underway OPC analysis of mesoplankton community size structure and abundance.

			START				END					
DATE	Jd	FILENAME	LAT +N, -S	LON W	START TIME (GMT)	START VOL USG	LAT N+, -S	LON W	END TIME (GMT)	END VOL USG	DURATION (h)	VOLUME ANAL'D USG
09-Oct	282	282_0815.D00	47.04	9.83	09/09/2013 08:15	4263	46.13	11.53	09/09/2013 18:02	4954	09:47	691
09-Oct	282	282_0815.D01	46.13	11.53	09/10/2013 18:02	4954	44.77	13.76	10/10/2013 07:25	7293	13:23	2339
10-Oct	283	283_0800.D00	44.73	13.80	10/10/2013 08:00	7336	43.35	14.83	10/10/2013 19:04	9265	11:04	1929
10-Oct	283	283_0800.D01	43.35	14.83	10/10/2013 18:04	9265	41.73	16.00	11/10/2013 06:10	11358	12:06	2093
11-Oct	284	284_0635.D00	41.67	16.05	11/10/2013 06:35	11416	40.06	17.21	11/10/2013 18:01	13416	11:26	2000
11-Oct	284	284_0635.D01	40.06	17.21	11/10/2013 18:02	13420	38.32	18.42	12/10/2013 06:09	15668	12:07	2248
12-Oct	285	285_0732.D00	38.26	18.46	12/10/2013 07:32	15725	36.54	19.62	12/10/2013 18:34	17921	11:02	2196
12-Oct	285	285_0732.D01	36.54	19.62	12/10/2013 18:35	17922	34.88	20.71	13/10/2013 06:13	19967	11:38	2045
13-Oct	286	286_0630.D00	34.84	20.74	13/10/2013 06:31	20012	33.10	21.71	13/10/2013 17:58	22048	11:27	2036
13-Oct	286	286_0630.D01	33.10	21.71	13/10/2013 18:00	22053	31.22	22.72	14/10/2013 07:05	24425	13:05	2372
14-Oct	287	287_0730.D00	31.14	22.76	14/10/2013 07:32	24480	29.67	23.52	14/10/2013 18:00	26356	10:28	1876
14-Oct	287	287_0730.D01	29.67	23.52	14/10/2013 18:01	26359	27.75	24.51	15/10/2013 06:35	28538	12:34	2179
15-Oct	288	288_0700.D00	27.68	24.55	15/10/2013 06:59	28596	25.93	25.42	15/10/2013 18:58	30734	11:59	2138
15-Oct	288	288_0700.D01	25.93	25.43	15/10/2013 19:00	30740	24.13	26.30	16/10/2013 06:40	32745	11:40	2005
16-Oct	289	289_1730.D00	22.55	27.07	16/10/2013 17:30	34742	20.60	28.01	17/10/2013 07:13	37067	13:43	2325
17-Oct	290	290_0740.D00	20.53	28.04	17/10/2013 07:41	37136	18.81	28.65	17/10/2013 18:56	39029	11:15	1893
17-Oct	290	290_0740.D01	18.81	28.65	17/10/2013 18:57	39033	16.97	29.19	18/10/2013 06:43	41049	11:46	2016
18-Oct	291	291_0720.D00	16.87	29.22	18/10/2013 07:19	41137	15.09	29.72	18/10/2013 19:00	43254	11:41	2117
18-Oct	291	291_0720.D01	15.10	29.72	18/10/2013 19:02	43258	13.23	29.67	19/10/2013 06:45	45258	11:43	2000
19-Oct	292	292_0720.D00	13.13	29.66	19/10/2013 07:20	45323	11.13	29.62	19/10/2013 19:12	unknown	11:52	unknown
19-Oct	292	292_0720.D01	11.13	29.62	20/10/2013 00:00	46445	9.20	29.53	20/10/2013 06:55	48156	06:55	1711
20-Oct	293	293_0730.D00	9.10	29.53	20/10/2013 07:29	48230	7.30	29.44	20/10/2013 19:00	50316	11:31	2086
20-Oct	293	293_0730.D01	7.30	29.49	20/10/2013 19:01	50319	5.33	29.40	21/10/2013 07:46	52364	12:45	2045
21-Oct	294	294_0815.D00	5.24	29.40	21/10/2013 08:17	52427	4.36	29.39	21/10/2013 13:15	53363	04:58	936
23-Oct	296	296_0730.D00	-2.70	28.95	23/10/2013 07:31	62134	-4.51	28.57	23/10/2013 18:58	64092	11:27	1958
23-Oct	296	296_0730.D01	-4.51	28.57	23/10/2013 19:00	64097	-6.42	28.16	24/10/2013 07:06	66268	12:06	2171
24-Oct	297	297_0730.D00	-6.49	28.15	24/10/2013 07:31	66321	-8.28	27.77	24/10/2013 19:01	68336	11:30	2015

24-Oct	297	297_0730.D01	-8.29	27.76	24/10/2013 19:02	68340	-10.04	27.39	25/10/2013 06:58	70506	11:56	2166
25-Oct	298	298_0725.D00	-10.11	27.37	25/10/2013 07:25	70565	-12.01	26.97	25/10/2013 18:59	72670	11:34	2105
25-Oct	298	298_0725.D01	-12.01	26.97	25/10/2013 19:00	72673	-14.01	26.54	26/10/2013 06:35	74692	11:35	2019
26-Oct	299	299_0700.D00	-14.07	26.53	26/10/2013 06:57	74731	-15.92	26.12	26/10/2013 19:12	77014	12:15	2283
26-Oct	299	299_0700.D01	-15.92	26.12	26/10/2013 19:13	77019	-17.80	25.68	27/10/2013 06:41	79063	11:28	2044
27-Oct	300	300_0715.D00	-17.90	25.66	27/10/2013 07:12	79128	-19.83	25.19	27/10/2013 19:06	81130	11:54	2002
27-Oct	300	300_0715.D01	-19.83	25.19	27/10/2013 19:07	81133	-21.60	25.21	28/10/2013 06:36	83217	11:29	2084
28-Oct	301	301_0655.D00	-21.65	25.25	28/10/2013 06:59	83252	-23.13	26.41	28/10/2013 18:57	85372	11:58	2120
28-Oct	301	301_0655.D01	-23.13	26.41	28/10/2013 18:58	85376	-24.46	27.67	29/10/2013 07:02	87497	12:04	2121
29-Oct	302	302_0720.D00	-24.50	27.71	29/10/2013 07:20	87530	-25.67	28.82	29/10/2013 18:37	89296	11:17	1766
29-Oct	302	302_0720.D01	-25.67	28.83	29/10/2013 18:38	89299	-26.98	30.10	30/10/2013 06:34	91602	11:56	2303
30-Oct	303	303_0659.D00	-27.03	30.15	30/10/2013 06:59	91644	-28.33	31.40	30/10/2013 19:00	93856	12:01	2212
30-Oct	303	303_0659.D01	-28.33	31.41	30/10/2013 19:01	93859	-29.57	32.63	31/10/2013 06:29	95857	11:28	1998
31-Oct	304	304_0655.D00	-29.61	32.67	31/10/2013 06:52	95908	-30.98	34.02	31/10/2013 18:58	98136	12:06	2228
31-Oct	304	304_0655.D01	-30.99	34.02	31/10/2013 06:34	98139	-32.32	35.36	01/11/2013 18:58	100274	12:24	2135
01-Nov	305	305_0700.D00	-32.38	35.42	01/11/2013 07:01	100318	-33.82	36.89	01/11/2013 18:53	102443	11:52	2125
01-Nov	305	305_0700.D01	-33.83	36.90	01/11/2013 18:54	102449	-35.23	38.34	02/11/2013 06:38	104510	11:44	2061
02-Nov	306	306_0710.D00	-35.30	38.42	02/11/2013 07:10	104565	-36.67	39.87	02/11/2013 18:47	106777	11:37	2212
02-Nov	306	306_0710.D01	-36.67	39.89	02/11/2013 18:48	106781	-38.15	41.43	03/11/2013 08:10	109040	13:22	2259
03-Nov	307	307_0810.D00	-38.15	41.43	03/11/2013 08:12	109046	-39.31	42.69	03/11/2013 19:03	110657	10:51	1611
03-Nov	307	307_0810.D01	-39.31	42.69	03/11/2013 19:04	110661	-40.68	44.18	04/11/2013 07:16	112864	12:12	2203
04-Nov	308	308_0720.D00	-40.68	44.19	04/11/2013 07:18	112869	-41.77	45.43	04/11/2013 19:00	115225	11:42	2356
04-Nov	308	308_0720.D01	-41.77	45.43	04/11/2013 19:01	115228	-42.99	46.83	05/11/2013 06:51	117117	11:50	1889
05-Nov	309	309_0915.D00	-43.27	47.15	05/11/2013 09:15	117179	-44.24	48.29	05/11/2013 19:01	119035	09:46	1856
05-Nov	309	309_0915.D01	-44.25	48.29	05/11/2013 19:02	119043	-45.58	49.90	06/11/2013 07:48	121035	12:46	1992
06-Nov	310	310_0725.D00	-45.66	49.99	06/11/2013 07:26	121146	-46.80	51.26	06/11/2013 19:03	123172	11:37	2026

Sample collection for AMT DNA/RNA archive

Andy Rees (Plymouth Marine Laboratory)

Seawaters were collected and filtered onto 0.22µm Sterivex filters from 2 depths (deep fluorescence maximum – where present, and near surface) at CTD stations. After filtration, 1 ml of RNA later was added to the filter capsule which was then sealed at both ends and stored at -80°C. Filters will be transferred to PML and held indefinitely at -80°C. Extracted DNA will be available on request.

Table 1. AMT-23 Sterivex Filter Collection

Sample No.	Date	Time	Lat	Long	CTD No.	CTD Bottle	DEPTH (m)	Vol. Filtered (l)
01	10.10.13	444	45.0020	-13.59458	3	8	47	10
02						21	2	10
03	10.10.13	1211	44.1115	-14.255	5	9	60	12.3
04						24	2	12.3
05	11.10.13	530	41.7774	-15.9685	6	9	60	10
06						21	2	10
07	11.10.13	1215	40.8090	-16.6761	7	11	75	12.3
08						24	2	12.3
09	12.10.13	445	38.3936	-18.37305	8	8	95	11
10						23	2	11
11	12.10.13	1218	37.	-19.04	9	12	85	12.3
12						24	2	12.3
13	13.10.13	446	34.9490	-20.6693	10	9	95	10
14						22	2	5
15	13.10.13	1213	33.920	-21.2805	11	10	122	10
16						24	2	11
17	14.10.13	448	31.3048	-22.67333	12	8	105	12.3
18						22	2	12.3
19	14.10.13	1213	30.369	-23.1565	14	11	110	12.3
20						24	2	12.3
21	15.10.13	516	27.8051	-24.49933	16	8	120	10
22						22	2	10
23	15.10.13	1321	26.6548	-25.0630	17	10	132	12.3
24						24	2	12.3
25	16.10.13	512	24.2152	-26.25622	19	7	115	10
26						22	2	10
27	16.10.13	1318	23.0793	-26.8148	20	11	95	12.3
28						24	2	12.3
29	17.10.13	513	20.6432	-27.9985	21	8	88	9
30						22	2	11
31	17.10.13	1315	19.6534	-28.39855	23	11	94	12.3
Sample No.	Date	Time	Lat	Long	CTD No.	CTD Bottle	DEPTH (m)	Vol. Filtered (l)

32						24	2	12.3
33	18.10.13	512	17.064	-29.159	24	8	90	8
34						22	2	11
35	18.10.13	1312	15.8951	-29.5015	25	12	50	12.3
36						24	2	12.3
37	19.10.13	513	13.3132	-25.6706	26	10	50	9
38						22	2	8
39	19.10.13	1315	12.0820	-29.64277	27	13	50	12.3
40	19.10.13	1315	12.0820	-29.64277	27	24	2	12.3
41	20.10.13	514	9.27496	-29.53993	28	8	57	10
42						22	2	12.3
43	20.10.13	1319	8.11948	-29.51012	29	10	60	12.3
44						24	2	12.3
45	21.10.13	524	5.45745	-29.41313	30	9	85	9
46						22	2	10
47	21.10.13	1317	4.3637	-29.3972	32	10	93	12.3
48						24	2	12.3
49	23.10.13	543	-2.54693	-28.9828	33	9	90	10
50						22	2	11
51	24.10.13	542	-6.3375	-28.1792	35	6	104	10
52						22	2	11
53	25.10.13	510	-10.0021	-27.3968	37	7	133	8.5
54						22	2	9
55	25.10.13	1315	-11.1183	-27.3968	39	10	135	8.5
56						24	2	9
57	26.10.13	511	-13.945	-26.5583	40	5	145	9.5
58						22	2	11
59	26.10.13	1313	-15.0023	-26.3297	41	10	145	12.3
60						22	2	12.3
61	27.10.13	1315	-18.9972	-25.3873	43	9	160	12.3
62						24	2	12.3
63	28.10.13	513	-21.5294	-25.1628	44	21	2	9.5
64						5	135	10.5
65	28.10.13	1315	-22.571	-25.9105	45	9	159	12.3
66						23	2	10.5
67	29.10.13	513	-24.4278	-27.6452	47	6	155	8
68						21	2	8
69	29.10.13	1313	-25.162	-28.3388	49	10	161	12.3
70						24	2	12.3
71	30.10.13	515	-26.9247	-30.0403	50	6	155	8.5
72						22	2	7
73	30.10.13	1315	-27.7893	-30.8695	51	11	125	12.3
74						22	2	12.3
75	31.10.13	513	-29.5222	-32.5792	52	6	135	7.5
76						22	2	11
77	31.10.13	1315	-30.332	-33.3747	53	12	100	12.3

78						22	2	12.3
79	01.11.13	514	-32.2612	-35.3025	54	10	75	6
80						22	2	5
81	01.11.13	1315	-33.2498	-36.256	55	13	60	12.3
82						22	2	12.3
83	2.11.13	513	-35.1588	-38.2738	56	11	40	12.3
Sample No.	**Date**	**Time**	**Lat**	**Long**	**CTD No.**	**CTD Bottle**	**DEPTH (m)**	**Vol. Filtered (l)**
84						21	2	12.3
85	2.11.13	1312	-35.9998	-39.1634	57	9	40	5
86						22	2	5
87	4.11.13	0523	-40.6112	-44.1299	61	10	35	>5
88						22	2	>5
89	5.11.13	0513	-42.8963	-46.7243	62	8	45	8
90						22	2	7
91	5.11.13	1315	-43.7087	-47.6670	63	13	30	8
92						23	2	6
93	6.11.13	0542	-45.4055	-47.6670	64	10	30	8
94						21	2	4

High volume aerosol sampling for characterisation of organic carbon and organic nitrogen

Sina Hackenberg (at sea – University of York)
Rosie Chance (ashore – University of York) & **Alex Baker (**University of East Anglia)

Introduction and Cruise Objectives

Organic compounds are a significant component of marine aerosol, but very little is known about the composition of this aerosol fraction. The chemical composition of marine organic aerosol affects particle hygroscopicity and the ability of particles to act as cloud condensation- and ice-nuclei (e.g. Gantt & Meskhidze, 2013). Consequently, organic aerosol composition is expected to play a role in determining cloud microphysical and radiative properties. Organic nitrogen compounds are also important because they can be a significant and assimilatable source of nutrient nitrogen to the water column (e.g. Lesworth et al., 2010)

The objective

- Collect a set of marine aerosol samples from a range of different air mass types, as a resource for projects investigating the molecular composition of organic aerosol (York) and aerosol organic and inorganic nitrogen deposition and aerosol background chemistry (UEA).

Sampling protocol

A high volume aerosol collector (Andersen) fitted with a total suspended particulate inlet was mounted on the monkey island deck of the ship. To avoid sampling contaminated air from the ships funnel, the collector was automatically controlled such that sampling only took place when the relative wind direction was between -80 and 110 degrees (with the bow set to 0 degrees), and the relative wind speed was greater than 2 m s^{-1}. This was achieved using a 2-dimensional sonic anemometer (Gill) coupled to a data logger (Campbell Scientific CR800), which sent a trigger voltage to the aerosol collector. When on, air flow through the collector was ~1 m^3 min^{-1}. Samples were collected onto precombusted (5 hours at 450^{o}C) Whatman QM-A quartz fibre filters deployed for periods of 24 hours each. The filters were loaded and unloaded from the sampling cassettes under a laminar flow hood; nitrile gloves were worn and the filters handled by the edges only. Exposed filters were folded in half, wrapped in clean aluminium foil, placed in sealed plastic bags and frozen at -20^{o}C for return to the UK. Unexposed filters were retained for use as filter blanks and a cassette blank, in which a filter is left in the cassette for 24 hours under clean conditions, was also taken.

Samples collected

Aerosol: 31 high volume aerosol samples were collected, including 5 blanks (see Table 1). The sampling cassette was also deployed once loaded with two filter papers stacked on top of each other, in order to assess absorption from the gas phase onto the substrate.

Sample analysis

The filters will be extracted using ultrapure water, and possibly also selected organic solvents. It is anticipated that the extracts will be analysed using the following methods:

WSOC: Samples will be analysed by Liquid Chromatography - ion trap tandem Mass Spectrometry (LC-MS) and Fourier Transform - Ion Cyclotron Resonance -Mass Spectrometry (FT-ICR-MS). These analyses provide structural information on functional groups, and can determine molecular masses to sub-ppm resolution levels for unambiguous determination of molecular formulae. Prior to analysis, aqueous extracts of the aerosol samples will undergo solid phase extraction (after Dittmar, 2008) to remove salts and isolate an operationally defined fraction for comparison with seawater extracts processed using the same method.

WSON: Aqueous extracts of the samples will be analysed by ion chromatography (IC) and high temperature catalytic oxidation (HTCO). Species determined by IC will include nitrate (NO_3^-) and ammonium (NH_4^+), while HTCO will yield total soluble nitrogen concentrations. Water soluble organic nitrogen concentrations will then be calculated from these data (WSON = TSN – (NO_3^- + NH_4^+). IC results for other ions will be used to assess likely sources for the nitrogen species measured.

References

Dittmar et al., 2008. A simple and efficient method for the solid-phase extraction of dissolved organic matter (SPE-DOM) from seawater. Limnol. Oceanogr: Methods, 6, 230-235.

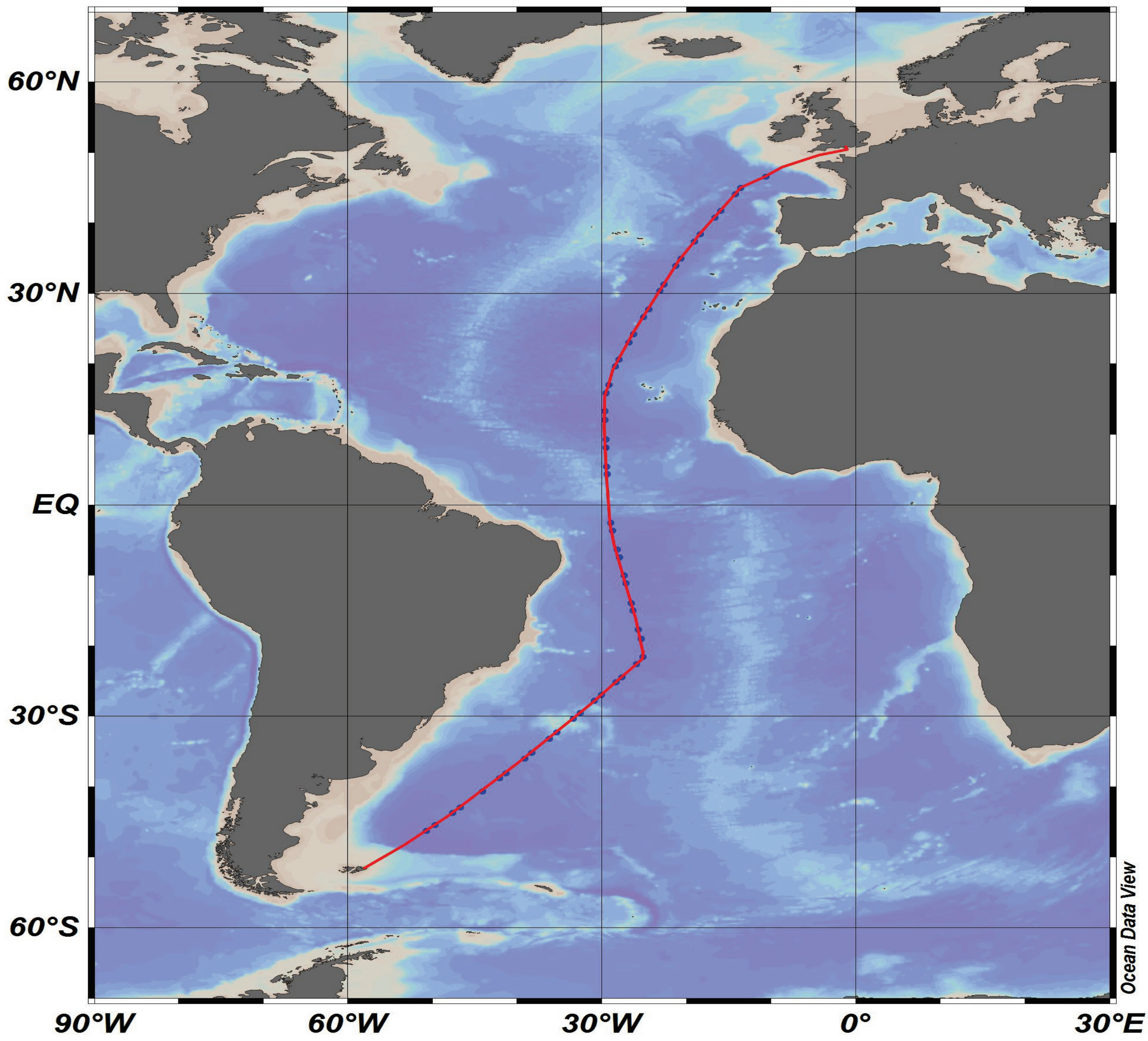
Gantt, P. & Meskhidze, N., 2013. Physical and chemical characteristics of marine POA Atmos. Chem. Phys., 13, 3979–3996, 2013

Lesworth, T., Baker, A.R. & Jickells, T., 2010. Aerosol organic nitrogen over the remote Atlantic Ocean. Atmospheric Environment, Volume 44, Issue 15, May 2010, Pages 1887–1893.

Table 1. Aerosol samples collected during AMT23

SAMPLE ID	TYPE	START				END			
		Date	Time (GMT)	Latitude (+ve N)	Latitude (+ve E)	Date	Time (GMT)	Latitude (+ve N)	Latitude (+ve E)
AMT23_01	Motor Blank	01/10/13	14:10	n/a	n/a	01/10/13	14:10	n/a	n/a
AMT23_02	Cassette Blank	01/10/13	14:33	n/a	n/a	02/10/13	13:56	n/a	n/a
AMT23_03	Sample	09/10/13	09:44	46˚52.14’	-10°09.10’	10/10/13	10:35	44˚19.31’	-14°05.99’
AMT23_04	Sample	10/10/13	11:00	44˚15.87’	-14°08.86’	11/10/13	10:24	41˚03.86’	-16°29.89’
AMT23_05	Sample	11/10/13	10:48	41˚00.20’	-16°32.60’	12/10/13	11:34	37˚27.97’	-19°00.13’
AMT23_06	Motor Blank	12/10/13	12:46	n/a	n/a	12/10/13	13:04	n/a	n/a
AMT23_07	Sample	12/10/13	13:29	37˚21.29’	-19°04.17’	13/10/13	14:57	33˚36.58’	-21°26.55’
AMT23_08	Sample	13/10/13	15:17	33˚33.20’	-21°28.30’	14/10/13	13:37	30˚22.16’	-23°09.36’
AMT23_09	Sample	14/10/13	13:55	30˚21.10’	-23°09.68’	15/10/13	14:01	26˚39.29’	-25°03.78’
AMT23_10	Sample	16/10/13	13:06	23˚04.76’	-26°48.89’	17/10/13	17:43	19˚01.92’	-28°35.60’
AMT23_11	Sample	17/10/13	19:23	18˚43.98’	-28°40.11’	18/10/13	17:22	15˚23.15’	-29°38.22’
AMT23_12	Sample	18/10/13	17:39	15˚20.20’	-29°39.95’	19/10/13	17:33	11˚26.90’	-29°37.61’
AMT23_13	Sample	19/10/13	17:49	11˚23.78’	-29°37.49’	20/10/13	16:14	07˚47.87’	-29°30.39’
AMT23_14	Sample	20/10/13	16:29	07˚44.57’	-29°30.35’	21/10/13	14:38	04˚17.14’	-23°23.56’
AMT23_15	Exposure Blank	22/10/13	20:06	-00˚54.85’	-29°08.27’	23/10/13	19:37	-04˚37.31’	-28°32.72’
AMT23_16	Filter Blank	23/10/13	19:45	n/a	n/a	n/a	n/a	n/a	n/a
AMT23_17	Sample	23/10/13	19:59	-04˚41.14’	-28°31.95’	24/10/13	19:25	-08˚20.98’	-27°45.61’
AMT23_18	Sample	24/10/13	19:40	-08˚23.51’	-27°44.55’	25/10/13	19:44	-12˚09.12’	-26°56.62’
AMT23_19	Sample	25/10/13	19:59	-12˚12.13’	-26°56.00’	26/10/13	19:41	-16˚00.48’	-26°05.96’
AMT23_20	Sample	26/10/13	20:06	-16˚05.51’	-26°04.80’	27/10/13	20:21	-20˚02.56’	-25°09.25’
AMT23_21	Sample	27/10/13	20:39	-20˚05.68’	-25°09.27’	28/10/13	19:52	-23˚14.84’	-26°31.37’
AMT23_22	Sample	28/10/13	20:08	-23˚16.88’	-26°33.24’	29/10/13	19:44	-25˚48.00’	-28°56.84’
AMT23_23	Sample	29/10/13	20:01	-25˚49.96’	-28°58.74’	30/10/13	20:02	-28˚26.56’	-31°30.68’
AMT23_24	Sample	30/10/13	20:20	-28˚28.57’	-31°32.69’	31/10/13	19:19	-31˚01.80’	-34°03.67’
AMT23_25	Sample	31/10/13	19:33	-31˚03.67’	-34°05.50’	01/11/13	19:44	-33˚55.92’	-37°00.44’
AMT23_26	Sample	01/11/13	20:03	-37˚02.98’	-37°02.98’	02/11/13	20:05	-36˚51.35’	-40°03.80’
AMT23_27	Sample	02/11/13	20:21	-36˚53.85’	-40°06.44’	03/11/13	19:59	-39˚26.15’	-42°49.76’
AMT23_28	Sample	03/11/13	20:20	-39˚28.98’	-42°52.90’	04/11/13	20:09	-41˚53.84’	-45°34.92’
AMT23_29	Sample	04/11/13	20:24	-41˚55.50’	-45°36.89’	05/11/13	19:54	-44˚19.54’	-48°23.55’
AMT23_30	Sample	05/11/13	20:16	-44˚22.11’	-48°26.60’	06/11/13	20:35	-46˚51.65’	-51°19.95’
AMT23_31	Double filter sample	06/11/13	20:55	-46˚52.99’	-51°22.47’	08/11/13	00:52	-50˚02.85’	-55°29.16’

APPENDIX 1: AMT23 CRUISE TRACK



APPENDIX 2: AMT23 EVENT LOG

Date and time (GMT) Start	Date and time (GMT) End	Station	Activity	EVENT ID	Lat (+ve N) Start	Lon (+ve E) Start	Lat (+ve N) End	Lon (+ve E) End	Comment
05/10/2013			Depart Immingham						Ship time = GMT+1
07/10/2013			Depart Portsmouth						
09/10/2013 12:05		1			46.61864	-10.62859			Vessel on station
09/10/2013 12:12	09/10/2013 12:47		CTD	CTD001	46.61869	-10.62847	46.61869	-10.62847	
09/10/2013 12:21	09/10/2013 12:25		SECCHI Disk		46.61869	-10.62847	46.61871	-10.62847	
09/10/2013 12:28	09/10/2013 12:32		SECCHI Disk		46.6187	-10.62847	46.61869	-10.62845	
09/10/2013 12:30	09/10/2013 12:42		OPTICS Rig		46.6187	-10.62847	46.61871	-10.62847	
09/10/2013 12:44	09/10/2013 12:59		OPTICS Rig		46.61872	-10.62846	46.6187	-10.62844	
09/10/2013 13:01	09/10/2013 13:12		CTD	CTD002	46.6187	-10.62843	46.6187	-10.62847	
09/10/2013 13:30					46.61593	-10.63668			Vessel continues on passage
10/10/2013 04:37		2			45.00197	-13.59466			Vessel stopped on D.P
10/10/2013 04:44	10/10/2013 05:14		CTD	CTD003	45.00203	-13.59469	45.00203	-13.5947	
10/10/2013 04:48	10/10/2013 05:18		OPTICS Rig		45.00203	-13.59469	45.00204	-13.59472	
10/10/2013 04:52	10/10/2013 05:13		BONGO Net		45.00201	-13.59469	45.00202	-13.5947	
10/10/2013 05:27	10/10/2013 05:56		CTD	CTD004	45.00206	-13.59468	45.00204	-13.59471	
10/10/2013 06:12					44.99657	-13.59694			Vessel continues on passage
10/10/2013 12:06		3			44.1115	-14.25498			Vessel on station
10/10/2013 12:09	10/10/2013 12:23		OPTICS Rig		44.11146	-14.25495	44.11149	-14.25495	
10/10/2013 12:11	10/10/2013 12:55		CTD	CTD005	44.11148	-14.25495	44.11151	-14.25492	
10/10/2013 12:23	10/10/2013 12:38		OPTICS Rig		44.11149	-14.25495	44.1115	-14.25494	
10/10/2013 13:06					44.11149	-14.25494			Vessel continues on passage
11/10/2013 04:36		4			41.77744	-15.96687			Vessel on station
11/10/2013 04:44	11/10/2013 05:17		CTD	CTD006	41.77738	-15.96687	41.77739	-15.96686	
11/10/2013 04:45	11/10/2013 05:00		OPTICS Rig		41.7774	-15.96685	41.77741	-15.96687	
11/10/2013 04:57	11/10/2013 05:18		BONGO Net		41.77738	-15.96687	41.77739	-15.96687	

11/10/2013 05:23	11/10/2013 05:37		OPTICS Rig		41.7774	-15.96687	41.77742	-15.96684	
11/10/2013 05:54					41.76915	-15.9723			Vessel continues on passage
11/10/2013 12:06		5			40.80923	-16.67604			Vessel on station
11/10/2013 12:11	11/10/2013 12:27		OPTICS Rig		40.80901	-16.67609	40.80906	-16.67605	
11/10/2013 12:15	11/10/2013 12:58		CTD	CTD007	40.80903	-16.67609	40.80903	-16.67606	
11/10/2013 12:28	11/10/2013 12:45		OPTICS Rig		40.80906	-16.67604	40.80903	-16.67607	
11/10/2013 13:12					40.80311	-16.67594			Vessel continues on passage
12/10/2013 04:37		6			38.39382	-18.37645			Vessel on station
12/10/2013 04:47	12/10/2013 05:29		CTD	CTD008	38.39363	-18.37642	38.39362	-18.37644	
12/10/2013 04:49	12/10/2013 12:30		OPTICS Rig		38.39364	-18.37642	37.39666	-19.04418	
12/10/2013 04:58	12/10/2013 05:19		BONGO Net		38.39364	-18.37643	38.39362	-18.37644	
12/10/2013 05:48					38.3808	-18.38382			Vessel continues on passage
12/10/2013 12:10		7			37.39666	-19.04416			Vessel on station
12/10/2013 12:12			OPTICS Rig		37.39666	-19.04418			
12/10/2013 12:18	12/10/2013 13:00		CTD	CTD009	37.39664	-19.04419	37.39661	-19.04421	
12/10/2013 12:30	12/10/2013 12:48		OPTICS Rig		37.39666	-19.04418	37.39662	-19.04418	
12/10/2013 13:12					37.39546	-19.04204			Vessel continues on passage
13/10/2013 04:39		8			34.94905	-20.66931			Vessel on station
13/10/2013 04:46	13/10/2013 05:35		CTD	CTD010	34.94909	-20.66933	34.94995	-20.66662	
13/10/2013 04:48	13/10/2013 05:05		OPTICS Rig		34.94908	-20.66933	34.94907	-20.66932	
13/10/2013 04:55	13/10/2013 05:20		BONGO Net		34.94907	-20.66933	34.94961	-20.66772	
13/10/2013 05:44					34.95002	-20.66645			Vessel continues on passage
13/10/2013 12:06		9			33.91688	-21.28084			Vessel on station
13/10/2013 12:13	13/10/2013 12:56		CTD	CTD011	33.91695	-21.28048	33.91692	-21.28048	
13/10/2013 12:14	13/10/2013 12:30		OPTICS Rig		33.91694	-21.28049	33.91693	-21.2805	
13/10/2013 12:32	13/10/2013 12:54		OPTICS Rig		33.91694	-21.2805	33.9169	-21.28048	
13/10/2013 13:12					33.90456	-21.28801			Vessel continues on passage
14/10/2013 04:37		10			31.30495	-22.67249			Vessel on station
14/10/2013 04:48	14/10/2013 05:28		CTD	CTD012	31.30483	-22.67335	31.30482	-22.67335	
14/10/2013 04:49	14/10/2013 05:06		OPTICS Rig		31.30482	-22.67335	31.30483	-22.67335	

14/10/2013 04:59	14/10/2013 05:17		BONGO Net		31.30484	-22.67335	31.30483	-22.67335	
14/10/2013 05:07	14/10/2013 05:47		OPTICS Rig		31.30483	-22.67335	31.3048	-22.67337	
14/10/2013 05:38	14/10/2013 06:05		CTD	CTD013	31.3048	-22.67336	31.30481	-22.67335	
14/10/2013 06:42					31.28822	-22.68176			Vessel continues on passage
14/10/2013 12:06		11			30.36902	-23.15667			Vessel on station
14/10/2013 12:10	14/10/2013 12:27		OPTICS Rig		30.36902	-23.15651	30.36902	-23.15652	
14/10/2013 12:13	14/10/2013 12:58		CTD	CTD014	30.36902	-23.1565	30.36904	-23.15653	
14/10/2013 12:28	14/10/2013 12:55		OPTICS Rig		30.36902	-23.15652	30.36905	-23.15652	
14/10/2013 13:09	14/10/2013 13:23		CTD	CTD015	30.36902	-23.15653	30.36901	-23.15655	
14/10/2013 13:36			FLOAT		30.36913	-23.15628			NKE01 float deployed
14/10/2013 13:38			FLOAT		30.36927	-23.15598			NKE02 float deployed
14/10/2013 13:41			FLOAT		30.36952	-23.15544			NKE03 float
14/10/2013 13:42			FLOAT		30.36963	-23.15521			NKE04 float
14/10/2013 13:54					30.35907	-23.1573			Vessel continues passage
14/10/2013 00:00			Clocks retarded 1 hour						Ship time = GMT + 0
15/10/2013 05:07		12			27.80557	-24.48493			vessel on station
15/10/2013 05:16	15/10/2013 05:54		CTD	CTD016	27.80516	-24.48496	27.80514	-24.48494	
15/10/2013 05:18			OPTICS Rig		27.80517	-24.48495			
15/10/2013 05:31	15/10/2013 05:41		BONGO Net		27.80515	-24.48494	27.80517	-24.48494	
15/10/2013 06:24					27.78405	-24.49419			Vessel continues passage
15/10/2013 13:06		13			26.65496	-25.06302			vessel on station
15/10/2013 13:08	15/10/2013 13:25		OPTICS Rig		26.65495	-25.06299	26.6549	-25.06299	
15/10/2013 13:17			CTD		26.6549	-25.06299			CTD returned to deck on scientists request
15/10/2013 13:21	15/10/2013 14:04		CTD	CTD017	26.65491	-25.06299	26.6549	-25.06299	
15/10/2013 13:26	15/10/2013 13:48		OPTICS Rig		26.6549	-25.06299	26.65488	-25.063	
15/10/2013 14:14	15/10/2013 14:26		CTD	CTD018	26.65488	-25.06299	26.65489	-25.06299	
15/10/2013 14:32			FLOAT		26.65488	-25.06295			First float deployed
15/10/2013 14:34			FLOAT		26.65486	-25.06262			Second float deployed

15/10/2013 14:42					26.65112	-25.06023				Vessel continues passage
16/10/2013 05:05		14			24.21529	-26.25621				vessel on station
16/10/2013 05:13	16/10/2013 05:55		CTD	CTD019	24.21503	-26.2562	24.21503	-26.25619		
16/10/2013 05:14	16/10/2013 05:30		OPTICS Rig		24.21504	-26.2562	24.21503	-26.25618		
16/10/2013 05:31	16/10/2013 05:43		BONGO Net		24.21504	-26.25619	24.21505	-26.25619		BONGO Net at 200m
16/10/2013 06:18					24.19656	-26.2638				Vessel continues passage
16/10/2013 13:10		15			23.07969	-26.81493				vessel on station
16/10/2013 13:12	16/10/2013 13:30		OPTICS Rig		23.07967	-26.81493	23.0797	-26.81493		
16/10/2013 13:17	16/10/2013 13:59		CTD	CTD020	23.07969	-26.81493	23.07969	-26.81493		
16/10/2013 13:31	16/10/2013 13:55		OPTICS Rig		23.0797	-26.81493	23.07969	-26.81489		OPTICS Rig redeployed
16/10/2013 14:12					23.07766	-26.81407				Vessel continues passage
17/10/2013 05:04		16			20.64319	-27.99009				vessel on station
17/10/2013 05:13	17/10/2013 06:00		CTD	CTD021	20.64316	-27.99004	20.64318	-27.99002		
17/10/2013 05:14	17/10/2013 05:36		OPTICS Rig		20.64316	-27.99003	20.64315	-27.99002		
17/10/2013 05:23	17/10/2013 05:44		BONGO Net		20.64315	-27.99002	20.64316	-27.99002		
17/10/2013 06:13	17/10/2013 06:49		CTD	CTD022	20.64318	-27.99002	20.64317	-27.99006		
17/10/2013 07:06					20.62629	-27.99724				Vessel continues passage
17/10/2013 13:08		17			19.65359	-28.39888				vessel on station
17/10/2013 13:12	17/10/2013 13:28		OPTICS Rig		19.65348	-28.39886	19.65352	-28.39889		
17/10/2013 13:15	17/10/2013 13:57		CTD	CTD023	19.6535	-28.39889	19.65351	-28.39889		
17/10/2013 13:29	17/10/2013 13:53		OPTICS Rig		19.65351	-28.3989	19.65349	-28.39889		OPTICS Rig redeployed
17/10/2013 14:12					19.65225	-28.3963				Vessel continues passage
18/10/2013 05:05		18			17.06397	-29.15905				vessel on station
18/10/2013 05:14	18/10/2013 05:59		CTD	CTD024	17.06404	-29.15897	17.06403	-29.15895		
18/10/2013 05:15	18/10/2013 05:31		OPTICS Rig		17.06404	-29.15897	17.06404	-29.15896		
18/10/2013 05:23	18/10/2013 05:42		BONGO Net		17.06403	-29.15894	17.06406	-29.15896		
18/10/2013 06:18					17.04475	-29.16417				Vessel continues passage
18/10/2013 13:06		19			15.8951	-29.50146				vessel on station
18/10/2013 13:09	18/10/2013 13:25		OPTICS Rig		15.89507	-29.50146	15.89514	-29.50148		
18/10/2013 13:13	18/10/2013 13:52		CTD	CTD025	15.89512	-29.50145	15.89511	-29.50147		

18/10/2013 13:26	18/10/2013 13:33		OPTICS Rig		15.89514	-29.50148	15.89513	-29.50147	OPTICS Rig redeployed
18/10/2013 13:57	18/10/2013 14:18		OPTICS Rig		15.89512	-29.50146	15.89081	-29.50049	OPTICS Rig redeployed
18/10/2013 14:24					15.89252	-29.50005			Vessel continues passage
19/10/2013 05:05		20			13.31307	-29.67076			vessel on station
19/10/2013 05:14	19/10/2013 06:03		CTD	CTD026	13.31325	-29.67059	13.31417	-29.67096	
19/10/2013 05:15	19/10/2013 05:57		OPTICS Rig		13.31326	-29.67059	13.314	-29.6709	
19/10/2013 05:23	19/10/2013 05:44		BONGO Net		13.31326	-29.67058	13.31372	-29.67076	
19/10/2013 06:24					13.2956	-29.67011			Vessel continues passage
19/10/2013 13:06		21			12.082	-29.64276			vessel on station
19/10/2013 13:09	19/10/2013 13:25		OPTICS Rig		12.08199	-29.64272	12.08199	-29.64274	
19/10/2013 13:14	19/10/2013 13:56		CTD	CTD027	12.08198	-29.64274	12.082	-29.64274	
19/10/2013 13:26	19/10/2013 13:50		OPTICS Rig		12.082	-29.64274	12.08201	-29.64273	OPTICS Rig redeployed
19/10/2013 14:06					12.08222	-29.64139			Vessel continues passage
20/10/2013 05:10		22			9.2751	-29.54069			vessel on station
20/10/2013 05:14	20/10/2013 06:02		CTD	CTD028	9.27508	-29.54071	9.274	-29.53778	
20/10/2013 05:16	20/10/2013 05:22		BONGO Net		9.27509	-29.54071	9.27507	-29.5407	
20/10/2013 05:18	20/10/2013 05:59		OPTICS Rig		9.27508	-29.54072	9.27418	-29.53816	
20/10/2013 06:04	20/10/2013 06:25		BONGO Net		9.27381	-29.53758	9.27128	-29.53374	
20/10/2013 06:28					9.27101	-29.53327			Vessel continues passage
20/10/2013 13:08		23			8.11958	-29.51141			vessel on station
20/10/2013 13:10	20/10/2013 13:29		OPTICS Rig		8.11967	-29.51116	8.11954	-29.51038	
20/10/2013 13:20	20/10/2013 13:59		CTD	CTD029	8.11964	-29.51106	8.11919	-29.50831	
20/10/2013 13:30	20/10/2013 13:54		OPTICS Rig		8.11953	-29.51037	8.11931	-29.50902	OPTICS Rig re deployed
20/10/2013 14:12					8.12067	-29.50674			Vessel continues passage
21/10/2013 05:08		24			5.4576	-29.42232			vessel on station
21/10/2013 05:26	21/10/2013 06:07		CTD	CTD030	5.4575	-29.41979	5.45747	-29.40927	
21/10/2013 05:28	21/10/2013 06:11		OPTICS Rig		5.4575	-29.41931	5.45746	-29.40811	
21/10/2013 05:42	21/10/2013 06:05		BONGO Net		5.45751	-29.41579	5.45746	-29.40979	
21/10/2013 06:20	21/10/2013 07:00		CTD	CTD031	5.45747	-29.40692	5.45773	-29.3995	
21/10/2013 07:12					5.44465	-29.39737			Vessel continues passage

21/10/2013 13:08		25			4.36355	-29.3897			vessel on station
21/10/2013 13:10	21/10/2013 13:32		OPTICS Rig		4.36361	-29.3897	4.36361	-29.38971	
21/10/2013 13:18	21/10/2013 13:58		CTD	CTD032	4.36361	-29.38971	4.3636	-29.38971	
21/10/2013 13:33	21/10/2013 13:55		OPTICS Rig		4.3636	-29.38971	4.3636	-29.38971	OPTICS Rig redeployed
21/10/2013 14:12					4.35968	-29.38828			Vessel continues passage
23/10/2013 05:36		26			-2.54693	-28.9829			vessel on station
23/10/2013 05:37	23/10/2013 06:20		OPTICS Rig		-2.54693	-28.98289	-2.5469	-28.98289	
23/10/2013 05:42	23/10/2013 06:27		CTD	CTD033	-2.54691	-28.9829	-2.54691	-28.9829	
23/10/2013 05:49	23/10/2013 06:14		BONGO Net		-2.54694	-28.98292	-2.54691	-28.9829	
23/10/2013 06:32					-2.54691	-28.98288			Vessel continues passage
23/10/2013 13:10		27			-3.65662	-28.74403			vessel on station
23/10/2013 13:12	23/10/2013 13:29		OPTICS Rig		-3.65661	-28.74402	-3.65663	-28.74399	
23/10/2013 13:19	23/10/2013 14:04		CTD	CTD034	-3.65661	-28.74401	-3.65673	-28.74379	
23/10/2013 13:30	23/10/2013 13:52		OPTICS Rig		-3.65663	-28.74399	-3.65674	-28.7438	OPTICS Rig redeployed
23/10/2013 14:12					-3.66176	-28.74291			Vessel continues passage
24/10/2013 05:37		28			-6.33802	-28.17919			vessel on station
24/10/2013 05:38	24/10/2013 06:21		OPTICS Rig		-6.33801	-28.17917	-6.33806	-28.17918	OPTICS Rig deployed
24/10/2013 05:42	24/10/2013 06:25		CTD	CTD_035	-6.33802	-28.17919	-6.33806	-28.17917	
24/10/2013 05:45	24/10/2013 06:10		BONGO Net		-6.33804	-28.17918	-6.33805	-28.17919	
24/10/2013 06:32					-6.33807	-28.17917			Vessel continues passage
24/10/2013 13:10		29			-7.42573	-27.94407			vessel on station
24/10/2013 13:12	24/10/2013 13:30		OPTICS Rig		-7.42573	-27.94407	-7.42573	-27.94405	
24/10/2013 13:16	24/10/2013 13:59		CTD	CTD_036	-7.42569	-27.94404	-7.4257	-27.94406	
24/10/2013 13:32	24/10/2013 13:55		OPTICS Rig		-7.42574	-27.94405	-7.42573	-27.94406	OPTICS Rig redeployed
24/10/2013 14:12					-7.43294	-27.94505			Vessel continues passage
25/10/2013 05:00		30			-10.0001	-27.40039			vessel on station
25/10/2013 05:08	25/10/2013 05:52		OPTICS Rig		-10.0021	-27.39677	-10.0021	-27.39676	
25/10/2013 05:10	25/10/2013 05:55		CTD	CTD037	-10.0021	-27.39677	-10.0021	-27.39676	
25/10/2013 05:15	25/10/2013 05:42		BONGO Net		-10.0021	-27.39677	-10.00209	-27.39678	BONGO Net deployed and veering to 200m

25/10/2013 06:04	25/10/2013 06:34		CTD	CTD038	-10.0021	-27.39676	-10.0021	-27.39675	2nd CTD deployed
25/10/2013 06:39			FLOAT		-10.0021	-27.39669			Navis FO251 float deployed
25/10/2013 06:41			FLOAT		-10.0022	-27.39643			Apex 6745 deployed
25/10/2013 06:54					-10.0193	-27.39261			Vessel continues passage
25/10/2013 13:10		31			-11.1183	-27.16141			vessel on station
25/10/2013 13:12	25/10/2013 13:30		OPTICS Rig		-11.1183	-27.16137	-11.11824	-27.16139	
25/10/2013 13:16	25/10/2013 14:05		CTD	CTD039	-11.1183	-27.16136	-11.11824	-27.16138	
25/10/2013 14:08			FLOAT		-11.1183	-27.1612			NOVA111 float deployed
25/10/2013 14:10			FLOAT		-11.1184	-27.16086			APEX6613 float deployed
25/10/2013 14:18					-11.1288	-27.15769			Vessel continues passage
26/10/2013 05:06		32			-13.945	-26.5583			vessel on station
26/10/2013 05:07	26/10/2013 05:25		OPTICS Rig		-13.945	-26.55831	-13.94503	-26.55832	
26/10/2013 05:11	26/10/2013 05:53		CTD	CTD040	-13.945	-26.55834	-13.945	-26.55827	
26/10/2013 05:19	26/10/2013 05:43		BONGO Net		-13.945	-26.55834	-13.945	-26.5583	
26/10/2013 06:06			FLOAT		-13.9453	-26.55788			Apex 6612 deployed
26/10/2013 06:07					-13.9509	-26.55567			Vessel continues passage
26/10/2013 13:06		33			-15.0022	-26.32967			vessel on station
26/10/2013 13:10	26/10/2013 13:34		OPTICS Rig		-15.0023	-26.32971	-15.00226	-26.32971	
26/10/2013 13:12	26/10/2013 13:54		CTD	CTD041	-15.0023	-26.32971	-15.00227	-26.32972	
26/10/2013 14:02			FLOAT		-15.0023	-26.32955			Float NAVIS FO252 deployed
26/10/2013 14:03			FLOAT		-15.0024	-26.32938			Float Apex 6746 deployed
26/10/2013 14:06					-15.0028	-26.32856			Vessel continues passage
27/10/2013 05:00		34			-17.6916	-25.70868			vessel on station
27/10/2013 05:12	27/10/2013 05:31		OPTICS Rig		-17.7016	-25.70497	-17.70189	-25.70533	
27/10/2013 05:16	27/10/2013 06:01		CTD	CTD042	-17.7016	-25.70491	-17.70245	-25.706	
27/10/2013 05:21	27/10/2013 05:44		BONGO Net		-17.7016	-25.70492	-17.7023	-25.70582	
27/10/2013 06:18					-17.7267	-25.70088			Vessel continues passage
27/10/2013 13:08		35			-18.9972	-25.3873			vessel on station
27/10/2013 13:10	27/10/2013 13:36		OPTICS Rig		-18.9973	-25.38734	-18.99722	-25.38735	
27/10/2013 13:15	27/10/2013 13:57		CTD	CTD043	-18.9972	-25.38733	-18.99723	-25.38734	

27/10/2013 14:08			FLOAT		-18.9973	-25.38711			APEX 6614 float deployed
27/10/2013 14:12					-18.9976	-25.38581			Vessel continues passage
28/10/2013 05:05		36			-21.5294	-25.16303			vessel on station
28/10/2013 05:10	28/10/2013 05:33		OPTICS Rig		-21.5293	-25.16295	-21.52926	-25.16293	
28/10/2013 05:14	28/10/2013 05:57		CTD	CTD044	-21.5293	-25.16295	-21.52926	-25.16292	
28/10/2013 05:18	28/10/2013 05:43		BONGO Net		-21.5293	-25.16292	-21.52926	-25.16294	
28/10/2013 06:12					-21.5388	-25.16539			Vessel continues passage
28/10/2013 13:10		37			-22.5711	-25.91052			vessel on station
28/10/2013 13:15	28/10/2013 13:58		CTD	CTD045	-22.5711	-25.91052	-22.57109	-25.91052	
28/10/2013 13:16	28/10/2013 13:40		OPTICS Rig		-22.5711	-25.91053	-22.57109	-25.91052	
28/10/2013 14:17	28/10/2013 14:35		CTD	CTD046	-22.5711	-25.91052	-22.57108	-25.91054	Second CTD deployed
28/10/2013 14:42			FLOAT		-22.5711	-25.91053			APEX float 6615 deployed
28/10/2013 14:48					-22.57	-25.91032			Vessel continues passage
29/10/2013 05:05		38			-24.4279	-27.64515			vessel on station
29/10/2013 05:10	29/10/2013 05:27		OPTICS Rig		-24.4279	-27.64519	-24.42786	-27.64518	
29/10/2013 05:14	29/10/2013 05:55		CTD	CTD047	-24.4279	-27.64519	-24.42773	-27.6451	
29/10/2013 05:20	29/10/2013 05:47		BONGO Net		-24.4279	-27.64517	-24.42787	-27.64516	
29/10/2013 06:09	29/10/2013 06:39		CTD	CTD048	-24.4277	-27.6451	-24.42772	-27.6451	
29/10/2013 06:54					-24.4417	-27.65733			Vessel continues passage
29/10/2013 13:06		39			-25.162	-28.33897			vessel on station
29/10/2013 13:12	29/10/2013 13:53		CTD	CTD049	-25.1621	-28.33897	-25.16203	-28.33898	
29/10/2013 13:15	29/10/2013 13:40		OPTICS Rig		-25.162	-28.33894	-25.16203	-28.33895	
29/10/2013 14:12					-25.1688	-28.3457			Vessel continues passage
30/10/2013 05:06		40			-26.925	-30.0404			vessel on station
30/10/2013 05:12	30/10/2013 05:33		BONGO Net		-26.9248	-30.04035	-26.92475	-30.04035	
30/10/2013 05:15	30/10/2013 05:59		CTD	CTD050	-26.9247	-30.04035	-26.92477	-30.04034	
30/10/2013 05:16	30/10/2013 05:42		OPTICS Rig		-26.9248	-30.04036	-26.92476	-30.04036	
30/10/2013 06:12					-26.9291	-30.0491			Vessel continues passage
30/10/2013 13:10		41			-27.7894	-30.86964			vessel on station
30/10/2013 13:15	30/10/2013 13:54		CTD	CTD051	-27.7894	-30.86965	-27.78945	-30.86968	

30/10/2013 13:17	30/10/2013 13:42		OPTICS Rig		-27.7894	-30.86966	-27.78945	-30.86967	
30/10/2013 14:12					-27.7899	-30.86971			Vessel continues passage
31/10/2013 05:06		42			-29.5215	-32.57972			vessel on station
31/10/2013 05:13	31/10/2013 05:54		CTD	CTD052	-29.5215	-32.57964	-29.52247	-32.5788	
31/10/2013 05:14	31/10/2013 05:41		OPTICS Rig		-29.5215	-32.57965	-29.52247	-32.5788	
31/10/2013 05:17	31/10/2013 05:42		BONGO Net		-29.5215	-32.57963	-29.52245	-32.57877	
31/10/2013 06:12					-29.537	-32.59322			Vessel continues passage
31/10/2013 13:10		43			-30.3321	-33.37465			vessel on station
31/10/2013 13:15	31/10/2013 13:56		CTD	CTD053	-30.332	-33.37465	-30.33203	-33.37466	
31/10/2013 13:17	31/10/2013 13:48		OPTICS Rig		-30.332	-33.37465	-30.33204	-33.37466	
31/10/2013 14:06					-30.5534	-33.58927			Vessel continues passage
01/11/2013 05:00		44			-32.2552	-35.29792			vessel on station
01/11/2013 05:13	01/11/2013 05:41		BONGO Net		-32.2612	-35.2995	-32.26121	-35.30054	
01/11/2013 05:15	01/11/2013 05:59		CTD	CTD054	-32.2612	-35.29951	-32.26126	-35.30078	
01/11/2013 05:39			OPTICS Rig		-32.2612	-35.3005			
01/11/2013 06:12					-32.2721	-35.31299			Vessel continues passage
01/11/2013 13:10		45			-33.1998	-36.25595			vessel on station
01/11/2013 13:19	01/11/2013 13:59		CTD	CTD055	-33.1999	-36.25606	-33.19983	-36.2561	
01/11/2013 13:21	01/11/2013 13:42		OPTICS Rig		-33.1998	-36.25609	-33.19983	-36.2561	
01/11/2013 14:12					-33.2047	-36.26294			Vessel continues passage
02/11/2013 05:04		46			-35.1588	-38.27385			vessel on station
02/11/2013 05:10	02/11/2013 05:31		BONGO Net		-35.1589	-38.27377	-35.1589	-38.27378	
02/11/2013 05:13	02/11/2013 05:56		CTD	CTD056	-35.1589	-38.27377	-35.15889	-38.27378	
02/11/2013 05:14	02/11/2013 05:33		OPTICS Rig		-35.1589	-38.27377	-35.1589	-38.27378	
02/11/2013 06:12					-35.1728	-38.28551			Vessel continues passage
02/11/2013 13:06		47			-35.9998	-39.16338			vessel on station
02/11/2013 13:12	02/11/2013 13:57		CTD	CTD057	-35.9998	-39.16338	-35.99963	-39.16355	
02/11/2013 13:15	02/11/2013 13:33		OPTICS Rig		-35.9998	-39.16337	-35.99962	-39.16354	
02/11/2013 14:04			FLOAT		-35.9998	-39.16338			ARGO float 6747 deployed
02/11/2013 14:12					-36.0583	-39.22334			Vessel continues passage

03/11/2013 05:00		48			-38.0599	-41.35046			Vessel on station
03/11/2013 05:28			BONGO Net		-38.0543	-41.34668			Cancelled BONGO Net and OPTICS Rigs due strong easterly current (2.5kts) and northerly wind (25kts)
03/11/2013 05:35	03/11/2013 06:13		CTD	CTD058	-38.0541	-41.34505	-38.04669	-41.32796	
03/11/2013 06:24	03/11/2013 06:58		CTD	CTD059	-38.0445	-41.32307	-38.03712	-41.30665	
03/11/2013 07:04					-38.0361	-41.30404			Vessel continues on passage
03/11/2013 13:12		49			-38.7518	-42.10616			Vessel on station
03/11/2013 13:21	03/11/2013 13:59		CTD	CTD060	-38.7536	-42.10957	-38.74657	-42.09787	
03/11/2013 14:24					-38.7914	-42.13785			vessel continues on passage
03/11/2013 16:12					-38.9974	-42.33854			Vessel slowing
03/11/2013 16:18			FLOAT		-38.9959	-42.34013			Argo float deployed
03/11/2013 16:36					-38.9877	-42.33585			vessel continues on passage
04/11/2013 05:07		50			-40.6105	-44.12733			Vessel on station
04/11/2013 05:23	04/11/2013 06:00		CTD	CTD061	-40.6108	-44.12834	-40.61184	-44.1306	
04/11/2013 06:48					-40.6282	-44.12824			Vessel continues on passage
04/11/2013 20:54					-41.9842	-45.68398			Commence slowing down for argo deployment.
04/11/2013 21:05			ARGO FLOAT		-41.9987	-45.69034			Argo float 6749 deployed
04/11/2013 21:12					-42.0043	-45.69736			Vessel continues on passage
05/11/2013 05:06		51			-42.8963	-46.72424			Vessel on DP
05/11/2013 05:14	05/11/2013 05:58		CTD	CTD062	-42.8963	-46.72426	-42.89637	-46.72429	
05/11/2013 05:15	05/11/2013 05:34		OPTICS Rig		-42.8963	-46.72425	-42.89636	-46.72425	
05/11/2013 05:17	05/11/2013 05:41		BONGO Net		-42.8963	-46.72426	-42.89636	-46.72425	
05/11/2013 06:12					-42.9096	-46.73887			Vessel continues on passage
05/11/2013 13:09		52			-43.7087	-47.66701			Vessel on station
05/11/2013 13:15	05/11/2013 13:57		CTD	CTD063	-43.7087	-47.66701	-43.70865	-47.66699	
05/11/2013 13:16	05/11/2013 13:38		OPTICS Rig		-43.7087	-47.667	-43.70866	-47.66698	
05/11/2013 14:12					-43.7144	-47.67345			Vessel continues on passage

06/11/2013 02:04					-45.0013	-49.20143			Vessel head to wind ready to deploy
06/11/2013 02:05			ARGO FLOAT		-45.0008	-49.20168			ARGO float 6750 deployed
06/11/2013 02:12					-45.0024	-49.21038			Vessel continues on passage
06/11/2013 05:35		53			-45.4049	-49.69085			Vessel on station
06/11/2013 05:42	06/11/2013 06:21		CTD	CTD064	-45.4048	-49.69086	-45.40359	-49.6896	
06/11/2013 05:43	06/11/2013 06:10		BONGO Net		-45.4048	-49.69084	-45.40384	-49.68985	
06/11/2013 05:46	06/11/2013 06:03		OPTICS Rig		-45.4048	-49.69081	-45.40401	-49.69003	
06/11/2013 06:36					-45.4166	-49.70519			Vessel continues on passage
06/11/2013 14:06		54			-46.2731	-50.74351			Vessel on station
06/11/2013 14:13	06/11/2013 14:52		CTD	CTD065	-46.2731	-50.74356	-46.26933	-50.74829	
06/11/2013 14:14	06/11/2013 14:44		OPTICS Rig		-46.2731	-50.74354	-46.26996	-50.74776	
06/11/2013 15:54					-46.3619	-50.72233			Sampling complete vessel proceeding on passage to Stanley

APPENDIX 3: AMT23 UNDERWAY SAMPLE LOG

Sample ID	Julian day 31/12/2012	Date + Time	Lat (+ve N)	Lon (+ve E)	Salinity Sample ID	Salinity Reading	Chl-a (ug/l)	RFU	TSG sal.	SST - hull (deg. C)	Fluor ug/l
AA	282	09/10/2013 08:28	47.01711	-9.8730898			0.12		35.58194	18.46401	0.222401
AB	282	09/10/2013 11:28	46.67948	-10.50783			0.11		35.64434	18.62601	0.217399
	282	09/10/2013 15:08	46.44166	-10.95243	1-1	35.731			35.71114	18.86194	0.218597
AC	282	09/10/2013 16:37	46.28392	-11.24571			0.03		35.70786	18.93599	0.215599
	282	09/10/2013 19:00	46.02976	-11.71273	1-2	35.6682			35.64874	18.87	0.215601
AD	282	09/10/2013 19:05	46.02064	-11.72912			0.07		35.658	18.9	0.215198
AE	283	10/10/2013 04:57	45.00203	-13.59468			0.05		35.66142	18.48798	0.236798
AF	283	10/10/2013 07:24	44.81774	-13.73033			0.08		35.64565	18.47	0.2355
	283	10/10/2013 07:27	44.81011	-13.73595	1-3	35.6596			35.64218	18.46	0.237601
	283	10/10/2013 11:06	44.2468	-14.16049	1-4	35.7965			35.77806	19.20996	0.211
AG	283	10/10/2013 11:56	44.12557	-14.24835			0.06		35.75722	19.19599	0.214
	283	10/10/2013 14:58	43.82996	-14.46357	1-5	35.7037			35.68978	19.17603	0.219
AH	283	10/10/2013 15:44	43.70569	-14.56156			0.05		35.69554	19.15	0.216
AI	283	10/10/2013 18:58	43.21049	-14.93352			0.02		35.90758	19.57	0.208601
AJ	284	11/10/2013 04:03	41.84469	-15.92188			0.03		35.87824	19.47	0.207603
	284	11/10/2013 05:33	41.77742	-15.96684	1-6	35.9085			35.8907	19.56397	0.207
AK	284	11/10/2013 07:53	41.4587	-16.200935			0.03		35.96908	19.99207	0.204603
	284	11/10/2013 11:20	40.92104	-16.6007	1-7	36.0439			36.02776	20.24	0.205
AL	284	11/10/2013 11:58	40.82007	-16.67271			0.03		36.00816	20.2	0.207
	284	11/10/2013 15:33	40.44525	-16.94558	1-8	36.1031			36.0843	20.37207	0.207
AM	284	11/10/2013 15:56	40.38547	-16.98691			0.03		36.09226	20.32	0.206207
	285	12/10/2013 04:22	38.42371	-18.357861	1-9	36.1663			36.14922	20.74402	0.202197
AN	285	12/10/2013 06:37	38.25307	-18.46913			0.04		36.1999	20.74197	0.201205
AP	285	12/10/2013 08:12	38.00287	-18.63084			0.04		36.18842	20.69	0.199197
	285	12/10/2013 10:58	37.56319	-18.936191	1-10	36.5125			36.49474	21.15197	0.197402

AQ	285	12/10/2013 11:45	37.44015	-19.019731			0.04	36.52798	21.27	0.196
	285	12/10/2013 15:09	37.09472	-19.253194	1-11	36.3635		36.32258	21.3419	0.197397
AR	285	12/10/2013 16:34	36.8674	-19.39948			0.02	36.62582	21.88397	0.196603
AO	285	12/10/2013 18:30	36.55354	-19.610825			0.02	36.55166	21.67	0.196397
AS	285	12/10/2013 19:07	36.45246	-19.676565			0.03	36.55704	21.63	0.196603
AT	286	13/10/2013 03:44	35.07889	-20.58069			0.02	36.61486	22.85215	0.195595
	286	13/10/2013 03:51	35.06053	-20.592875	1-12	36.6384		36.62126	22.87793	0.195207
AU	286	13/10/2013 07:48	34.63344	-20.87418			0.02	36.76445	22.92405	0.192785
	286	13/10/2013 07:57	34.6091	-20.890329	1-13	36.7449		36.72634	22.92017	0.193397
	286	13/10/2013 11:44	33.97048	-21.261881	1-14	36.8786		36.87802	22.86	0.195603
AV	286	13/10/2013 11:50	33.9525	-21.269409			0.03	36.87244	22.87	0.196
	286	13/10/2013 15:10	33.57586	-21.45969	1-15	36.9301		36.91482	22.95405	0.196
AW	286	13/10/2013 16:01	33.43574	-21.53249			0.02	36.9428	23.11	0.195405
AX	286	13/10/2013 18:32	33.00835	-21.760654			0.02	36.9763	23.07787	0.195402
	287	14/10/2013 03:57	31.40548	-22.615269	1-16	36.8755		36.8594	23.16017	0.195397
AY	287	14/10/2013 06:51	31.26296	-22.695105			0.02	36.85796	23.11	0.195
	287	14/10/2013 08:10	31.03481	-22.812855	1-17	36.8873		36.87202	23.09197	0.194402
AZ	287	14/10/2013 08:21	31.00329	-22.830029			0.02	36.91394	23.15402	0.194197
	287	14/10/2013 11:45	30.41571	-23.137696	1-18	37.0167		37.00264	23.79	0.193
BB	287	14/10/2013 15:23	30.10742	-23.285695			0.01	36.96154	23.95397	0.193603
	287	14/10/2013 15:48	30.0374	-23.322575	1-19	36.979		36.96156	24.08402	0.194
BC	287	14/10/2013 19:00	29.50288	-23.604994			0.01	37.20802	24.37603	0.191
BD	288	15/10/2013 04:09	27.96451	-24.407965			0.01	37.27538	24.27787	0.19218
	288	15/10/2013 04:21	27.92975	-24.425185	1-20	37.2786		37.26318	24.27	0.192213
BE	288	15/10/2013 08:22	27.44536	-24.66523			0.02	37.29826	24.69394	0.194393
	288	15/10/2013 09:07	27.31581	-24.72994	1-21	37.3175		37.30235	24.6859	0.19459
BF	288	15/10/2013 12:26	26.75211	-25.015751			0.02	37.48452	24.87607	0.190607
	288	15/10/2013 12:51	26.68257	-25.052601	1-22	37.5091		37.4932	24.898	0.191
BG	288	15/10/2013 16:48	26.29634	-25.239849			0.02	37.49934	25.1	0.191
	288	15/10/2013 16:50	26.29081	-25.242649	1-23	37.5082		37.49448	25.0882	0.191

BH	289	16/10/2013 04:40	24.27945	-26.227551			0.04		37.04812	25.318	0.191
	289	16/10/2013 06:09	24.21456	-26.25585	1-24	37.2498			37.23304	25.20771	0.19341
BI	289	16/10/2013 08:39	23.80458	-26.46138			0.05		36.96572	25.44	0.194
BJ	289	16/10/2013 13:02	23.07889	-26.816811			0.04		36.93108	25.656	0.193
	289	16/10/2013 14:07	23.07971	-26.81492	10-1	36.9442			36.92818	25.6882	0.193607
BK	289	16/10/2013 16:05	22.78941	-26.958441			0.04		36.86152	25.74787	0.193
BL	289	16/10/2013 19:44	22.19364	-27.24448			0.03		36.8515	25.73393	0.193607
BM	290	17/10/2013 04:46	20.68637	-27.973339				5.15	36.52614	26.05607	0.193
	290	17/10/2013 05:55	20.6432	-27.99003	10-2	36.5426			36.52768	26.062	0.193
BN	290	17/10/2013 09:15	20.2674	-28.17148				10.11	36.61432	26.23	0.193
	290	17/10/2013 10:52	20.00667	-28.29468	10-3	36.7251			36.70938	26.058	0.1922
BO	290	17/10/2013 12:33	19.74228	-28.376869				7.5	36.7051	26.184	0.1918
	290	17/10/2013 14:03	19.65351	-28.39889	10-4	36.6892			36.67392	26.24213	0.193393
BP	290	17/10/2013 16:32	19.22787	-28.52808				7.56	36.73304	26.2882	0.19182
	290	17/10/2013 18:38	18.86311	-28.63582	10-5	36.6775			36.66562	26.28	0.194
BQ	290	17/10/2013 19:36	18.69823	-28.67907				10.75	36.64114	26.32393	0.191787
	291	18/10/2013 04:24	17.1715	-29.13286	10-6	36.5611			36.54682	26.77	0.194
BR	291	18/10/2013 06:55	16.93877	-29.19475				6.52	36.54102	26.89	0.195393
BS	291	18/10/2013 09:44	16.45633	-29.34004				10.57	36.22818	27.144	0.1976
BT	291	18/10/2013 12:31	15.98023	-29.48173				12.23	36.21434	27.2582	0.19659
	291	18/10/2013 12:54	15.915	-29.50009	10-7	36.2357			36.22132	27.2041	0.19641
BU	291	18/10/2013 16:51	15.47534	-29.611179				9.32	36.20928	27.53787	0.197
	291	18/10/2013 18:21	15.22216	-29.68527	10-8	36.2309			36.2184	27.36	0.197
BV	291	18/10/2013 19:48	14.97829	-29.71381				11.09	36.27378	27.4559	0.19759
	292	19/10/2013 04:19	13.43578	-29.674459	10-9	35.8517			35.83822	27.792	0.1946
BW	292	19/10/2013 04:54	13.33234	-29.673491				7.04	35.873	27.83393	0.196
BX	292	19/10/2013 08:50	12.85611	-29.660231				9.11	35.67608	27.86	0.193
	292	19/10/2013 12:25	12.19155	-29.647249	10-10	35.7114			35.70148	27.79	0.192213
BY	292	19/10/2013 12:46	12.12655	-29.64665				6.64	35.69086	27.78	0.19282
BZ	292	19/10/2013 16:37	11.62124	-29.634951				9.24	35.49756	27.97393	0.193

	293	20/10/2013 04:26	9.3857	-29.551941	10-11	35.2949		35.27811	28.18394	0.191787
CA	293	20/10/2013 04:51	9.30602	-29.547649			13.95	34.98919	28.3718	0.19182
CB	293	20/10/2013 08:46	8.85985	-29.523479			14.94	34.61636	28.3041	0.19359
	293	20/10/2013 09:26	8.74125	-29.5247	10-12	34.6811		34.65669	28.42394	0.192213
CC	293	20/10/2013 12:52	8.1437	-29.51815			9.9	34.71305	28.7841	0.19018
	293	20/10/2013 16:18	7.77548	-29.50635	10-13	34.7514		34.75674	28.756	0.2006
CD	293	20/10/2013 16:42	7.70672	-29.505199			12.06	34.72171	28.67	0.198787
CE	293	20/10/2013 20:07	7.10866	-29.48686			20.07	34.61739	28.51639	0.21141
	294	21/10/2013 04:20	5.58733	-29.431299	10-14	35.8119		35.80556	27.996	0.1904
CF	294	21/10/2013 04:50	5.49553	-29.42766			11.61	35.8294	27.84787	0.189
CG	294	21/10/2013 08:56	5.12122	-29.39678			10.39	35.25383	27.20574	0.188
CH	294	21/10/2013 12:14	4.51304	-29.398291			9.58	35.26642	27.6818	0.186
	294	21/10/2013 12:34	4.44963	-29.396931	10-15	35.5966		35.5062	27.646	0.186
	294	21/10/2013 14:38	4.28564	-29.39242	10-16	35.7736		35.75148	27.968	0.184
CI	294	21/10/2013 14:39	4.28268	-29.39258			7.3	35.76071	27.98	0.186
	296	23/10/2013 05:19	-2.50875	-28.99004	10-18	36.1764		36.16572	26.332	0.176
CJ	296	23/10/2013 07:47	-2.74486	-28.941311			6.8	36.17056	26.26613	0.177774
	296	23/10/2013 12:47	-3.61345	-28.755449	10-19	36.1852		36.17376	26.05	0.1764
CK	296	23/10/2013 14:41	-3.74527	-28.727461			6.68	36.17397	26.14	0.175613
CL	296	23/10/2013 16:28	-4.06099	-28.662615			9.82	36.1529	26.14	0.176
CM	296	23/10/2013 19:43	-4.63548	-28.542665			5.12	36.15974	26.026	0.181
	297	24/10/2013 04:53	-6.23243	-28.20343	10-20	36.1949		36.18364	26.104	0.179
CN	297	24/10/2013 04:57	-6.24354	-28.20118			8.87	36.18489	26.14	0.177774
	297	24/10/2013 08:22	-6.63282	-28.118415	10-21	36.1788		36.16942	25.92226	0.175613
CO	297	24/10/2013 08:31	-6.65677	-28.113341			9.11	36.16717	25.94581	0.175419
CP	297	24/10/2013 12:42	-7.36969	-27.95996			6.94	36.18824	25.956	0.1724
	297	24/10/2013 12:48	-7.38688	-27.956115	10-22	36.1975		36.18754	25.94	0.173
CQ	297	24/10/2013 16:50	-7.90128	-27.851885			7.65	36.22346	25.938	0.1726
	297	24/10/2013 17:46	-8.06495	-27.812805	10-23	36.2425		36.23126	25.924	0.173
CR	297	24/10/2013 19:56	-8.4358	-27.73307			3.55	36.24302	25.86	0.172613

	298	25/10/2013 04:19	-9.87486	-27.426929	10-24	36.4092		36.41912	25.614	0.169
CS	298	25/10/2013 04:54	-9.98209	-27.40403			5.26	36.43216	25.64	0.17
CT	298	25/10/2013 08:44	-10.3469	-27.32621			6.06	36.44916	25.63581	0.169419
	298	25/10/2013 08:53	-10.372	-27.321159	4-1	36.4723		36.45629	25.63387	0.168
CU	298	25/10/2013 12:38	-11.0464	-27.17845			5.31	36.5076	25.50323	0.167
	298	25/10/2013 14:07	-11.1183	-27.161329	4-2	36.5008		36.48912	25.554	0.1686
CV	298	25/10/2013 20:18	-12.2614	-26.9214			4.52	36.43814	25.352	0.168
	299	26/10/2013 04:12	-13.7874	-26.595751	4-3	36.6823		36.67312	25	0.167419
CW	299	26/10/2013 05:09	-13.945	-26.558331			3.8	36.67787	24.95839	0.166419
	299	26/10/2013 07:18	-14.1201	-26.5158	4-4	36.7194		36.70874	24.9	0.166
CX	299	26/10/2013 09:06	-14.4014	-26.46196			4.52	36.82069	24.59	0.166419
CY	299	26/10/2013 12:37	-14.9443	-26.343519			3.83	37.01804	24.53	0.164027
CZ	299	26/10/2013 15:47	-15.2955	-26.262899			3.75	37.1174	24.25	0.163
	299	26/10/2013 17:54	-15.6763	-26.1765	4-5	37.0574		37.12753	24.16	0.163
	300	27/10/2013 04:28	-17.5927	-25.73214	4-6	37.1943		37.18538	23.544	0.162
DA	300	27/10/2013 06:42	-17.8012	-25.68198			2.55	37.19764	23.576	0.16
DB	300	27/10/2013 08:59	-18.2284	-25.57617			3.77	37.2115	23.53	0.161
	300	27/10/2013 09:45	-18.374	-25.53977	4-7	37.1471		37.13724	23.44	0.161
	300	27/10/2013 12:32	-18.9025	-25.414339	4-8	37.147		37.13678	23.778	0.159
DC	300	27/10/2013 12:49	-18.9575	-25.401649			3.06	37.13896	23.75613	0.159
DD	300	27/10/2013 15:51	-19.2762	-25.319019			3.47	37.15212	24.27	0.158613
DE	300	27/10/2013 19:15	-19.8523	-25.187401			3.21	37.09723	24.07	0.16
	301	28/10/2013 04:18	-21.4079	-25.164829	4-9	36.9896		36.97874	22.674	0.16
DF	301	28/10/2013 04:48	-21.4934	-25.165541			2.73	36.87086	22.43387	0.158
DG	301	28/10/2013 08:51	-21.927	-25.445551			4.27	36.73318	22.164	0.159
	301	28/10/2013 12:17	-22.4573	-25.82435	4-10	36.6498		36.64016	21.93419	0.158419
DH	301	28/10/2013 12:49	-22.5407	-25.88438			5.2	36.63959	21.90226	0.158
DI	301	28/10/2013 17:19	-22.9192	-26.211571			4.86	36.64278	21.978	0.1596
	301	28/10/2013 17:37	-22.9588	-26.24893	4-11	36.6847		36.67504	22.08	0.1604
DJ	301	28/10/2013 19:17	-23.1712	-26.45192			3.34	36.66892	21.966	0.16

	302	29/10/2013 04:21	-24.3479	-27.564199	4-12	36.6843		36.68078	21.764	0.1596
DK	302	29/10/2013 04:52	-24.4104	-27.624599			5.79	36.68646	21.758	0.1594
DL	302	29/10/2013 08:47	-24.6737	-27.87377			6.04	36.66072	21.644	0.1594
	302	29/10/2013 10:20	-24.8572	-28.047859	4-13	36.687		36.68354	21.642	0.1584
DM	302	29/10/2013 12:46	-25.136	-28.312441			6.14	36.69428	21.684	0.158
DN	302	29/10/2013 16:31	-25.4272	-28.5888			6.32	36.78146	22.014	0.1584
	302	29/10/2013 17:38	-25.5573	-28.711545	4-14	36.7822		36.778	22.026	0.1588
DO	302	29/10/2013 19:24	-25.7593	-28.907584			5.74	36.82924	22.14613	0.160613
	303	30/10/2013 04:25	-26.8505	-29.962617	4-15	36.4331		36.4286	20.78226	0.16
DP	303	30/10/2013 04:55	-26.9129	-30.02394			6.08	36.47864	20.926	0.1594
DQ	303	30/10/2013 08:30	-27.2262	-30.326679			9.37	36.47723	20.93613	0.159
DR	303	30/10/2013 12:41	-27.7486	-30.829599			6.75	36.48166	21.066	0.158
	303	30/10/2013 15:20	-27.9237	-31.005051	4-16	36.1066		36.10418	19.938	0.1562
DS	303	30/10/2013 16:29	-28.0547	-31.1266			8.32	36.0552	19.648	0.1554
DT	303	30/10/2013 19:32	-28.3865	-31.455919			4.7	36.0154	19.484	0.159
	304	31/10/2013 04:18	-29.4348	-32.494259	4-17	36.4387		36.4388	20.624	0.161
DU	304	31/10/2013 04:57	-29.5099	-32.568871			12.56	36.43552	20.58774	0.160387
	304	31/10/2013 08:18	-29.7708	-32.81601	4-18	36.4555		36.4545	20.704	0.1614
DV	304	31/10/2013 08:44	-29.8205	-32.864681			15.62	36.44896	20.67	0.161
	304	31/10/2013 12:42	-30.2906	-33.334942	4-19	36.1181		36.11752	19.6	0.1554
DW	304	31/10/2013 12:46	-30.2993	-33.343472			10.95	36.11286	19.574	0.1568
DX	304	31/10/2013 19:03	-30.9924	-34.024651			12.76	36.10847	19.62	0.159581
	305	01/11/2013 04:16	-32.1605	-35.2006	4-20	35.8867		35.88556	17.754	0.166
DY	305	01/11/2013 05:11	-32.2612	-35.2995			12.5	35.79982	17.336	0.1748
DZ	305	01/11/2013 08:07	-32.5329	-35.574131			13.47	35.59372	16.61	0.172
	305	01/11/2013 12:33	-33.1325	-36.189314	4-21	35.7609		35.7442	16.64	0.1866
EA	305	01/11/2013 12:44	-33.157	-36.215914			25	35.8068	16.784	0.177
EB	305	01/11/2013 14:37	-33.2616	-36.317719			14.31	35.89298	17.296	0.173
EC	305	01/11/2013 16:34	-33.5171	-36.583241			25.76	35.9579	17.806	0.17
	306	02/11/2013 04:21	-35.0696	-38.188381	4-22	35.8235		35.82422	16.58	0.216

ED	306	02/11/2013 04:52	-35.1377	-38.256512			24.57	35.85972	16.652	0.194
EE	306	02/11/2013 08:54	-35.4997	-38.634289			29.8	35.73255	15.80581	0.238581
	306	02/11/2013 11:14	-35.7836	-38.939732	4-23	35.872		35.87132	16.494	0.191
EF	306	02/11/2013 12:42	-35.9669	-39.127129			24.85	35.86054	16.568	0.1844
	306	02/11/2013 16:47	-36.3657	-39.555759	4-24	35.7876		35.78225	16.21	0.198
EG	306	02/11/2013 17:02	-36.4011	-39.593361			29.87	35.77354	16.206	0.2114
EH	306	02/11/2013 19:47	-36.8115	-40.017189			44.38	35.76168	15.91	0.265
EI	307	03/11/2013 04:50	-38.0393	-41.328468			78.65	34.8657	12.71	0.3768
	307	03/11/2013 04:54	-38.0477	-41.337238	7-1	34.8472		34.84616	12.734	0.383
	307	03/11/2013 09:11	-38.271	-41.57291	7-2	34.9391		34.92488	12.926	0.3768
EJ	307	03/11/2013 09:25	-38.2995	-41.60585			134.99	34.94518	12.964	0.3868
EK	307	03/11/2013 12:31	-38.6984	-42.041512			96.09	34.97526	13.024	0.315
	307	03/11/2013 15:16	-38.8689	-42.22438	7-3	34.9694		34.96749	12.92387	0.261839
EL	307	03/11/2013 16:51	-39.0182	-42.371159			70.9	35.31424	14.012	0.2998
	308	04/11/2013 04:24	-40.5336	-44.052929	7-4	34.8616		34.83302	12.66581	0.329
EM	308	04/11/2013 04:46	-40.5762	-44.09947			20	34.99762	12.92	0.309258
EN	308	04/11/2013 08:52	-40.8126	-44.339329			29.7	34.81309	12.28774	0.298
EO	308	04/11/2013 12:27	-41.1088	-44.697811			21.18	35.02774	11.92774	0.264387
	308	04/11/2013 12:37	-41.1242	-44.714329	7-5	35.0367		35.03056	11.884	0.2548
	308	04/11/2013 15:51	-41.436	-45.051111	7-6	35.0193		35.01328	12	0.258613
EP	308	04/11/2013 16:38	-41.5156	-45.136395			31.51	34.94801	11.98387	0.332
EQ	308	04/11/2013 19:23	-41.8089	-45.478495			20.72	34.94783	12.11419	0.246
	309	05/11/2013 04:23	-42.8198	-46.63755	7-7	34.7641		34.75648	11.54	0.266419
ER	309	05/11/2013 04:54	-42.8786	-46.70546			17.95	34.50816	10.484	0.3168
ES	309	05/11/2013 08:40	-43.2011	-47.0756			20.69	34.63554	10.994	0.2766
	309	05/11/2013 09:00	-43.2383	-47.118481	7-8	34.6949		34.70448	11.224	0.257
ET	309	05/11/2013 12:29	-43.6438	-47.589451			19.14	34.40995	10.05161	0.217161
	309	05/11/2013 12:31	-43.6478	-47.59404	7-9	34.4182		34.41048	10.046	0.2146
EU	309	05/11/2013 16:38	-43.9959	-48.00375			25.67	34.41734	10.36	0.2242
EV	309	05/11/2013 19:34	-44.2923	-48.35128			9.49	34.48057	10.75613	0.231613

	310	06/11/2013 04:50	-45.3205	-49.583809	7-10	34.5898		34.5857	10.138	0.434
EW	310	06/11/2013 05:23	-45.3876	-49.666779			101.07	34.72982	10.642	0.392
EX	310	06/11/2013 08:49	-45.7073	-50.046286			89.98	34.7922	11.028	0.322
	310	06/11/2013 09:06	-45.7429	-50.090072	7-11	34.8185		34.81527	11.21387	0.294
EY	310	06/11/2013 13:34	-46.2285	-50.681622			65.56	35.43972	13.67	0.226
	310	06/11/2013 13:38	-46.2356	-50.689899	7-12	35.453		35.44377	13.69226	0.228387
EZ	310	06/11/2013 16:34	-46.431	-50.81041			95.25	35.60519	14.15387	0.229613
	311	07/11/2013 06:42	-48.0774	-52.906324	7-13	34.6909		34.68294	10.28	0.3142
	311	07/11/2013 11:44	-48.6836	-53.693768	7-14	34.0383		34.0297	5.856129	0.505935

APPENDIX 4: Technical details of deployed equipment

BAS S/S CTD

Primary sensor stream on cast JR300_009 (temperature, conductivity & dissolved oxygen) noisy and reading inconsistently. No obvious obstruction found upon examination after recovery, no fault with tubing either. Pumps remained ‘on’ during entire cast, thus replaced primary pump with s/n 4488 beginning cast 010.

No surface values after soak because of rough weather on cast 058 and 061.

NOC S/S CTD

No surface values after soak because of rough weather on cast 059.

LADCP

No problems with instrument deployed.

Shortened log file (no script recorded) for deployment JR300_009m.
Shortened log file (no script recorded) for deployment JR300_028m.
Shortened log file (no script recorded) for deployment JR300_061m.

LADCP battery charged and vented at end of cruise.

Total number of casts - 54 BAS S/S frame, 11 NOC S/S frame.
Casts deeper than 2000m - 0 BAS S/S frame, 0 NOC S/S frame.
Deepest casts -504m BAS S/S frame, 502m NOC S/S frame.

Autosal

A heater lamp required replacement during the analysis of the first salinity crate (crate 9; all samples beginning with 9-10 through 9-999 should be viewed as suspect). Salinometer was therefore re-standardised prior to analyzing crate 5 on 18 October.

FRRF

Raw data files JR300_041.bin, JR300_047.bin and JR300_062.bin are partial files because of low battery pack voltage. Raw data file JR300_053.bin is a partial file because of a full flash card.

APPENDIX 5: Configuration, protocol & command files for deployed equipment

BAS Stainless Steel CTD frame:

Date: 10/09/2013

Instrument configuration file: D:\Data\JR300\JR300_BAS.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : No

1) Frequency 0, Temperature

Serial number : 03P-4472
Calibrated on : 30 August 2012
G : 4.41398102e-003
H : 6.42799022e-004
I : 2.19747460e-005
J : 1.88664616e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2222
Calibrated on : 24 August 2012
G : -9.57287162e+000
H : 1.33670231e+000
I : -4.60412961e-005
J : 7.67811135e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 89973
Calibrated on : 22 August 2012
C1 : -4.925971e+004
C2 : -2.136250e-001
C3 : 9.435710e-003
D1 : 3.900400e-002
D2 : 0.000000e+000
T1 : 2.983458e+001
T2 : -3.883229e-004

T3 : 3.262440e-006
T4 : 3.429810e-009
T5 : 0.000000e+000
Slope : 1.00010000
Offset : -1.27140
AD590M : 1.277500e-002
AD590B : -9.391460e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-2366
Calibrated on : 30 August 2012
G : 4.31974772e-003
H : 6.44172106e-004
I : 2.35210024e-005
J : 2.26433319e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-2289
Calibrated on : 21 August 2012
G : -1.04066323e+001
H : 1.38729309e+000
I : -2.46034773e-003
J : 2.40168672e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Transmissometer, WET Labs C-Star

Serial number : CST-846DR
Calibrated on : 13 March 2013
M : 21.6360
B : -1.2938
Path length : 0.250

7) A/D voltage 1, Fluorometer, Chelsea Aqua 3

Serial number : 088216
Calibrated on : 19 February 2013
VB : 0.219400
V1 : 2.068800
Vacetone : 0.228700
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

8) A/D voltage 2, PAR/Irradiance, Biospherical/Licor

Serial number : 7235
Calibrated on : 24 April 2013
M : 1.00000000
B : 0.00000000
Calibration constant : 33557046980.00000000
Multiplier : 1.00000000

Offset : -0.04219064

9) A/D voltage 3, Altimeter

Serial number : 244740
Calibrated on : 16 May 2012
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Oxygen, SBE 43

Serial number : 43-2290
Calibrated on : 31 March 2012
Equation : Sea-Bird
Soc : 3.97900e-001
Offset : -4.91300e-001
A : -2.09220e-003
B : 1.03780e-004
C : -1.69350e-006
E : 3.60000e-002
Tau20 : 1.57000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

11) A/D voltage 5, Turbidity Meter, WET Labs, ECO-BB

Serial number : BBRTD-849
Calibrated on : 19 March 2012
ScaleFactor : 0.002218
Dark output : 0.063000

12) A/D voltage 6, Free

13) A/D voltage 7, Turbidity Meter, WET Labs, ECO-BB, 2

Serial number : BBRTD-949
Calibrated on : 8 March 2012
ScaleFactor : 0.004230
Dark output : 0.073600

Scan length : 37

NOC Stainless CTD frame:

Date: 10/09/2013

Instrument configuration file: D:\Data\JR300\JR300_NOC.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1

NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : No

1) Frequency 0, Temperature

Serial number : 03P-4712
Calibrated on : 15 February 2013
G : 4.40411437e-003
H : 6.33312005e-004
I : 1.91163346e-005
J : 1.15573879e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2858
Calibrated on : 19 April 2013
G : -1.02400780e+001
H : 1.44051530e+000
I : -3.89818072e-005
J : 7.74219593e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 93896
Calibrated on : 12 May 2011
C1 : -8.331332e+004
C2 : -3.281962e-001
C3 : 2.216060e-002
D1 : 2.906000e-002
D2 : 0.000000e+000
T1 : 3.005232e+001
T2 : -3.843669e-004
T3 : 4.436390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 0.99996000
Offset : -1.07670
AD590M : 1.289250e-002
AD590B : -8.106440e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5660
Calibrated on : 4 April 2013
G : 4.33146870e-003
H : 6.25508499e-004
I : 1.92261535e-005
J : 1.43140311e-006
F0 : 1000.000

Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-3054
Calibrated on : 15 February 2013
G : -1.01955156e+001
H : 1.40295175e+000
I : -2.76149896e-004
J : 9.00984845e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 43-1940
Calibrated on : 21 August 2012
Equation : Sea-Bird
Soc : 5.02200e-001
Offset : -4.97800e-001
A : -2.50270e-003
B : 8.66410e-005
C : -1.51490e-006
E : 3.60000e-002
Tau20 : 1.39000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Transmissometer, Chelsea/Seatech

Serial number : 161-2642-002
Calibrated on : 4 September 1996
M : 22.9312
B : -0.5504
Path length : 0.250

9) A/D voltage 3, Fluorometer, Chelsea Aqua 3

Serial number : 88-2615-126
Calibrated on : 4 May 2012
VB : 0.316800
V1 : 2.173800
Vacetone : 0.370300
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor

Serial number : PAR 10
Calibrated on : 14 June 2011
M : 0.47873100

B : 1.03249300
Calibration constant : 100000000000.00000000
Multiplier : 0.99970000
Offset : 0.00000000

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2

Serial number : PAR 11
Calibrated on : 14 June 2011
M : 0.43350400
B : 1.75470300
Calibration constant : 100000000000.00000000
Multiplier : 0.99980000
Offset : 0.00000000

12) A/D voltage 6, Turbidity Meter, WET Labs, ECO-BB

Serial number : BBRTD-169
Calibrated on : 9 August 2013
ScaleFactor : 0.004011
Dark output : 0.092400

13) A/D voltage 7, Altimeter

Serial number : 6196.112522
Calibrated on : 15 July 2013
Scale factor : 15.000
Offset : 0.000

Scan length : 37

LADCP command file:

```
;
$P ************************************************************************
$P *******  LADCP Deployment with one ADCP.  Usually looking down **********
$P ************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt (sent after each command)
$W62
;**Start**
; Display real time clock setting
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
WM15
$W62
; Save settings as User defaults
CK
$W62
; Name data file
RN JR300
$W62
; Set transducer depth to zero
```

```
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
; Set system coordinate.
EX11111
$W62
; Set one ensemble/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good
LD111100000
$W62
; Set one ping per ensemble. Use WP if LADCP option is not enabled.
LP1
$W62
; Set to record 25 bins. Use WN if LADCP option is not enabled.
LN025
$W62
; Set bin size to 400 cm. Use WS if LADCP option is not enabled.
LS400
$W62
; Set blank to 176 cm (default value) Use WF if LADCP option is not enabled.
LF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 176 cm/sec.
; Use WV if LADCP option is not enabled.
LV170
$W62
; Set ADCP to narrow bandwidth and extend range by 10%
LW1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value.   1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
$W62
; Start pinging
CS
; Delay 3 seconds
$D3
$p *************************************************************************
$P Please disconnect the ADCP from the computer.
```

```
$P ***********************************************************************
; Close the log file
$l
```

FRRF boot protocols:

```
 =====================
   System Setup
 =====================

Fast Repetition Rate Fluorometer -  Ver 1.18
FPGA Version -  Ver 0.1
Instrument ID - Ser 05-4845-001
Flashcard Size -  24 MB
AutoAcquire is ENABLED

Mon Oct  7 10:04:57 2013
System Battery Voltage = 17.46 V
System Current         = 0.129 A
Electronics Temp       = 17.16 Deg C

A:      Set Date and Time
B:      Boot protocol slot number -     0
C:      AutoAcquire is ENABLED
D:      REF Amplifier offset (counts)-  117
E:      PMT Amplifier offset (counts)-  125
F:      Reserved
G:      Reserved
H:      F0 analog output scale maximum - 1.000000
I:      FM analog output scale maximum - 1.000000
J:      PMT calibration threshhold is -  200 counts
K:      Ref calibration threshhold is -  200 counts
L:      Set PMT gain constants
M:      Check PMT calibration
X:      Reset to Safe values

Select option or '0' to return:

 =====================
   Main Menu
 =====================

   1. Run
   2. File
   3. System Status & Setup
   4. Error and PMT Log
   X. Shutdown

 =====================
   Run Menu
 =====================

   1. Discrete Acquire
   2. Programmed Acquire
   3. View/Edit Current Protocol
   4. Save Protocol
   5. Restore Protocol

   0. to Return:
```

```
*** Boot Protocol = 0 ***

6. 32000     Acquisitions
7.     8     Flash sequences per acquisition
8.   100     Saturation flashes per sequence
9.     8     Saturation flash duration (in instrument units)
A.     0     Saturation interflash delay (in instrument units)
B. ENABLED  Relaxation flashes
C.    20     Relaxation flashes per sequence
D.     8     Relaxation flash duration (in instrument units)
E.    61     Relaxation interflash delay (in instrument units)
F.    10     ms Sleeptime between acquisition pairs
G.    16     PMT Gain in Autoranging Mode
H. DISABLED  Analog Output
I. DISABLED  Desktop (verbose) Mode
J. ACTIVE    Light Chamber (A)
K. ACTIVE    Dark Chamber (B)
L. ENABLED   Logging mode to internal flashcard
M:    90     Upper Limit Autoranging Threshold value
N:    15     Lower Limit Autoranging Threshold value

=====================
  System Setup
=====================

Fast Repetition Rate Fluorometer -  Ver 1.18
FPGA Version -  Ver 0.1
Instrument ID - Ser 05-4845-001
Flashcard Size -  24 MB
AutoAcquire is ENABLED

Mon Oct  7 10:02:32 2013
System Battery Voltage = 17.44 V
System Current         = 0.131 A
Electronics Temp       = 16.53 Deg C

A:     Set Date and Time
B:     Boot protocol slot number -     1
C:     AutoAcquire is ENABLED
D:     REF Amplifier offset (counts)-  117
E:     PMT Amplifier offset (counts)-  125
F:     Reserved
G:     Reserved
H:     F0 analog output scale maximum - 1.000000
I:     FM analog output scale maximum - 1.000000
J:     PMT calibration threshhold is -  200 counts
K:     Ref calibration threshhold is -  200 counts
L:     Set PMT gain constants
M:     Check PMT calibration
X:     Reset to Safe values

Select option or '0' to return:

=====================
  Main Menu
=====================

  1. Run
```

```
 2. File
 3. System Status & Setup
 4. Error and PMT Log
 X. Shutdown

=====================
 Run Menu
=====================

 1. Discrete Acquire
 2. Programmed Acquire
 3. View/Edit Current Protocol
 4. Save Protocol
 5. Restore Protocol

 0. to Return:

      *** Boot Protocol = 1 ***

 6. 65535     Acquisitions
 7.    16     Flash sequences per acquisition
 8.   100     Saturation flashes per sequence
 9.     4     Saturation flash duration (in instrument units)
 A.     0     Saturation interflash delay (in instrument units)
 B. DISABLED  Relaxation flashes
 C.    20     Relaxation flashes per sequence
 D.     4     Relaxation flash duration (in instrument units)
 E.    61     Relaxation interflash delay (in instrument units)
 F.    30     ms Sleeptime between acquisition pairs
 G.     1     PMT Gain in Normal Mode
 H. DISABLED  Analog Output
 I. DISABLED  Desktop (verbose) Mode
 J. ACTIVE    Light Chamber (A)
 K. ACTIVE    Dark Chamber (B)
 L. ENABLED   Logging mode to internal flashcard
 M:    90     Upper Limit Autoranging Threshold value
 N:    15     Lower Limit Autoranging Threshold value
```